



**RULES FOR THE CLASSIFICATION AND  
CONSTRUCTION**

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**PART 2. INLAND WATERWAYS SHIP**

**VOLUME III  
RULES FOR MACHINERY  
INSTALLATIONS  
2015 EDITION**

**BIRO KLASIFIKASI INDONESIA**





# **RULES FOR THE CLASSIFICATION AND CONSTRUCTION**

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## **PART 2. INLAND WATERWAYS SHIP**

### **VOLUME III RULES FOR MACHINERY INSTALLATIONS 2015 EDITION**

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## Foreword

Rules for Machinery Installation – Inland Waterways Volume III 2015. Reference source of the rules are derived from Safety of Life at Sea (SOLAS), IACS Unified Requirement, IACS Recommendation, others standard and input from BKI Branch Office and Technical Division of BKI Head Office.

The content of this rules consist of eight section below :

### Section 1 Machinery and Systems

- A. General Requirements
- B. Propelling and Auxiliary Machinery
- C. Pipes, Valves, Fittings and Pumps
- D. Pressure Vessels and Heat Exchangers, Boilers and Thermal Oil Heaters
- E. Steering Gears
- F. Lateral Thrust Units
- G. Domestic Gas Installations
- H. Fire-Protection and Fire-Extinguishing
- I. Tests on Board

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## **Section 1**

### **Machinery and Systems**

#### **A. General Requirement**

##### **1. General**

##### **1.1 Application**

**1.1.1** This Section applies to the design, construction, installation, tests and trials of main propulsion and essential (needed for navigation) auxiliary machinery systems and associated equipment, boilers and pressure vessels and piping systems installed on board classed inland navigation vessels, as indicated in each Subsection (A. to I.) of this Section.

##### **1.2 Additional requirements**

**1.2.1** Additional requirements for machinery are given in the Rules for Additional Requirements of Notations-Inland Waterways (Part 2, Vol V), for the assignment of the type and service notations and for Additional Requirements of Notations.

##### **1.3 Documentation to be submitted**

**1.3.1** The drawings and documents requested in the relevant parts of this Section are to be submitted to BKI for review/approval.

#### **2. Design and construction**

##### **2.1 General**

**2.1.1** The machinery, boilers and other pressure vessels, associated piping systems and fittings are to be of a design and construction adequate for the service for which they are intended and shall be so installed and protected as to reduce to a minimum any danger to persons on board, due regard being paid to moving parts, hot surfaces and other hazards.

The design is to have regard to materials used in construction, the purpose for which the equipment is intended, the working conditions to which it will be subjected and the environmental conditions on board.

Engines and their ancillaries shall be designed, built and installed in accordance with best practice.

**2.1.2** Machinery installations or essential parts have been constructed in accordance with a design, for which sufficient experience is not available. Special dispensations may only be considered by the Administration provided that alternative design can be taken which maintain the same degree of safety. The nature of the alternative measures shall be approved and clearly stated and be available to the Port Administration.

##### **2.2 Materials, welding and testing**

##### **2.2.1 General**

Materials, welding and testing procedures are to be in accordance with the requirements of the Rules for Materials and Welding (Part 1, Vol. V and Vol. VI) and those given in the other parts of this Section. In addition, for machinery components fabricated by welding the requirements given in 2.2.2 apply.

### 2.2.2 Welded machinery components

Welding processes are to be approved and welders certified by BKI in accordance with the Rules for Welding (Part 1, Vol. VI).

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

Joints transmitting loads are to be either:

- full penetration
- T- or cruciform joints

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

T-joints on scalloped edges are not permitted.

Lap-joints and T-joints subjected to tensile stresses are to have a throat size of fillet welds equal to 0.7 times the thickness of the thinner plate on both sides.

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

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

### 2.3 Vibrations

Special consideration (see B.5.) is to be given to the design, construction and installation of propulsion machinery systems and auxiliary machinery so that any mode of their vibrations shall not cause undue stresses in this machinery in the normal operating ranges.

### 2.4 Operation in inclined position

Main propulsion machinery and all auxiliary machinery essential to the propulsion and the safety of the vessel are, as fitted in the vessel, to be designed to operate when the vessel is upright and when inclined at any angle of list either way and trim by bow or stern as stated in Table 1.1. Machinery with a horizontal rotation axis is generally to be fitted on board with such axis arranged along ships. If this is not possible, the manufacturer is to be informed at the time the machinery is ordered.

**Table 1.1. Permanent inclination of vessel**

Installations, components	Angle of inclination [°] <sup>1</sup>	
	Athwartship	Fore and aft
Main and auxiliary machinery <sup>2</sup>	12	5
<sup>1</sup> Athwartship and fore-and-aft inclinations may occur simultaneously		
<sup>2</sup> Higher angle values may be required depending on vessel		

## 2.5 Ambient conditions

Machinery and systems covered by the Rules are to be designed to operate properly under the ambient conditions specified in Table 1.2, unless otherwise specified.

**Table 1.2. Ambient conditions**

<b>AIR TEMPERATURE</b>	
<b>Location, arrangement</b>	<b>Temperature range [°C]</b>
In enclosed spaces	between 0 and +40 (+45 in tropical zone) <sup>1</sup>
On machinery components, boilers In spaces subject to higher or lower temperatures	according to specific local conditions
On exposed decks	between -20 and +40 (+45 in tropical zone)

<b>WATER TEMPERATURE</b>	
<b>Coolant</b>	<b>Temperature [°C]</b>
River water or, if applicable, river water at charge air coolant inlet	up to +25 in tropical zone up to +32 in tropical zone
1 Different temperatures may be accepted by BKI in case of vessels intended for restricted service.	

## 2.6 Approved fuels

**2.6.1** The flash point of liquid fuels for the operation of machinery and boiler installations shall be above 55 °C.

**2.6.2** Liquid fuel is to be carried in oiltight tanks which shall either form part of the hull or be solidly connected with the vessel's hull.

## 2.7 Power of machinery

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

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

## 2.8 Astern power

Sufficient power for going astern is to be provided to secure proper control of the vessel in all normal circumstances.

The main propulsion machinery is to be capable of maintaining in free route astern at least 70 % of the maximum ahead revolutions for a period of at least 10 min.

For main propulsion systems with reversing gears or controllable pitch propellers, running astern is not to lead to an overload of propulsion machinery.

During the river trials, the ability of the main propulsion machinery to reverse the direction of thrust of the propeller is to be demonstrated and recorded (see also I.3.2).

## **2.9 Safety devices**

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

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

**2.9.3** Main internal combustion propulsion machinery and auxiliary machinery shall be provided with automatic shut-off arrangements in the case of failures, such as lubricating oil supply failure, which could lead rapidly to complete breakdown, serious damage or explosion.

BKI may permit provisions for overriding automatic shut-off devices.

## **3. Arrangement and installation on board**

### **3.1 General**

Provision shall be made to facilitate cleaning, inspection and maintenance of main propulsion and auxiliary machinery, including boilers and pressure vessels.

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

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

Engines shall be installed and fitted in such a way as to be adequately accessible for operation and maintenance, and shall not endanger the persons assigned to those tasks. It shall be possible to make them secure against unintentional starting.

### **3.2 Floors**

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

### **3.3 Bolting down**

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

Propulsion Plants are to be mounted and secured to their shipboard foundations in conformity with the Guidelines for the Seating of Propulsion Plants and Auxiliary Machinery

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

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

The same requirements apply to thrust block and shaft line bearing foundations.

Particular care is to be taken to obtain a perfect leveling and general alignment between the propulsion

engines and their shafting.

**3.3.2** Chocking resins are to be type-approved.

### **3.4 Safety devices on moving parts**

Suitable protective devices are to be provided in way of moving parts (flywheels, couplings, etc.) in order to avoid injuries to personnel.

### **3.5 Gauges**

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

### **3.6 Ventilation in machinery spaces**

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

This sufficient amount of air is to be supplied through suitably protected openings arranged in such a way that they can be used in all weather conditions.

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

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

### **3.7 Hot surfaces and fire protection**

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

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

Fire protection, detection and extinction is to comply with the requirements of H.

### **3.8 Machinery remote control, alarms and safety systems**

For remote control systems of main propulsion machinery and essential auxiliary machinery and relevant alarms and safety systems, see Section 2, M.2.7.

## **4. Tests and trials**

### **4.1 Works tests**

Equipment and its components are subjected to works tests which are detailed in the relevant parts of this Section and are to be witnessed by the Surveyor.

Where such tests cannot be performed in the workshop, BKI may allow them to be carried out on board, provided this is not judged to be in contrast either with the general characteristics of the machinery being

tested or with particular features of the shipboard installation. In such cases, the Surveyor is to be informed in advance and the tests are to be carried out in accordance with the provisions of the BKI Rules for Materials and Welding (Part 1 Vol.V and Vol.VI) relative to incomplete tests.

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

## 4.2 Tests on board

Trials on board of machinery are detailed in I.

## B. Propelling and Auxiliary Machinery

### 1. Symbols

$N$  = speed of the shaft for which the check is carried out [rev/min]  
 $N_N$  = nominal speed of the engine [rev/min]  
 $\lambda$  = speed ratio  
 $= N/N_N$

### 2. Internal combustion engines

#### 2.1 General

##### 2.1.1 Scope

The Rules contained in the following apply to internal combustion engines used as main propulsion units and auxiliary units.

For the purpose of these Rules, internal combustion engines are diesel engines.

##### 2.1.2 Rated Power

Diesel engines are to be designed such that their rated power running at rated speed can be delivered as a continuous net brake power. Diesel engines are to be capable of continuous operation within power range (1) of Fig. 1.1 and of short-period operation in power range (2). The extent of the power range is to be stated by the engine manufacturer.

In determining the power of all engines used on board inland waterway vessels with unlimited range of service, the ambient conditions given in Table 1.3 are to be used.

**Table 1.3. Ambient conditions**

<b>Barometric pressure</b>	<b>1000 mbar</b>
Suction air temperature	- 40 °C, in general - 45 °C, in tropical zone
Relative humidity	60 %
Raw water temperature (inlet temperature of charge air coolant)	- 25 °C, in general - 32 °C, in tropical zone

Continuous power is understood to mean the net brake power which an engine is capable of delivering

continuously, provided that the maintenance prescribed by the engine manufacturer is carried out, between the maintenance intervals stated by the engine manufacturer.

To verify that an engine is rated at its continuous power, it is to be demonstrated on the test bed that the engine can run at an overload power corresponding to 110 % of its rated power at corresponding speed for an uninterrupted period of 30 minutes.

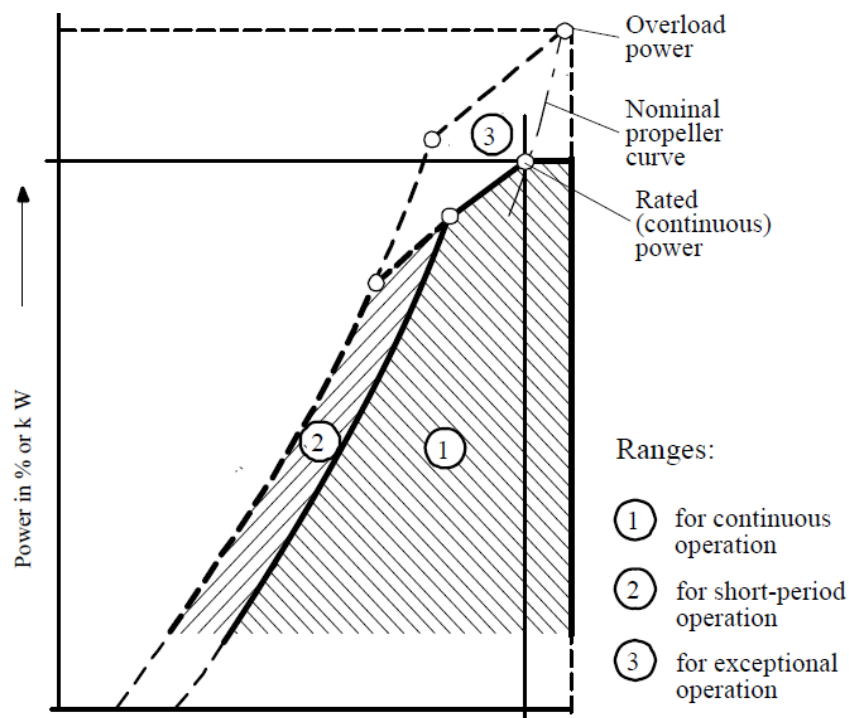
After running on the test bed, the fuel delivery system of main engines is normally to be so adjusted that overload power cannot be given in service.

Subject to the prescribed conditions, diesel engines driving electric generators shall be capable of overload operation even after installation on board.

Subject to the approval of BKI, diesel engines for special vessels and applications may be designed for a blocked continuous power which cannot be exceeded.

For main engines, a power diagram (Fig. 1.1) is to be prepared showing the power ranges within which the engine is able to operate continuously and for short periods under service conditions.

**Fig. 1.1 Power/speed diagram**



### 2.1.3 Fuels

The use of liquid fuels is subject to the Rules contained in A.2.6.

Only internal combustion engines burning liquid fuels having a flash point of more than 55 °C may be installed.

The use of gaseous fuels is subject to a further design approval.

For fuel systems, see C.7.

### 2.1.4 Accessibility of engines

Engines are to be so arranged in the engine room that all the erection holes and inspection ports provided by the engine manufacturer for inspections and repairs are accessible or easily be made accessible (see A.3.1).

### 2.1.5 Installation and mounting of engines

Engines are to be mounted and secured to their shipboard foundations in conformity with the Guidelines for the Seating of Propulsion Plants and Auxiliary Machinery.

### 2.1.6 Documents for review/approval

For each engine type, one or three copies, as specified, of the drawings and documents listed in Table 1.4 shall, wherever applicable, be submitted for review/approval (A) or information (R).

**Table 1.4 Documents for review**

No.	A/R	Description	Quantity	Remarks
1	R	Details required on BKI forms when applying for review/approval of a internal combustion engine	3	
2	R	Engine transverse cross section	3	
3	R	Engine longitudinal section	3	
4	R	Bedplate or crankcase	1	
5	R	Engine block	1	
6	R	Tie rod	1	
7	R	Cylinder cover assembly	1	
8	R	Cylinder liner	1	1
9	A	Crankshaft details, for each number of cylinders	3	
10	A	Crankshaft assembly, for each number of cylinders	3	
11	A	Counterweights including fastening bolts	3	
12	A	Connecting rod, details	3	
13	R	Connecting rod assembly	3	1
14	R	Piston assembly	1	
15	R	Camshaft drive assembly	1	
16	A	Material specifications of main components	3	
17	A	Arrangement of foundation bolts (for main engines only)	3	
18	A	Schematic diagram of engine control and safety system	3	
19	R	Shielding and insulation of exhaust pipes-assembly	1	
20	A	Shielding of high-pressure fuel pipes – assembly	3	2
21	A	Arrangement of crankcase explosion relief valves	3	3
22	R	Operation and service manuals	1	
Remarks : 1 Only necessary if sufficient details are not shown on the transverse cross section and longitudinal section 2 For attended engine: only engines with a cylinder bore of $\geq 250$ mm 3 only for engines with a cylinder diameter of $> 200$ mm, or a crankcase volume exceeding $0,6\text{m}^3$				

The type specification of an internal combustion engine is defined by the following data:

- manufacturer's type designation
- cylinder bore
- stroke
- method of injection (direct, indirect)



- valve and injection operation (by cams or electronically controlled)
- working cycle (4-stroke, 2-stroke)
- method of gas exchange (naturally aspirated or supercharged)
- rated power per cylinder at rated speed and mean effective working pressure
- method of pressure charging (pulsating pressure system or constant pressure system)
- charge air cooling system
- cylinder arrangement (in-line, vee)

Following initial approval of an engine type by BKI, only those documents listed in Table 1.4 require to be resubmitted for examinations which embody important design modifications.

## **2.2 Crankshaft design**

### **2.2.1 Design methods**

Crankshafts are to be designed to withstand the stresses occurring when the engine runs at rated power. Calculations are to be based on the Rules for Machinery (Part 1 Vol.III). Other methods of calculation may be used provided that they do not result in crankshaft dimensions smaller than those specified in the most recent edition of the aforementioned BKI Rules.

Outside the end bearings, crankshafts designed according to the BKI Rules may be adapted to the diameter of the adjoining shaft by a generous fillet ( $r > 0,06 \cdot d$ ) or a taper.

Design methods for application to crankshafts of special construction and to the crankshafts of engines of special type are to be agreed with BKI.

### **2.2.2 Split crankshaft**

Fitted bolts or equivalent fastenings are to be used for assembling split crankshafts.

### **2.2.3 Torsional vibration, critical speeds**

See 5.

## **2.3 Materials**

### **2.3.1 Approved materials**

The mechanical characteristics of materials used for the components of diesel engines shall conform to the Rules for Materials (Part 1, Vol. VI). The materials approved for the various components are shown in Table 1.6 together with their minimum required characteristics.

Materials with properties deviating from those specified may be used only with BKI consent.

### **2.3.2 Testing of materials**

For the following components:

- crankshaft

- crankshaft coupling flange (non-integral) for main power transmission
- crankshaft coupling bolts
- connecting rods

**Table 1.6 Approved Materials**

<b>Minimum required characteristics</b>	<b>Components</b>
Forged steel $R_m \geq 360 \text{ N/mm}^2$	Crankshafts connecting rods tie rods bolts and studs
Rolled steel rounds $R_m \geq 360 \text{ N/mm}^2$	Tie rods bolts and studs
Nodular cast iron. Preferably ferritic grades	Engine blocks Bedplates Cylinder covers Flywheels Valve bodies and similar Parts
Lamellar cast iron $R_m \geq 200 \text{ N/mm}^2$	Engine blocks Bedplates Cylinder covers liners Flywheels
Shipbuilding steel All grade D for plates $\leq 25 \text{ mm}$ thick	Welded bedplates Welded engine blocks
Shipbuilding steel All grade D for plates $>25 \text{ mm}$ thick or equivalent structural Steel, cast in the fully killed conditional and normalized	
Weldable cast steel	Bearing transverse girders

Evidence is to be supplied that the materials used meet the requirements of the Rules for Materials (Part 1, Vol. VI). This evidence may take the form of a manufacturer's acceptance certificate.

In addition, crankshafts and connecting rods are to be subjected to non-destructive crack tests at the works and the results placed on record.

Where there is reason to doubt the satisfactory nature of an engine component, further additional tests according to recognized procedures may be stipulated.

## **2.4 Tests and trials**

### **2.4.1 Pressure tests**

Appointed components of internal combustion engines are to be subjected at the works to pressure tests at the test pressures indicated in Table 1.5 or to equivalent tests.

**Table 1.5 Pressure tests**

Component		Test pressure, Pp <sup>1</sup>
Cylinder cover		7 bar
Cylinder liner, over whole length of cooling water space		7 bar
Cylinder jacket, cooling water space		4 bar, at least 1,5. P <sub>e,zul</sub>
Exhaust valve, cooling water space		4 bar at least 1,5. P <sub>e,zul</sub>
Piston, cooling water space (after assembly with piston rod, if applicable)		7 bar
Fuel injection system	Pump body, Delivery side	1,5. P <sub>e,zul</sub> or P <sub>e,zul</sub> + 300 bar (whichever is less)
	Valves pipes	1,5. P <sub>e,zul</sub> or P <sub>e,zul</sub> + 300 bar (whichever is less)
Exhaust gas turbocharger, cooling water space		4 bar, at least 1,5. P <sub>e,zul</sub>
Exhaust gas line, cooling water space		4 bar, at least 1,5. P <sub>e,zul</sub>
Main engine-driven compressor: Cylinder, cover, intercooler	Air side	4 bar, at least 1,5. P <sub>e,zul</sub>
After cooler	Water side	
Cooler, both sides  (charger air cooler only on water side)		4 bar, at least 4 bar, at least 1,5. P <sub>e,zul</sub>
4 bar, at least 4 bar, at least 1,5. P <sub>e,zul</sub>		
Main engine-driven pumps (oil, water, fuel and bilge pumps)		4 bar, at least 1,5. P <sub>e,zul</sub>
Starting and control air system		1,5. P <sub>e,zul</sub> before installation
<sup>1</sup> component shall normally be hydraulically tested. Other equivalent test methods may be accepted. P <sub>e,zul</sub> = maximum permissible working pressure of component concerned [bar]		

#### 2.4.2 Test bed trials

In general, engines are to be subjected under BKI supervision to a test bed trial of the scope stated below. Exceptions to this require the agreement of BKI.

Main engines for direct propeller drive:

- 100 % power (rated power) at rated speed  $n_0$ : 60 minutes
- 100 % power at  $n = 1,032 \times n_0$ : 45 minutes
- 90 %, 75 %, 50 % and 25 % power in accordance with the nominal propeller curve.

In each case the measurements shall not be carried out until the steady operating condition has been achieved.

- Starting and reversing maneuvers
- Test of governor and independent over speed protection device

f) Test of engine shut-down devices

For main engines for indirect propeller devices, the test is to be performed at rated speed with a constant governor setting under conditions of:

- a) 100 % power(rated power): 60 minutes
- b) 110 % power : 45 minutes
- c) 75 %, 50 % and 25 % power and idle run

In each case the measurements shall not be carried out until the steady operating condition has been achieved.

d) Start-up tests

For auxiliary driving engines and engines driving electric generators, tests are to be performed in accordance with the above paragraph (main engines for indirect propeller devices). The manufacturer's test bed reports are acceptable for auxiliary driving engines rated at < 100 kW.

## **2.5 Safety devices**

### **2.5.1 Speed control and engine protection against over speed**

a) Main and auxiliary engines

Each diesel engine not used to drive an electric generator shall be equipped with a speed governor or regulator so adjusted that the engine speed cannot exceed the rated speed by more than 15 %.

In addition to governor, each main engine with a rated power of 220 kW or over which can be declutched in service or which drives a variable pitch propeller shall be fitted with an additional over speed device so adjusted that the engine speed cannot exceed the rated speed by more than 20 %.

Equivalent equipment may be approved by BKI.

b) Engine driving electric generators

Each diesel engine used to drive an electric generator shall be fitted with a governor which, in the event of the sudden complete removal of the load, prevents any transient speed variation ( $\delta r_s$ ) in excess of 10 % of the rated speed. The permanent speed variation ( $\delta r$ ) may not exceed 5 %.

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

In addition to the governor, each diesel engine with a rated power of 220 kW or over shall be equipped with an over speed protection device independent of the normal governor which prevents the engine speed from exceeding the rated speed by more than 15 %.

Unless other requirements have been agreed with BKI regarding the connection of loads, the speed variations specified above shall not be exceeded when the engine, running on no-load, is suddenly loaded to 50 % of its rated power followed by the remaining 50 %.

Generating sets of different capacities operating in parallel are required to run within the limits specified in Section 2, B.6.

The speed shall be stabilized within five seconds, inside the permissible range specified for the permanent speed variation  $\delta r$ .

Generator sets which are installed to serve stand-by circuits shall satisfy these requirements even when the engine is cold. The start-up and loading sequence is to be concluded in about 45 seconds.

Emergency generator sets shall satisfy the above governor conditions even when their total consumer load is applied suddenly.

The governors of the engines mentioned above shall enable the rated speed to be adjusted over the entire power range with a maximum deviation of 5 %.

The rate of speed variation of the adjusting mechanisms shall permit satisfactory synchronization in a sufficiently short time. The speed characteristic should be as linear as possible over the whole power range. The permanent deviation from the theoretical linearity of the speed characteristic may, in the case of generating sets intended for parallel operation, in no range exceed 1 % of the rated speed.

### Notes

- *The rated power and the corresponding rated speed relate to the conditions under which the engines are operated in the system concerned.*
  - *Additional over speed protection device means a system all of whose component parts, including the drive, function independently of the governor.*
- c) Use of electrical/electronic governors

The electrical/electronic governors used shall have been type-tested by BKI.

In the case of engines with electrical starters, the governor may be supplied direct from the starter battery allocated to each engine.

For each engine without an electric starter, the governor shall be supplied from the floating shipboard supply battery or from a permanently assigned battery of suitable capacity.

Arrangements are to be made to ensure that the batteries are kept charged and monitored at all times.

When an engine is taken out of service, the supply to its governor shall cut out automatically.

### 2.5.2 Cylinder overpressure warning device

All the cylinders of engines with a cylinder bore > 230 mm are to be fitted with cylinder overpressure control valves. The response threshold of these valves shall be set at not more than 40 % above the combustion pressure at rated power.

A warning device may be dispensed with if it is ensured by an appropriate engine design or by control functions that an increased cylinder pressure cannot create danger.

### 2.5.3 Crankcase airing and venting

The airing of crankcases is not allowed.

Crankcases are to be equipped with venting systems with a clear opening not larger than is strictly necessary. The crankcase vent pipes of engines having a swept volume of more than 50 dm<sup>3</sup> per row of cylinders are to be led into the open and protected to prevent the entry of water.

Engine with a swept volume of up to 50 dm<sup>3</sup> per row of cylinders are to be fitted with vent pipes which are to be covered over to prevent the entry of foreign matter and which may not terminate at hot points.

Where provision has been made for extracting the lubricating oil vapours, e.g. for monitoring the oil vapour concentration, the negative pressure in the crankcase may not exceed 2,5 mbar.

Joining together the crankcase vent pipes of two or more engines is not permitted.

#### 2.5.4 Crankcase safety devices

Crankcase safety devices have to be type-approved in a configuration that represents the installation arrangements that will be used on an engine according to the requirements defined in the Guidelines Test Requirements for Components and Systems.

Safety valves to safeguard against overpressure in the crankcase are to be fitted to all engines with a cylinder bore of > 200 mm or a crankcase volume of > 0,6 m<sup>3</sup>.

All other spaces communicating with the crankcase, e.g. gear or chain casings for camshafts or similar drives, are to be equipped with additional safety valves if the volume of these spaces likewise exceeds 0,6 m<sup>3</sup>.

Engines with a cylinder bore of > 200 mm < 250 mm shall be equipped with at least one safety valve at each end of the crankcase. If the crankshaft has more than 8 throws, an additional safety valve is to be fitted near the middle of the crankcase.

Engines with a cylinder bore of > 250 mm < 300 mm shall have at least one safety valve close to every second crank throw, subject to a minimum number of two.

Engines with a cylinder bore of > 300 mm shall have at least one safety valve close to each crank throw.

Each safety valve shall have a free cross sectional area of at least 45 cm<sup>2</sup>.

The total free sectional area of the safety valves fitted to an engine to safeguard against overpressure in the crankcase may not be less than 115 cm<sup>2</sup>/m<sup>3</sup> of crank- case volume.

#### Notes

- *In estimating the gross volume of the crankcase, the volume of the fixed parts which it contains may be deducted.*
- *A space communicating with the crankcase via a total free cross sectional area of > 115 cm<sup>2</sup>/m<sup>3</sup> of the volume need not be considered as a separate space. In calculating the total free cross sectional area, individual sections of < 45 cm<sup>2</sup> are to be disregarded.*
- *Each safety valve required may be replaced by not more than two safety valves of smaller cross sectional area provided that the free cross sectional area of each safety valve is not less than 45 cm<sup>2</sup>.*

The safety devices shall take the form of flaps or valves of proven design. In service they shall be oiltight when closed and shall prevent air from flowing in into the crankcase. The gas flow caused by the response of the safety device shall be deflected in such a way as not to endanger persons standing nearby.

Safety device shall respond to as low an overpressure in the crankcase as possible (maximum 0,2 bar).

Covers of crankcase openings shall be so dimensioned as not to suffer permanent deformation due to the pressure occurring during the response of the safety equipment.

Crankcase doors and hinged inspection ports are to be equipped with appropriate latches to effectively prevent unintended closing.

A warning sign is to be mounted on the engine control platform or, if appropriate, on both sides of the engine drawing attention to the fact that the crankcase may not be opened immediately following stoppage of the hot run engine, but only after a sufficient cooling period has elapsed.

### **2.5.5 Safety devices in the starting air system**

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

- a) An isolation non-return valve is to be fitted to the starting airline serving each engine.
- b) Engines with cylinder bore of > 230 mm are to be equipped with flame arresters as follows:
  - on directly reversible engines, in front of each start-up valve of each cylinder
  - on non-reversing engines, in the main starting airline to each engine
- c) Equivalent safety devices may be approved by BKI.

### **2.5.6 Safety devices in the lubricating oil system**

If the lubricating oil pressure falls below the minimum level specified by the engine manufacturer, thereby necessitating the immediate shutdown of the main engine, an audible and visual alarm shall be given which is clearly perceptible throughout the engine room and the control stand.

This alarm shall be clearly distinguishable from the alarm required under A.3.8.

## **2.6 Pipes and filters**

### **2.6.1 General**

The general engine piping system is subject to the requirements of C.

### **2.6.2 Fuel lines**

Only pipe connections with metal sealing surfaces or equivalent pipe connections of approved design may be used for fuel injection lines.

External high-pressure fuel delivery pipes of diesel engines, between the high-pressure fuel pumps and fuel injectors, shall be protected with a jacketed piping system capable of containing fuel from a high-pressure pipe failure. The jacketed piping system shall include a means for the collection of leakages, and arrangements shall be provided for an alarm to be given of a fuel pipe failure, except that an alarm is not required for engines with no more than two cylinders.

Jacketed piping systems need not be applied to engines on open decks operating windlasses and capstans.

If pressure variations of > 20 bar occur in the fuel return lines, these are also to be shielded.

Leaking fuel is to be safely drained away at zero excess pressure. Care is to be taken to ensure that leaking fuel cannot become mixed with the engine lubricating oil.

### 2.6.3 Filters

a) Lubricating oil filters for main engines

Lubricating oil lines are to be fitted with lubricating oil filters located in the main oil flow on the delivery side of the pumps.

Steps are to be taken to ensure that main flow filters can be cleaned without interrupting operation. This requirement is considered to be satisfied by switch-over duplex filters, automatic filters or equivalent devices of approved design.

On main engines with a rated power of up to 220 kW, fitted with a lubricating oil line supplied from the engine oil sump, simplex filters may be fitted provided that they are equipped with a pressure alarm behind the filter and provided also that the filter can be changed during operation. For this purpose, a by-pass with manually operated shut-off valves is to be provided.

The switch positions shall be clearly recognizable.

b) Lubricating oil filters for auxiliary engines

For auxiliary engines, simplex filters are sufficient.

c) Fuel filters for main engines

The supply lines to fuel-injection pumps are to be fitted with switch-over duplex filters or automatic filters.

d) Fuel filters for auxiliary engines

For auxiliary engines, simplex filters are sufficient.

e) Filter arrangements

Fuel and lubricating oil filters which are to be mounted directly on the engine are not to be located above rotating parts or in immediate proximity of hot components.

Where the arrangement stated here before is unfeasible, the rotating parts and the hot components are to be sufficiently shielded.

Drip pans of suitable size are to be mounted under fuel filters. The same applies to lubricating oil filters if oil can escape when the filter is opened.

Switch-over filters with two or more filter chambers are to be fitted with devices ensuring a safe relief of pressure before opening and venting when a chamber is placed in service. Shut-off valves shall normally be used for this purpose. It shall be clearly discernible which filter chambers are in service and which are out of operation at any time.

### 2.6.4 Exhaust gas lines

Exhaust gas pipes from engines are to be installed separately from each other with regard to structural fire protection.

The pipes shall be so installed that no exhaust gases can penetrate into accommodation spaces.

Account is to be taken of thermal expansion when laying out and suspending the lines.



Where exhaust gas lines discharge near water level, provisions are to be taken to prevent water from entering the engines.

Exhaust gas lines are to be insulated and/or cooled in such a way that the surface temperature cannot exceed 220 °C at any point. Insulating materials shall be non-combustible and non asbestos.

Exhaust gas lines are to be provided with suitable protection, e.g. sheet metal cladding or approved hard sheathing, to prevent leaking oil from seeping into the insulation.

Insulation material used in engine rooms shall be protected against the intrusion of fuel and fuel vapours.

The exhaust gas lines of main and auxiliary engines are to be fitted with efficient silencers.

For engine exhaust gas lines on tankers, see the Rules for Additional Requirements of Notations-Inland Waterways (Part 2, Vol V), Section 3, A.2.7.6 and Section 3, A.4.8.

## **2.7 Starting equipment**

### **2.7.1 Electric starting equipment**

Where main engines are started electrically, one independent set of starter batteries is to be provided for each engine. The set of batteries shall enable the main engine to be started from cold.

Starter batteries is to be installed and protected as to reduce to a minimum any danger to persons on board, due regard being paid to moving parts, water spray/ spill, explosive gas atmosphere, and other hazards.

The capacity of the starter set of batteries shall be sufficient for at least 6 start-up operations within 30 minutes without recharging.

Electrical starters for auxiliary engines are to be provided with independent batteries. The capacity of the batteries shall be sufficient for at last 3 start-up operations within 30 minutes.

Where machinery installations comprise 2 or more electrically started main engines, the starting equipment for auxiliary engines can also be supplied from the latter's starter batteries. Separate circuits are to be installed for this purpose.

The starter batteries may only be used for starting (and possibility for preheating) as well as for monitoring equipment associated with the engine.

Arrangements are to be made to ensure that batteries are kept charged and monitored at all times.

### **2.7.2 Starting with compressed air**

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

The total capacity of the starting air compressors is to be such that the starting air receivers can be charged to their final pressure within one hour (the receivers being at atmospheric pressure at the start of the charging operation).

Normally, compressors of equal capacity are to be installed.

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

The total volume of the starting air receivers shall be such that it can be proved during the river trials that the quantity of air available is sufficient for at least 6 start-up operations with non-reversible main engines and at least 12 start-up operations with reversible main engines. Recharging of the starting air receivers during the execution of the start-ups is not allowed.

For multi-engine propulsion plants, the capacity of the starting air receivers is to be sufficient to ensure at least 3 consecutive starts per engine. However, the total capacity is not to be less than 12 starts and need not exceed 18 starts.

No special starting air storage capacity needs to be provided for auxiliary engines in addition to the starting air storage capacity specified above. The same applies to pneumatically operated regulating and manoeuvring equipment and to the air requirements of typhon units.

Other consumers with a high air consumption may be connected to the starting air system only if the stipulated minimum supply of starting air for the main engines remains assured.

### **2.7.3 Air compressor equipment**

Coolers are to be so designed that the temperature of the compressed air does not exceed 160 °C at the discharge of each stage of multi-stage compressors or 200 °C at the discharge of single-stage compressors.

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

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

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

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

## **2.8 Control equipment**

### **2.8.1 Main engines room control platform**

As a minimum requirement, the engine room control platform is to be equipped with the following main engine indicators, which are to be clearly and logically arranged:

- engine speed indicator
- lubricating oil pressure at engine inlet
- cylinder cooling water pressure
- starting air pressure(if using air starting)
- charge air pressure
- control air pressure at engine inlet
- shaft revolution indicator

Indicators are to be provided for the following on the control platform and/or directly on the engine:

- lubricating oil temperature
- coolant temperature
- fuel temperature at engine inlet only for engines running on heavy fuel oil
- exhaust gas temperature, wherever the dimensions permit, at each cylinder outlet and at the turbocharger inlet/outlet

In the case of geared transmissions or controllable pitch propellers, the scope of the control equipment is to be extended accordingly.

On the pressure gauges the permissible pressures, and on the tachometers any critical speed ranges, are to be indicated in red.

A machinery alarm system is to be installed for the pressures and temperatures specified above, with the exception of the charge air pressure, the control air pressure and the exhaust gas temperature.

See also Section 2, Table 2.16.

### **2.8.2 Main engines control from the bridge**

The vessel's control stand is to be fitted with indicators, easily visible to the operator, showing the starting and manoeuvring air pressure as well as the direction of rotation and revolutions of the propeller shaft.

In addition, the alarm system required under last paragraph of 2.8.1 is to signal faults on the bridge. Faults may be signalled in accordance with A.3.8. An indicator in the engine room and on the bridge shall show that the alarm system is operative.

### **2.8.3 Auxiliary engines**

Instruments or equivalent devices mounted in a logical manner on the engine shall indicate at least:

- engine speed
- lubricating oil pressure
- cooling water pressure
- cooling water temperature

In addition, engines of over 50 kW power are to be equipped with an engine alarm system responding to the lubricating oil pressure and to the pressure or flow rate of the cooling water or a failure of the cooling fan, as applicable.

See also Section 2, Table 2.16.

## **2.9 Auxiliary systems**

### **2.9.1 Lubricating oil system**

General requirements relating to lubricating oil systems are contained in C.8.; for filters, see 2.6.3.

Engines whose sumps serve as oil reservoirs shall be so equipped that the oil level can be established and, if necessary, topped up during operation. Means shall be provided for completely draining the oil sump.

The combination of the oil drainage lines from the crankcases of two or more engines is not allowed.

Main lubricating oil pumps driven by the engine are to be designed to maintain the supply of lubricating oil over the entire operating range of the engine.

### **2.9.2 Cooling system**

General requirements relating to the design of cooling water systems are contained in C.9.

Main cooling water pumps driven by the engine are to be designed to maintain the supply of cooling water over the entire operating range of the engine.

If cooling air is drawn from the engine room, the design of the cooling system is to be based on a room temperature of at least 40 °C.

The exhaust air of air-cooled engines may not cause any unacceptable heating of the spaces in which the plant is installed. The exhaust air is normally to be led to the open air through special ducts.

See also A.3.6.

Where air-cooled engines are used on tankers, the Rules Additional Requirements for Notations – Inland waterways (Part 2, Vol.V) Section 3, A.2.7.4 is applicable

### **2.9.3 Exhaust gas turbochargers**

Exhaust gas turbochargers may exhibit no critical speed ranges over the entire operating range of the engine.

The lubricating oil supply shall also be ensured during start-up and run-down of the exhaust gas turbochargers.

Even at low engine speeds, main engines shall be supplied with charge air in a manner to ensure reliable operation.

Emergency operation shall be possible in the event of the failure of an exhaust gas turbocharger.

### **2.9.4 Charge air cooling**

Means are to be provided for regulating the temperature of the charge air within the temperature range specified by the engine manufacturer.

The charge air lines of engines with charge air coolers are to be provided with sufficient means of drainage.

## **2.10 Installation and mounting of engines**

**2.10.1** Engines are to be mounted and secured to their shipboard foundations in conformity with the BKI Rules.

## **3. Main shafting**

### **3.1 General**

#### **3.1.1 Scope**

The following requirements apply to typical and proven types of main shafting. Novel designs require BKI special approval.

Main shafts of reinforced design are additionally subject to the requirements of the Rules Additional Requirements for Notations (Part 2, Vol V), Section 4, A. BKI reserves the right to call for propeller shaft

dimensions in excess of those specified in the following if the propeller arrangement results in increased bending stresses.

### 3.1.2 Documents for review/approval

General drawings of the entire shafting, from the main engine coupling flange to the propeller, and detail drawings of the shafts, couplings and other component parts transmitting the propelling engine torque, are each to be submitted to BKI for review/approval. To facilitate a smooth and efficient approval process, they shall be submitted electronically. In specific cases and following prior agreement with BKI, they can also be submitted in paper form in triplicate<sup>1</sup>. The drawings shall contain all the data necessary to enable the stresses to be evaluated.

## 3.2 Materials

### 3.2.1 Approved materials

Propeller, intermediate and thrust shafts together with flanged connections and couplings are to be made of forged steel; where appropriate, couplings may also be made of cast steel or nodular cast iron with a ferritic matrix.

Rolled round steel may also be used for plain, flange-less shafts. In general, the tensile strength of steels used for shafting shall be between 400 N/mm<sup>2</sup> and 800 N/mm<sup>2</sup>. However, the value of  $R_m$  used for calculating the material factor  $C_w$  defined in 3.3.2 for propeller shaft shall not be greater than 600 N/mm<sup>2</sup>.

Where parts of the main shafting are made of material other than steel, the special consent of BKI shall be obtained.

### 3.2.2 Materials testing

All materials of torque transmitting shafting components shall possess the properties specified in the Rules for Materials (part 1, vol V). This may be proven by an acceptance test certificate issued by the manufacturer.

## 3.3 Shaft dimensions

### 3.3.1 General

All parts of the shafting are to be dimensioned in accordance with the following formulas in compliance with the requirements relating to critical speeds set out in 6.

The dimensions of the shafting shall be based on the total installed power. Where the geometry of a part is such that it cannot be dimensioned in accordance with these formulas, special evidence of the mechanical strength of the part or parts concerned is to be furnished to BKI.

### 3.3.2 Minimum diameter

The minimum diameter is to be determined by applying the following formula:

$$d \geq F \cdot k \cdot \sqrt[3]{\frac{P_w \cdot C_w}{n \cdot \left[1 - \left(\frac{d_i}{d_a}\right)^4\right]}} \leq d_a$$

$d$  = minimum required outside diameter of shaft [mm]

<sup>1</sup> For ship flying Indonesian flag in quadruplicate, one of which intended for the Indonesian government

$d_i$  = diameter of the shaft bore, where present [mm]

If  $d_i < 0,4 \cdot d_a$

$$\left[ 1 - \left( \frac{d_i}{d_a} \right)^4 \right] = 1$$

$d_a$  = actual outside shaft diameter [mm]

$P_w$  = shaft power [kW]

$n$  = Shaft speed [rev/min]

$F$  = factor for the type of propulsion installation

= 90 for turbine installations, engine installations with slip couplings and electrical propulsion installations

= 94 for all other types of propulsion installations

$C_w$  = material factor

$$= \frac{560}{R_m + 160}$$

$R_m$  = tensile strength of the shaft material [N/mm<sup>2</sup>]

$k$  = factor for the type of shaft

= 1,0 for intermediate shafts with integral forged coupling flanges or with shrink-fitted keyless coupling flanges

= 1,10 for intermediate shafts with keyed coupling hubs. At a distance of at least  $0,2 \cdot d$  from the end of the keyway, such shafts can be reduced to a diameter corresponding to  $k = 1,0$

= 1,10 for intermediate shafts with radial holes with a diameter less than  $0,3 \cdot d_a$

= 1,10 for thrust shafts near the plain bearings on either side of the thrust collar, or near the axial bearings where an antifriction bearing design is used

= 1,15 for intermediate shafts designed as multi-splined shafts where  $d$  is the outside diameter of the splined shaft. Outside the splined section, the shafts can be reduced to a diameter corresponding to  $k = 1,0$

= 1,20 for intermediate shafts with longitudinal slots where the length and width of the slot do not exceed  $0,8 \cdot d_a$  and  $0,1 \cdot d_a$  respectively

= 1,22 for propeller shafts from the area of the aft stern tube or shaft bracket bearing to the forward load-bearing face of the propeller boss subject to a minimum of  $2,5 \cdot d$ , if the propeller is shrink-fitted, without key, on the tapered end of the propeller shaft using a method approved by BKI, or if the propeller is bolted to a flange forged on the propeller shaft

= 1,26 for propeller shafts in the aft area as specified for  $k = 1,22$ , with tapered key/keyway connection

= 1,40 for propeller shafts in the area specified for  $k = 1,22$ , if the shaft inside the stern tube is lubricated with grease

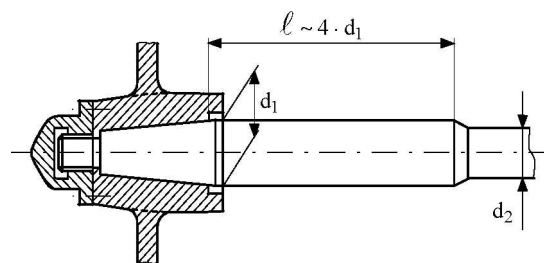
= 1,15 for propeller shafts forward part outside the bearing area but inside the stern tube. The portion of the propeller shaft located forward of the stern tube can be reduced to the size of the intermediate shaft

Parts of the propeller shaft exposed to water and without effective corrosion protection shall be strengthened by 5 %.

### 3.4 Design

#### 3.4.1 Changes in diameter

Changes from larger to smaller shaft diameters are to be effected by tapering or ample radiusing.



**Fig. 1.2 Propeller shaft**

#### 3.4.2 Sealing

Propeller shafts running in oil or grease are to be fitted with seals of proven efficiency and approved by BKI at the stern tube ends. The propeller boss seating is to be effectively protected against the ingress of water. The seals at the propeller can be dispensed with if the propeller shaft is made of corrosion resistant material.

Means shall be provided so that polluting lubricants do not spread into the water.

#### 3.4.3 Shaft tapers and propeller nut threads

Keyways in the shaft taper for the propeller should be so designed that the forward end of the groove makes a gradual transition to the full shaft section. In addition, the forward end of the keyway should be spoon shaped. The edges of the keyway at the surface of the shaft taper for the propeller may not be sharp. The forward end of the keyway shall lie well within the seating of the propeller boss. Threaded holes to accommodate the securing screws for propeller keys should be located only in the aft half of the keyway (see Fig. 1.3).

##### **Note**

*In Fig. 1.3  $d_2$  is the propeller shaft diameter.*

*For most simplified designs of the keyway, the consent of BKI will be required*

In general, tapers for securing flange couplings should have a cone of between 1:10 and 1:20. In the case of shaft tapers for propellers, the cone shall be between 1:10 and 1:15. Where the oil injection method is used to mount the propeller on the shaft, a taper of the cone between 1:15 and 1:20 is to be preferred.

The outside diameter of the threaded end propeller retaining nut should not be less than 60 % of the calculated major taper diameter.

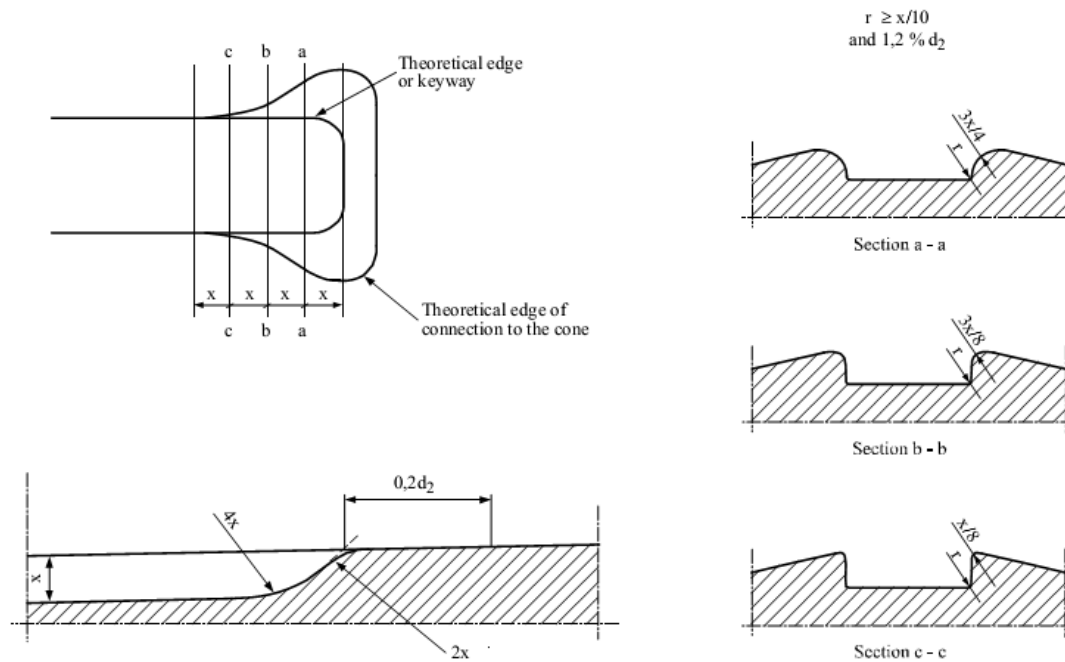


Fig. 1.3 Design of keyway in propeller shaft

#### 3.4.4 Shaft liners

Propeller shafts which are not made of corrosion-resistant material are to be protected against contact with brackwater by metal liners or other liners approved by BKI and by seals of proven efficiency at the propeller.

Metal liners, in accordance with the requirement here above, shall be made in a single piece. Only with the express consent of BKI may particularly long liners be made up of two parts, provided that, after fitting, the abutting edges are connected and made watertight by a method approved by BKI and the area of the joint is subjected to special testing.

The minimum wall thickness,  $t$  [mm] of metal shaft liners in way of bearings is to be determined using the following formula:

$$t = \frac{75 \cdot d}{d + 1000}$$

$d$  = shaft diameter under the liner [mm]

In the case of continuous liners, the wall thickness between the bearings may be reduced to 0,75.  $T$

#### 3.5 Couplings

**3.5.1** The thickness of forged coupling flanges on intermediate and thrust shafts and on the forward end of the propeller shaft shall be equal at least 20 % of the calculated minimum diameter..

Where propellers are attached to a forged flange on the propeller shaft, the flange shall have a thickness equal to at least 25 % of the calculated minimum diameter.

These flanges may not be thinner than the Rule diameter of the fitted bolts if these are based on the same tensile strength as that of the shaft material.



The radius at integrally forged flanges is to be at least  $0,08 \cdot d$  [mm].

In 3.5.2 to 3.5.6, the following symbols are used:

A	= effective area of shrink fit seating [mm <sup>2</sup> ]
C <sub>A</sub>	= coefficient for shrink-fitted joints = 1,0 for gear drives and electric motors = 1,2 for direct diesel drives
C	= conicity of shaft ends = difference in taper diameter/length of taper
d	= shaft diameter in area of clamp-type coupling [mm]
d <sub>f</sub> , d <sub>k</sub>	= diameters of fitted bolts and plain bolts [mm]
D	= diameter of pitch circle of bolts [mm]
f	= coefficient for shrink-fitted joints $= \left( \frac{\mu_0}{S} \right)^2 \cdot \Theta^2$
n	= propeller speed [rev/min]
P	= interface pressure of shrink fits [N/mm <sup>2</sup> ]
Q	= peripheral force at the mean joint diameter of a shrink-fitted joint [N] $= \frac{2000 \cdot T_D}{d_m}$
T <sub>D</sub>	= drive torque [N.m] $= \frac{9550 \cdot P_w}{N}$
P <sub>w</sub>	= shaft power [kW]
d <sub>m</sub>	= mean joint diameter of the shrink fit [mm]
S	= safety factor against slipping of shrink fits in the shafting = 3,0 between motor and gearing = 2,5 for all other applications number of fitted or plain bolts
z	= number of fitted or plain bolts
R <sub>m</sub>	= tensile strength of fitted or plain bolt material [N/mm <sup>2</sup> ]
T	= propeller thrust [N]

$\Theta$  = half-conicity of shaft ends

$$= C/2$$

$\mu_0$  = coefficient of static friction

= 0,15 for hydraulic shrink fits

= 0,18 for dry shrink fits minimum shrink interference [mm]

$\Delta_{\min}$  = minimum shrink interference [mm]

**3.5.2** The bolts used to connect flange couplings are normally to be designed as fitted bolts. The minimum diameter  $d_f$  of fitted bolts at the coupling flange faces is to be determined by applying the following formula:

$$d_f = 16 \cdot \sqrt{\frac{10^6 \cdot P_w}{n \cdot z \cdot D \cdot R_m}} [\text{mm}]$$

**3.5.3** Where, in special circumstances, the use of fitted bolts is not feasible, BKI may agree to the use of an equivalent frictional transmission.

**3.5.4** The minimum thread root diameter  $d_k$  of connecting bolts used for clamp-type couplings is to be determined using the following formula:

$$d_f = 12 \cdot \sqrt{\frac{10^6 \cdot P_w}{n \cdot z \cdot D \cdot R_m}} [\text{mm}]$$

**3.5.5** The shank of necked-down bolts can be designed to a minimum diameter of 0.9 times the thread root diameter. If, besides the torque, the bolted connection is also required to transmit considerable additional forces, the size of the bolts shall be increased accordingly.

**3.5.6** Where shafts are coupled together without keys by shrink-fitted coupling flanges or coupling sleeves, the dimensions of these shrink fits should be such that the maximum Von Mises equivalent stress in the boss of the coupling or the bore of the coupling sleeve, based on the "go" end of the prescribed tolerance gauge, does not exceed 80 % of the yield strength of the coupling material.

The margin of safety against slipping of the joint is to be based on the "no go" ends of the prescribed tolerance gauges, and the necessary interface pressure  $p$  [ $\text{N/mm}^2$ ], in the shrunk joint is to be determined as follows:

$$p = \frac{\sqrt{\Theta^2 \cdot T^2 + f \cdot (c_A^2 \cdot Q^2 + T^2)} - \Theta \cdot T}{A \cdot f}$$

$T$  has to be introduced as a positive value if the propeller thrust increases the surface pressure at the taper. Change of direction of propeller thrust is to be neglected as far as power and thrust are essentially less.

$T$  has to be introduced as a negative value if the propeller thrust reduces the surface pressure at the taper, e.g. for tractor propellers.

### 3.6 Shaft bearings

#### 3.6.1 Arrangement of shaft bearings

Shaft bearings both inside and outside the stern tube are to be so disposed that, when the plant is hot and irrespective of the condition of loading of the ship, each bearing is subjected to positive reaction forces equivalent to not less than 20 % of the weight of the shaft length carried by the bearing. By appropriate spacing of the bearings and by alignment of the shafting in relation to the coupling flange at the engine or gearing, care is to be taken to ensure that no undue transverse forces or bending moments are exerted on the crankshaft or gear shafts when the plant is hot. By spacing the bearings sufficiently far apart, steps are also to be taken to ensure that the reaction forces of line or gear shaft bearings are not appreciably affected should the alignment of one or more bearings be altered by hull deflections or by displacement or wear of the bearings themselves.

Guide values for the maximum permissible distance between bearings  $l_{\max}$  [mm] can be determined using the following formula:

$$l_{\max} = K_1 \cdot \sqrt{d_a}$$

$K_1$  = coefficient defined as:

= 450 for oil-lubricated white metal bearing

= 280 for grey cast iron, grease-lubricated stern tube bearings

= 280 - 350 for water-lubricated rubber bearings in stern tubes and shaft brackets (upper values for special designs only)

#### **Note**

*Where the shaft speed exceeds 350 rev/min, it is recommended that the maximum bearing spacing in accordance with formula here below be observed in order to avoid excessive loads due to bending vibrations. In borderline cases a bending stress analysis should be made for the shafting system.*

$$l_{\max} = K_2 \cdot \sqrt{\frac{d_a}{N}}$$

$K_2$  = coefficient defined as:

= 8400 for oil-lubricated white metal bearings

= 5200 for grease-lubricated, grey cast iron bearings and for rubber bearings inside stern tubes and tail shaft brackets

#### 3.6.2 Stern tube bearings

Inside the stern tube, the propeller shaft should normally be supported by two bearings. In short stern tubes, the forward bearing may be dispensed with.

Where the propeller in the stern tube runs in water lubricated stern tube bearings made of rubber or plastic, the length of the after bearing should equal approximately 3 - 4 times the shaft diameter, while the length of the forward bearing should be approximately 1 - 1.5 times the shaft diameter.

Where the propeller shaft inside the stern tube runs in oil-lubricated white metal bearings, the lengths of the after and forward stern tube bearings should be approximately 2 and 0.8 times the shaft diameter respectively.

Where the propeller shaft runs in grease-lubricated, grey cast iron bushes the lengths of the after and forward stern tube bearings should be approximately 2.5 and 1 times the shaft diameter respectively.

The peripheral speed of the propeller shafts in grease-lubricated, grey cast iron bearings should not exceed 2,5 - 3 m/s, while that of propeller shafts in water-lubricated rubber bearings should not exceed 6 m/s.

Where the propeller shafts are intended to run in antifriction bearings within the stern tube, such bearings should be preferably cylindrical roller bearings with cambered rollers or bearing races and with an increased bearing clearance. The camber shall be sufficient to tolerate without adverse effects an angular deviation of 0,1 % between the shaft and the bearing axis. Self-aligning roller bearings may be used to carry the propeller shaft only if provision is made for the axial adjustment of such bearings.

Propeller shafts running in anti-friction bearings shall be fitted at the stern tube ends with seals approved by BKI for this type of bearing.

### **3.6.3 Bearing lubrication**

The lubrication and the matching of the materials used for journal and anti-friction bearings inside and outside the stern tube shall satisfy the requirements of inland water service.

Lubricating oil or grease shall be introduced into the stern tube in such a way as to ensure a reliable supply of oil or grease to the forward and after stern tube bearings. With grease lubrication, the forward and after bearings are each to be provided with a grease connection. Wherever possible, a grease pump driven by the shaft is to be used to secure a continuous supply of grease.

Where the shaft runs in oil within the stern tube, a header tank is to be fitted at a sufficient height above the ship load line. Facilities are to be provided for checking the level of oil in the tank at any time.

### **3.6.4 Stern tube connections**

Oil-lubricated stern tubes are to be fitted with filling, testing and drainage connections as well as with a vent pipe. Connections and stern tube shall be designed to ensure that oil, infiltrated water and air can be completely expelled.

Where the propeller shaft runs in water, a flushing line is to be fitted which is to be connected to a suitable pump or another pressure system.

### **3.6.5 Cast resin mounting**

The mounting of stern tubes and stern tube bearings made of cast resin and also the seating of plumber bearings on cast resin parts is to be carried out by BKI approved companies in the presence of a BKI Surveyor.

Only cast resins approved by BKI may be used for seatings.

Note is to be taken of the installation instructions issued by the manufacturer of the cast resin.

## **3.7 Shaft locking device**

To prevent dragging of a shutdown propulsion unit, the shafting is to be fitted with a locking device.

### **3.8 Pressure tests**

#### **3.8.1 Shaft liners**

Prior to fitting in the finish-machined condition, shaft liners are to be subjected to a hydraulic tightness test at 2 bar pressure.

#### **3.8.2 Stern tubes**

Prior to fitting in the finish-machined condition, cast stern tubes are to be subjected to a hydraulic tightness test at 2 bar pressure. A further tightness test is to be carried out after fitting.

For stern tubes fabricated from welded steel plates, it is sufficient to test for tightness during the pressure tests applied to the hull spaces traversed by the stern tube.

**3.9** For the propulsion arrangement of passenger ships, see also Rules Additional Requirements for Notations – Inland waterways (Part 2, Vol.V) Section 2, D.3.3

## **4. Gears and couplings**

### **4.1 General**

#### **4.1.1 Scope**

The following requirements apply to spur, planetary and bevel gears and to all types of couplings for application in the main propulsion plant or important auxiliary machinery such as:

- electric generator sets
- windlasses
- bow thruster units
- lubricating oil, cooling water, bilge pumps, etc.

The design requirements laid down here may also be applied to the gears and couplings of auxiliary machinery other than that mentioned above, if equivalent evidence of mechanical strength is not available.

**4.1.2** Application of these Rules to the auxiliary machinery couplings mentioned above may generally be limited to a basic design approval by BKI of the particular coupling type. Regarding the design of elastic couplings for use in generator sets, reference is made to 4.7.

**4.1.3** For the dimensional design of gears and couplings for ships with reinforced design, see the Rules Additional Requirements for Notations (Part 2, Vol V), Section 4, A.

#### **4.1.4 Documents for review / approval**

Assembly and sectional drawings together with the necessary detail drawings and parts lists are to be submitted to BKI for review/approval. To facilitate a smooth and efficient approval process they shall be submitted electronically. In specific cases and following prior agreement with BKI they can also be submitted in paper form in triplicate<sup>2</sup>. They shall contain all data necessary to enable the load calculations to be checked.

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<sup>2</sup> For ship flying Indonesian flag in quadruplicate, one of which intended for the Indonesian government

## **4.2 Materials**

### **4.2.1 Approved materials**

- a) Shafts, pinions, wheels and wheel rims of gears in the main propulsion plant should preferably be made of forged steel. Rolled steel bar may also be used for plain, flangeless shafts. Gear wheel may be of grey cast iron (see Note) or nodular cast iron or may be fabricated from welded steel or cast steel hubs.
- b) Couplings in the main propulsion plant shall be made of steel, cast steel or nodular cast iron with a mostly ferritic matrix. Grey cast iron or suitable cast aluminium alloys may also be permitted for lightly stressed external components of couplings and the rotors and casings of hydraulic slip couplings.
- c) The gears of important auxiliary machinery are subject to the same requirements as those specified in a) as regards the materials used. For gears intended for auxiliary machinery different to those mentioned in a), other materials may also be permitted.
- d) Flexible coupling bodies for important auxiliary machinery according to a) may generally be made of grey cast iron, and for the outer coupling bodies a suitable aluminium alloy may also be used.

However, for generator sets use should only be made of coupling bodies preferably made of nodular cast iron with a mostly ferritic matrix, of steel or of cast steel, to ensure that the couplings are well able to withstand the shock torques occasioned by short circuits. BKI reserves the right to impose similar requirements on the couplings of particular auxiliary drive units.

#### *Note*

*The peripheral speed of cast iron gear wheels shall generally not exceed 60 m/s, that of cast iron coupling clamps or bowls, 40 m/s.*

### **4.2.2 Testing of materials**

All materials of torque transmitting components of gearing and couplings and the plates and steel parts of welded gear casings shall possess the properties specified in the Rules for Materials (Part 1 . Vol V). This may be proven by an acceptance test certificate issued by the manufacturer.

With the consent of BKI, the tests prescribed in the Rules for Materials (Part 1 Vol V) may be reduced if the execution of such tests is rendered impracticable by the small size of certain components or by the particular manufacturing techniques used. For such parts, proof of quality is to be furnished to BKI by other means.

## **4.3 Calculation of the load bearing capacity of cylindrical and bevel gearing**

### **4.3.1 General**

The sufficient load capacity of the gear-tooth system of main and auxiliary gears in main propulsion systems of inland water vessels is to be demonstrated by load calculations according to the international standards ISO 6336 and ISO 9083 for spur gear tooth systems respectively, ISO 10300 for bevel gears.

For the design and calculation of the gears, the requirements for the design and construction of gears according to the Rules for Machinery Installations (Part 1, Vol III), Section 5 are applicable.

### **4.3.2 Application factor $K_A$**

The application factor  $K_A$  takes into account the increase in rated torque caused by external increases in dynamic and transient load. Normally, the application factor  $K_A$  should be determined by measurements or by system analysis acceptable by BKI.

Where a value as described above cannot be supplied, the application factor  $K_A$  is to be determined for main and auxiliary systems in accordance with Table 1.7.

**Table 1.7 Application factor**

System type	$K_A$
<b>Main propulsion</b>	
Diesel engine with fluid coupling or electro magnetic coupling	1,05
Diesel engine drive systems with highly flexible coupling between engine and	1,30
Diesel engine drive systems with other couplings than flexible	1,50
Shaft generator drives	1,50
<b>Auxiliary propulsion</b>	
Electric motor or diesel engine with fluid coupling or electromagnetic coupling	1,0
Diesel engine drive systems with highly flexible coupling between engine and	1,2
Diesel engine drive systems with other couplings than flexible	1,4
<i>Note</i>	
<i>For other types of systems, the factor <math>K_A</math> is to be stipulated separately</i>	

#### 4.4 Gear shafts

##### 4.4.1 Minimum diameter

The dimensions of shafts of reversing and reduction gears are to be calculated by applying the following formula:

$$d \geq F.k. \sqrt[3]{\frac{P_w}{N \cdot \left[1 - \left(\frac{d_i}{d_a}\right)^4\right]}} \cdot C_w$$

For  $d_i/d_a \leq 0,3$ :

$$1 - \left(\frac{d_i}{d_a}\right)^4 = 1,0$$

$d_i$  =diameter of shaft bore, if applicable [mm]

$d_a$  =actual shaft diameter [mm]

$P_w$  =driving power of shaft [kW]

$N$  =shaft rotational speed [rev./min]

F =factor for the type of drive

= 90 for turbine plants, electrical drives and engines with slip couplings

= 94 for all other types of drive. BKI reserves the right to specify higher F values if this appears necessary in view of the loading of the plant.

$C_w$  = material factor

$$= \frac{560}{R_m + 160}$$

However, for wheel shafts, the value substituted for  $R_m$  in the formula shall not be higher than 800 N/mm<sup>2</sup>. For pinion shafts the actual tensile strength value may generally be substituted for  $R_m$ .

k = coefficient defined as:

= 1,10 for gear shafts

= 1,15 for gear shafts in the area of the pinion or wheel body, if this is keyed to the shaft, and for multi-spline shafts.

Higher values of k may be specified by BKI where increased bending stresses in the shaft are liable to occur because of the bearing arrangement, the casing design, the tooth pressure, etc.

## **4.5 Equipment**

### **4.5.1 Oil level indicator**

For monitoring the lubricating oil level in main and auxiliary gears, equipment shall be fitted to enable the oil level to be determined.

### **4.5.2 Pressure and temperature control**

Temperature and pressure gauges are to be fitted to monitor the lubricating oil pressure and the lubricating oil temperature at the oil-cooler outlet before it enters the gears.

Plain journal bearings are also to be fitted with temperature indicators.

Where gears are fitted with anti-friction bearings, a temperature indicator is to be mounted at a suitable point. For gears rated up to 2000 kW, special arrangements may be agreed with BKI.

Where ships are equipped with automated machinery, the requirements for automation are to be complied with.

### **4.5.3 Lubricating oil pumps**

Lubricating oil pumps driven by the gearing shall be mounted in such a way that they are accessible and can be replaced.

### **4.5.4 Gear casings**



The casings of gears belonging to the main propulsion plant and important auxiliaries shall be fitted with removable inspection covers to enable the gears to be inspected and the thrust bearing clearance to be measured and oil sump to be cleaned.

#### 4.5.5 Seating of gears

The seating of gears on steel or cast resin chocks is to conform "Regulation for seating of diesel engine installation".

In the case of cast resin seatings, the thrust shall be absorbed by means of stoppers. The same applies to cast resin seatings of separate thrust bearings.

### 4.6 Balancing and testing

#### 4.6.1 Balancing

Gear wheels, pinions, shafts, gear couplings and, where applicable, high-speed flexible couplings shall be assembled in a properly balanced condition.

The generally permissible residual imbalance  $U$  [kg · mm] per balancing plane of gears for which static or dynamic balancing is rendered necessary by the method of manufacture and by the operating and loading conditions can be determined by applying the formula:

$$U = \frac{9,6.Q.G}{z.n}$$

$G$  = mass of body to be balanced [kg]

$N$  = operating rotational speed [rev./min] of body to be balanced

$z$  = number of balancing planes

$Q$  = degree of balance

= 6,3, for gear shafts, pinions and coupling members for engine gears

=2,5, for torsion shafts and gear couplings, pinions and gear wheels belonging to turbine transmissions

#### 4.6.2 Testing in the manufacturer's works

When the testing of material and component tests have been carried out, gearing systems for the main propulsion plant and for important auxiliaries are to be presented to BKI for final inspection and operational testing in the manufacturer's works. The final inspection is to be combined with a trial run lasting several hours under part or full-load conditions, on which occasion the tooth clearance and contact pattern are to be checked. In the case of a trial at full-load conditions, any necessary running-in of the gears shall have been completed beforehand. Where no test facilities are available for the operational and on-load testing of large gear trains, these tests may also be performed on board ship on the occasion of the river trials.

Tightness tests are to be performed on those components to which such testing is appropriate.

Reductions in scope of tests require the consent of BKI.

### 4.7 Design and construction of couplings

For the design and construction of couplings in main and auxiliary propulsion systems, such as tooth couplings, flexible couplings, etc., BKI Rules and requirements for the design and construction of couplings are applicable.

## 5. Propellers

### 5.1 General

#### 5.1.1 Scope

The following requirements apply to screw propellers and controllable pitch propellers. Where a design is proposed to which the following Rules cannot be applied, special strength calculations are to be submitted to BKI and the necessary tests are to be agreed with BKI.

The propellers of propulsion units of strengthened design are additionally subject to the provisions of the Rules for Additional Requirements of Notations-Inland Waterways (Part 2, Vol V) Section 4, A.

#### 5.1.2 Documents for review/approval

Design drawings of propellers are to be submitted to BKI for review/ approval. To facilitate a smooth and efficient approval process, the drawings could be submitted in electronic format. In specific cases and following prior agreement with BKI they can also be submitted in paper form in triplicate<sup>3</sup>. Drawings are to contain all the details necessary to verify compliance with the following Rules.

#### 5.13 Symbols and terms

A = effective area of shrink fit [mm<sup>2</sup>]

B = developed blade width of cylindrical sections at radii 0,25.R, 0,35.R and 0,60.R [mm]

c<sub>A</sub> = coefficient for shrunk joints [-]

= 1,0 for gear transmissions, electric motors

= 1,2 for direct diesel drives

C<sub>G</sub> = size factor [-]

$$= \sqrt{\frac{f_1 + 0,001 \cdot D}{12,2}}$$

with  $1,1 > C_G > 0,85$

C<sub>Dyn</sub> = dynamic factor

C<sub>w</sub> = characteristic value for propeller material as shown in Table 1.8 (corresponds to the minimum tensile strength R<sub>m</sub> of the propeller material where this has been shown to possess sufficient fatigue strength under alternating bending stresses in accordance with 5.2)

C = conicity of shaft ends [-]

= difference in taper diameter/length of taper

d = pitch circle diameter of blade or propeller fastening bolts [mm]

d<sub>k</sub> = root diameter of blade or propeller fastening bolts [mm]

d<sub>s</sub> = nominal diameter of studs or bolts [mm]

D = diameter of propeller [mm]

d<sub>m</sub> = mean taper diameter [mm]

<sup>3</sup>For ships flying Indonesian flag in quadruplicate, one of which intended for the Indonesian Government

**Table 1.8 Characteristic values CW for propeller materials**

Material	Description <sup>1</sup>	C <sub>w</sub>
Cu 1	Cast manganese brass	440
Cu 1	Cast manganese nickel brass	440
Cu 1	Cast nickel aluminium bronze	590
Cu 1	Cast manganese aluminium bronze	630
Fe 1	Unalloyed cast steel	440
Fe 1	Low-alloy cast steel	440
Fe 1	Martensitic cast chrome steel 13/1-6	600
Fe 1	Martensitic cast chrome steel 17/4	600
Fe 1	Ferritic-austenitic cast steel 24/8	600
Fe 1	Austenitic cast steel 18/8-11	500
<sup>1</sup> For the chemical composition of the alloys, see Rules for material (Part 1, Vol. V) and Rules for Welding (Part 1, Vol. VI)		

e = blade rake to aft [mm]

$$= 0,5 \cdot D \cdot \tan \varepsilon \text{ (see Fig. 1.4)}$$

f = Coefficient for shrink fitted joint

$$= \left( \frac{\mu_0}{s} \right)^2 - \Theta^2 [-]$$

f<sub>1</sub> = factor for CG.

f<sub>1</sub> = 7,2 for solid propellers [-]

= 6,2 for separately cast blades of variable pitch or built-up propellers [-]

H = propeller blade face pitch at radii 0,25·R; 0,35·R; and 0,60·R [mm]

H<sub>m</sub> = mean effective propeller pitch on blade face for pitch varying with the radius[mm]

$$= \frac{\sum (R \cdot B \cdot H)}{\sum (R \cdot B)}$$

where R, B and H are to be substituted by values corresponding to the pitch at the various radii

k = coefficient for various profile shapes in accordance with Table 1.9 [-]

l<sub>M</sub> = 2/3 of the leading edge component of the blade width at 0,9R, but at least 1/4 of the total blade width at 0,9R for propellers with heavily skewed blades [mm]

L = pull-up length when mounting propeller on taper [mm]

L<sub>mech</sub> = pull-up length at t = 35 °C [mm]

L<sub>temp</sub> = temperature-related portion of pull-up length at t < 35 °C [mm]

n<sub>2</sub> = propeller speed [min<sup>-1</sup>]

P<sub>w</sub> = nominal power of driving engine [kW]

P = specific pressure in shrunk joint between propeller and shaft [N/mm<sup>2</sup>]

Q<sub>n</sub> = nominal peripheral force at mean taper diameter at maximum continuous rating(MCR) condition [N]

$$= 19,1 \cdot \frac{P_w}{n_2 \cdot d_m} \cdot 10^6$$

Q<sub>FR</sub> = peripheral force at mean taper diameter at MCR condition including Q<sub>n</sub> and Q<sub>V-MCR</sub>[N]

Q<sub>V-MCR</sub> = peripheral force at mean taper diameter at MCR condition due to torsional vibration[N]

R<sub>P0,2</sub> = 0,2 % proof stress of propeller material[N/mm<sup>2</sup>]

$R_{eH}$	= yield strength [N/mm <sup>2</sup> ]
$R_m$	= tensile strength of the material of fitted or conventional bolts [N/mm <sup>2</sup> ]
$S$	= margin of safety against propeller slipping on taper = 2,8 [–]
$t$	= maximum blade thickness of developed cylindrical section at radii 0,25·R, 0,35·R and 0,60·R [mm]
$T$	= propeller thrust [N]
$T_M$	= impact moment in accordance with 5.4.3 [N·m]
$W_{0,35R}$	= section modulus of cylindrical blade section at radius 0,35 R [mm <sup>3</sup> ]
$W_{0,6R}$	= section modulus of cylindrical blade section at radius 0,6 R [mm <sup>3</sup> ]
$Z$	= total number of bolts used to retain one blade or propeller
$z$	= number of blades
$\alpha$	= pitch angle of profile at radii 0,25·R; 0,35·R; and 0,60·R [°] $\alpha_{0,25} = a \tan \frac{1,27 \cdot H}{D}$ $\alpha_{0,35} = a \tan \frac{0,91 \cdot H}{D}$ $\alpha_{0,60} = a \tan \frac{0,53 \cdot H}{D}$
$\alpha_A$	= tightening factor for retaining bolts and studs, depending on the method of tightening used [–] guidance values: = 1,2 for angle control = 1,3 for bolt elongation control = 1,6 for torque control
$\varepsilon$	= angle included by face generatrix and normal (see Fig. 1.4) [°] $= a \tan \frac{2 \cdot e}{D}$
$\Theta$	= half-conicity of shaft ends [–] = C/2
$\mu_0$	= coefficient of static friction [–] = 0,13 for hydraulic oil shrunk joints = 0,15 for fitted joints, bronze to steel = 0,18 for dry shrunk joints, steel to steel

Friction improving agents are not taken into account.

## 5.2 Materials

### 5.2.1 Approved materials

Wherever possible, propellers are to be made of established cast copper or cast steel alloys with a tensile strength of at least 440 N/mm<sup>2</sup> and of proven sufficient fatigue strength under alternating bending stresses.

The use of grey cast iron, un- and low-alloyed cast steel for propellers may be permitted in exceptional cases.

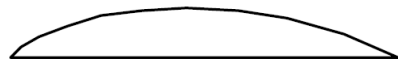

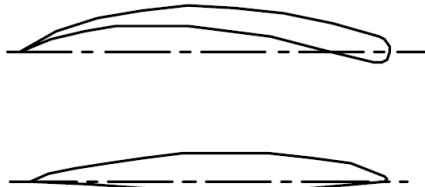
Composite materials may also be used, provided that a sufficient strength has been demonstrated and the propeller is manufactured according to an approved procedure.

Where use is to be made of propeller materials whose performance has not yet been sufficiently established, special proof of their suitability shall be furnished to BKI.

### 5.2.2 Testing of materials

Propeller materials and materials of blade mounting screws/bolts as well as those of important components involved in the adjustment of variable pitch propellers shall possess the properties specified in the Rules for Material (Part1, Vol V). This may be demonstrated by an acceptance test certificate issued by the manufacturer.

**Table 1.9 Values of k for various profile shapes**

Profile shape	Values of k		
	0,25 R	0,35 R	0,6 R
Segmental profiles with circular arced suction side	73	62	44
			
Segmental profiles with parabolic suction side	77	66	47
			
Blade profiles asfor Wageningen B Series propellers	80	66	44
			

## 5.3 Calculation of blade thickness

**5.3.1** At radii  $0,25 \cdot R$ , and  $0,60 \cdot R$  (see Fig. 1.4),the blade thickness of solid propellers shall, as a minimum requirement, comply with the following formula:

$$t = K_o \cdot k \cdot K_1 \cdot C_G \cdot C_{dyn}$$

$K_o$  = coefficient defined as

$$= 1 + \frac{e \cdot \cos \alpha}{H} + \frac{n_2}{15000}$$

$K_1$  = coefficient defined as

$$= \sqrt{\frac{P_W \cdot 10^5 \cdot \left(2 \cdot \frac{D}{H_m} \cdot \cos \alpha + \sin \alpha\right)}{n_2 \cdot B \cdot z \cdot C_W \cdot (\cos \varepsilon)^2}}$$

$$C_{dyn} = 1,0$$

**5.3.2** The blade thicknesses of controllable pitch propellers are to be determined at radii  $0,35 \cdot R$  and  $0,60 \cdot R$  by applying the formula given in 5.3.1.

For the controllable pitch propellers of tugs and pushing vessels with similar operating conditions, the diameter/pitch ratio  $D/H_m$  for the maximum static bollard pull is to be used in formula given in 5.3.1.

For other vessels, the diameter/pitch ratio  $D/H_m$  applicable to open-water navigation can be used in formula given in 5.3.1.

**5.3.3** The blade thicknesses calculated by applying formula given in 5.3.1 are minima for the finish machined propellers without fillets.

If the propeller is subjected to an essential wear, e.g. abrasion in muddy waters, the thickness determined under 5.3.1 has to be increased. If the actual thickness in service is below 50 % at the tip and 90 % at other radii of the values obtained from formula given in 5.3.1 countermeasures have to be taken.

**5.3.4** The fillet radii at the transition from the face and back of the blades should correspond, in the case of three and four-bladed propellers, to about 3,5 % of the propeller diameter. For propellers with a larger number of blades, the maximum fillet radii allowed by the propeller design should be aimed at, and the radii shall not in any case be made smaller than  $0,4 \cdot t_{0,25R}$ .

**5.3.5** For special designs such as propellers with skew angle  $\psi \geq 25^\circ$ , end plate propellers, tip fin propellers, special profiles, etc., special mechanical strength calculations are to be submitted to BKI Head office together with the design documents to enable the evaluation of the blade stress of these special designs to be carried out.

## **5.4 Controllable pitch propellers**

### **5.4.1 Documents for review/approval**

In the case of controllable pitch propellers, besides the design drawings of the blades and propeller boss, general and sectional drawings of the entire controllable pitch propeller installation are to be submitted to BKI for review/approval. To facilitate a smooth and efficient approval process the drawings could be submitted in electronic format. In specific cases and following prior agreement with BKI they can also be submitted in paper form in triplicate<sup>4</sup>. Diagrams of control systems and piping are to be accompanied by a functional description. For new designs and controllable pitch propellers which are to be installed for the first time on a vessel, a description of the controllable pitch propeller system is to be submitted at the same time.

### **5.4.2 Hydraulic control equipment**

Where the pitch control mechanism is operated hydraulically, one set of pumps might be sufficient for the pitch setting. However, one hand pump shall be provided, by which blade adjustment is possible.

### **5.4.3 Pitch control mechanism**

<sup>4</sup>For ships flying Indonesian flag in quadruplicate, one of which intended for the Indonesian Government

For the pitch control mechanism, proof is required that, when subjected to an impact moment  $T_M$  as defined by the formula below, the individual components still have a safety factor of 1,5. The calculated stress should not exceed the yield strength value.

$$T_M = \frac{1,5 \cdot R_{p0,2} \cdot W_{0,6R} \cdot 10^{-3}}{\sqrt{\left(\frac{0,15 \cdot D}{\ell_M}\right)^2 + 0,75}}$$

$W_{0,6R}$  = parameter defined in 5.1.3  
 $= 0,12 \cdot (B \cdot t^2)_{0,6R}$

#### 5.4.4 Blade retaining bolts and studs

The blade retaining bolts shall be designed in such a way as to withstand the forces induced in the event of plastic deformation at the root section at  $0,35 \cdot R$  caused by a force acting on the blade at  $0,9 \cdot R$ . The bolt material shall have a safety margin of 1,5 against its yield strength which has to be demonstrated.

The demonstration can be dispensed from, if the thread core diameter is not less than:

$$d_k = 2,6 \cdot \sqrt{\frac{M_{0,35R} \cdot \alpha_A}{d \cdot Z \cdot R_{eH}}}$$

$M_{0,35R} = W_{0,35R} \cdot R_{p0,2}$

The blade retaining bolts or studs are to be tightened in a controlled manner in such a way that the loading on the bolts or studs is about 60 – 70 % of their yield strength.

The shank of the blade retaining bolts may be designed with a minimum diameter equal to 0.9 times the root diameter of the thread. Blade retaining bolts shall be secured against unintentional loosening.

#### 5.4.5 Flanges for connection of blades to hubs

The diameter  $D_F$ , in mm, of the flange for connecting the blade to the propeller hub is not to be less than that obtained from the following formula:

$$D_F = d + 1,8 \cdot d_s$$

The thickness of the flange is not to be less than 1/10 of the diameter  $D_F$ .

This formula is also applicable for built-up propellers.

#### 5.4.6 Indicators

Controllable pitch propeller systems are to be provided with an engine room indicator showing the actual pitch setting of the blades. If the controllable pitch propeller is operated from the steering stand of the vessel, the steering stand is also to be equipped with an indicator showing the actual blade pitch setting.

For vessels with automated machinery installations, see also A.3.8.

#### 5.4.7 Failure of control system

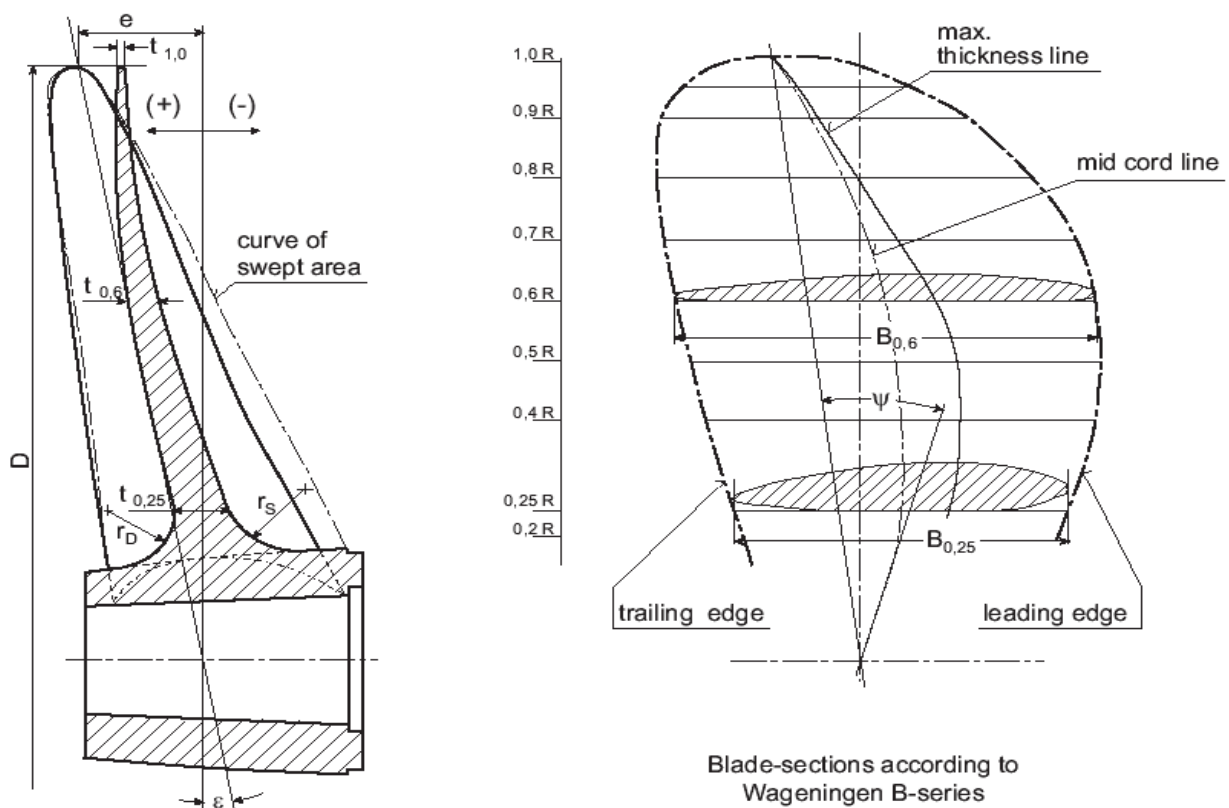
Suitable devices are to be fitted to ensure that an alteration of the blade pitch setting cannot overload the propulsion plant or cause it to stall.

Steps shall be taken to ensure that, in the event of failure of the control system, the setting of the blades:

- does not change or
- reaches a final position slowly enough to allow the emergency control system to be put into operation or to take other suitable countermeasures.

#### 5.4.8 Emergency control

Controllable pitch propeller systems shall be equipped with means of emergency control enabling the controllable pitch propeller to remain in operation, should the remote control system fail. It is recommended that a device has to be fitted which locks the propeller blades in the “ahead” setting.



**Fig. 1.4 Blade Section**

### 5.5 Balancing and testing

#### 5.5.1 Balancing

The finished propeller and the blades of controllable pitch and built-up propellers are required to undergo static balancing.

#### 5.5.2 Testing

The finished propeller is to be presented at the manufacturer's premises to BKI Surveyor for final inspection and verification of the dimensions.



BKI Surveyor reserves the right to require non-destructive tests to be conducted to detect surface cracks and casting defects.

In addition, controllable pitch propeller systems are required to undergo pressure, tightness and operational tests.

## 5.6 Propeller mounting

### 5.6.1 Tapered mountings

Where the tapered joint between the shaft and the propeller is fitted with a key, the propeller is to be mounted on the tapered shaft in such a way that approximately the mean torque can be transmitted from the shaft to the propeller by the frictional bond. The propeller nut is to be secured in a suitable manner.

Where the tapered fit is performed by the hydraulic oil technique without the use of a key, the necessary pull-up distance on the tapered shaft is given by the expression:

$$L = L_{\text{mech}} + L_{\text{temp}}$$

Where appropriate, allowance is also to be made for surface smoothening when calculating  $L$ .

$L_{\text{mech}}$  is determined according to the formulas of elasticity theory applied to shrunk joints for a specific pressure  $p$  [N/mm<sup>2</sup>] at the mean taper diameter determined by applying the following formula and for a temperature of 35 °C:

$$P = \sqrt{\frac{\Theta^2 \cdot T^2 + f \cdot (C \cdot A^2 \cdot Q^2 \cdot T^2) \pm \Theta \cdot T}{A \cdot f}}$$

“+” = sign applying to shrunk joints of tractor propeller

“−” = sign applying to shrunk joints of pusher propeller

$$L_{\text{temp}} = \frac{d_m}{C} \cdot (\alpha_N - \alpha_W) \cdot (35 - t_1)$$

Values for  $\alpha_N$  and  $\alpha_W$  can be taken from Table 1.10. At least the temperature range between 0 °C and 35 °C has to be considered

**Table 1.10 Material values according to IACS UR K3**

Material	Modulus of elasticity E [N/mm <sup>2</sup> ]	Poisson's ratio $\nu$ [−]	Coefficient of linear thermal expansion $\alpha$ [1/°C]
Steel	205000	0.29	$12.0 \cdot 10^{-6}$
Copper based alloys Cu1 and Cu2	105000	0.33	$17.5 \cdot 10^{-6}$
Copper based alloys Cu3 and Cu4	115000	0.33	$17.5 \cdot 10^{-6}$
Note: for austenitic stainless steel see manufacturer's specification.			

$t_1$  = temperature [°C] at which the propeller is mounted

The safety factor has to be taken as  $S = 2,8$  for geared plants and  $Q = Q_n$ .

For direct drives the safety factor has to be taken as  $S = 1,0$  and the circumferential force  $Q$  has to be replaced by  $Q_{FR}$  according to the following formula:

$$Q_{FR} = 2,0 \cdot Q_n + 1,8 \cdot Q_{V-MCR}$$

$Q_{FR}$  replaces  $Q$  in the formula of specific pressure  $p$  given here above.

$Q_{V-MCR}$  = maximum value from torsional vibration evaluations, but is not to be taken less than 0,44 times the  $Q_n$

The torsional vibration evaluation is to consider the worst relevant operating conditions, e.g. such as misfiring (one cylinder with no injection) and cylinder unbalance (the latter is subject to the BKI Rules).

The tapers of propellers which are mounted on the propeller shaft with the aid of hydraulic oil technique should not be more than 1:15 or less than 1:20.

The Von Mises equivalent stress based on the maximum specific pressure  $p$  and the tangential stress in the bore of the propeller hub may not exceed 75 % of the 0,2 % proof stress or yield strength of the propeller material in the installed condition and 90 % during mounting and dismounting

The propeller nut shall be secured to the propeller shaft by mechanical means.

### **5.6.2 Flange connections**

Flanged propellers and the bosses of controllable pitch propellers are to be attached using fitted pins and bolts (necked down bolts for preference).

The diameter of the fitted pins is to be calculated by applying formula given in 3.5.2.

The propeller retaining bolts are to be of similar design to those described in 5.4.4.

The thread core diameter shall not be less than:

$$d_k = 4,4 \cdot \sqrt{\frac{M_{0,35R} \cdot \alpha_A}{d \cdot Z \cdot R_{eH}}}$$

The propeller retaining bolts have to be secured against unintentional loosening.

## **6. Torsional vibrations**

### **6.1 General**

#### **6.1.1 Application**

The following requirements apply to the shafting of the following installations:

- propulsion systems with prime movers developing 220 kW or more
- other systems with internal combustion engines developing 110 kW or more and driving auxiliary machinery intended for essential services.

#### **6.1.2 Definition**

For the purposes of these Rules, torsional vibration stresses are additional loads due to torsional vibrations. They result from the alternating torque which is normally superimposed on the mean torque.

### **6.2 Calculation of torsional vibrations**

**6.2.1** A torsional vibration analysis covering the torsional vibration stresses to be expected in the main engine shafting system including its branches is to be submitted to BKI for examination.

The following data shall be included in the analysis:

- equivalent dynamic system comprising individual masses and inertia less torsional elasticities
- prime mover: engine type, rated power, rated speed, engine cycle, engine type (in-line/V type), number of cylinders, firing order, cylinder diameter, crank pin radius, stroke to connecting rod ratio, oscillating weight of one crank gear
- vibration dampers, damping data
- coupling, dynamic characteristics and damping data
- gearing data
- shaft diameter of crankshafts, intermediate shafts, gear shafts, thrust shafts and propeller shafts
- propellers: propeller diameter, number of blades, pitch and area ratio.
- natural frequencies with their relevant vibration forms and the vector sums for the harmonics of the engine excitation
- estimated torsional vibration stresses in all important elements of the system with particular reference to clearly defined resonance speeds of rotation and continuous operating ranges

**6.2.2** The calculations are to be performed both for normal operation and misfiring operation caused by irregularities in ignition. In this respect, the calculations are to assume operation for one cylinder without ignition (misfiring).

**6.2.3** Where the arrangement of the installation allows various different operation modes, the torsional vibration characteristics are to be investigated for all possible modes, e.g. in installations fitted with controllable pitch propellers for zero and full pitch, with power take off from the gearing or on the output side of the engine for loaded and idling conditions of the generator unit, and for installations with disconnectable branches for clutches in the engaged and disengaged states.

**6.2.4** The calculation of torsional vibrations shall also take account of the stresses resulting from the superimposition of several orders of vibration (synthesized torques/stresses).

**6.2.5** If modifications are introduced into the system which have a substantial effect on the torsional vibration characteristics, the calculation of the torsional vibrations is to be repeated and submitted for checking.

## **6.3 Permissible torsional vibration stresses**

### **6.3.1 General**

The calculation of the permissible torsional vibration stresses as well as the determination of the permissible vibratory torques for gearing, couplings and crankshaft shall be performed in accordance with the Rules for Machinery Installation (Part 1, Vol.III) , Section16.

## **6.4 Torsional vibration measurements**

**6.4.1** After consideration of the results of the calculations according to 6.2, BKI may request the performance of torsional vibration measurements during river trials.

**6.4.2** Torsional vibration measurements may also be required by BKI in the case of conversions affecting significantly and resulting to major alterations of the main propulsion plant.

## **6.5 Barred speed range**

### **6.5.1 Normal operation**

Operating ranges which, because of the magnitude of the torsional vibration stresses, may only be passed through are to be indicated as barred ranges for continuous operation by red marks on the tachometer or in some other suitable manner at the operating stations from which the plant can be controlled. Barred speed ranges are to be passed through as quickly as possible. In specifying barred speed ranges it is important to ensure that the navigating and manoeuvring functions are not unreasonably restricted.

The speed range  $\lambda \geq 0,8$  is to be kept free of barred speed ranges.

Even within prohibited ranges of operation, exceeding the maximum permissible loads for shafting, twice the rated torque for gear tooth systems and maximum impulse torque for flexible couplings is not permitted.

### **6.5.2 Deviations from normal operation**

This is understood to include firing irregularities or, in an extreme case, the complete interruption of the fuel supply to a cylinder. The actions necessary to prevent overloading of the propulsion plant in case of deviation from normal operation are to be clearly displayed on tables at all the operating stations from which the plant can be controlled.

The major components of the propulsion plant should be capable of withstanding for a reasonable time the consequences of an abnormal operation. Running under abnormal conditions should not lead to overloading as defined in 6.5.1.

Even in the event of an abnormal operation due to ignition failure of one cylinder, a continuous operation over extended time periods within certain speed ranges shall still remain possible, thus maintaining the manoeuvrability for safe operation of the vessel.

## **6.6 Auxiliary machinery**

**6.6.1** Important auxiliary machinery such as diesel generators and lateral thrust units are to be so designed that the operating speed range is free from undue stresses caused by torsional vibrations. For installations of more than 110 kW, the torsional vibration calculation is to be submitted to BKI.

**6.6.2** Essential auxiliary machinery shall be designed such that, operation under misfiring condition is possible, so far as adequate redundancy is provided.

**6.6.3** In the case of diesel generators with rigidly coupled generators, the torsional vibration torque in continuous operation shall not exceed 2.5 times the generator's normal torque.

## **7. Windlasses**

### **7.1 General**

#### **7.1.1 Scope**

The Rules contained in this Article apply to bow anchor windlasses, stern anchor windlasses and wire rope windlasses. For anchors, chains and ropes, see Rules for Equipment in the BKI Rules for Hull-Inland Waterways (Part 2, Volume II) Section 7, D.

#### **7.1.2 Documents for review/approval**

For each type of anchor windlass, general and sectional drawings, circuit diagrams of the hydraulic and electrical systems and detail drawings of the main shaft, cable lifter and brake are to be submitted to BKI for review/approval. To facilitate a smooth and efficient approval process the drawings could be submitted in electronic format. In specific cases and following prior agreement with BKI they can also be submitted in paper in triplicate.

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

Where an anchor windlass is to be reviewed for several strengths and types of chain cable, the calculation relating to the maximum braking torque is to be submitted and proof furnished of the power and hauling-in speed in accordance with 7.4.1 corresponding to all the relevant types of anchor and chain cable.

## **7.2 Materials**

### **7.2.1 Approved materials**

The provisions contained in the Rules for Material and Welding (Part 1, Vol V dan VI) are to be applied as appropriate to the choice of materials.

### **7.2.2 Testing of materials**

The material of components which are stressed by the pull of the chain when the cable lifter is disengaged (main shaft, cable lifter, brake bands, brake spindles, brake bolts, tension strap) shall possess mechanical characteristics in conformity with the Rules for Material and Welding (Part 1, Vol V dan VI). Evidence of this may take the form of a certificate issued by the steelmaker which contains details of composition and the results of the tests prescribed in the Rules for Material and Welding (Part 1, Vol V dan VI).

In the case of hydraulic systems, the material used for pipes as well as for pressure vessels is also to be tested.

## **7.3 Design and equipment**

### **7.3.1 Type of drive**

Windlasses are normally to be driven by an engine which is independent of other deck machinery. The piping systems of hydraulic windlass engines may be connected to other hydraulic systems provided that this is permissible for the latter.

Manual operation as the main driving power can be allowed for anchors with a weight up to 250 kg.

Hand-operated winches shall be fitted with devices to prevent kick-back of the crank. Winches that are both power- and manually driven shall be designed in such a way that the motive-power control cannot actuate the manual control.

### **7.3.2 Overload protection**

For protection of the mechanical parts in the case of the windlass jamming, an overload protection (e.g. slip coupling, relief valve) is to be fitted to limit the maximum torque of the drive engine (see 7.4.1). The setting of the overload protection is to be specified (e.g. in the operating instructions)

### **7.3.3 Clutches**

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

### **7.3.4 Braking equipment**

Windlasses shall be fitted with cable lifter brakes which are capable of holding a load equal to 80 % of the nominal breaking load of the chain. In addition, where the gear mechanism is not of self-locking type, a

device (e.g. gearing brake, lowering brake, oil hydraulic brake) is to be fitted to prevent paying out of the chain should the power unit fail while the cable lifter is engaged.

### **7.3.5 Pipes**

For the design and dimensions of pipes, valves, fittings and hydraulic piping systems, etc. see C.

### **7.3.6 Cable lifters**

Cable lifters shall have at least five snugs. For cable lifters used for studless chains, the requirements of EN 14874 can be applied.

### **7.3.7 Windlass as warping winch**

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

### **7.3.8 Electrical equipment**

The electrical equipment is to comply with Section 2.

### **7.3.9 Hydraulic equipment**

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

The lowest permissible oil level is to be monitored.

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

### **7.3.10 Wire rope windlass**

The rope drum diameter shall be at least 14 times the required rope diameter.

The drive of the windlass shall be capable of being uncoupled to the rope drum.

The rope end fastening of the windlass shall brake if the wire rope has to be released.

Rope drums shall be provided with flanges whose outer diameter extend above the top layer of the rope by at least 2.5 times rope diameter unless the rope is prevented from overriding the flange by a spooling device or other means.

### **7.3.11 Chain stoppers**

Where a chain stopper is fitted, it is to be able to withstand a pull of 80 % of the chain breaking load.

Where no chain stopper is fitted, the windlass shall be able to withstand a pull of 80 % of the chain breaking load. The caused stress in the loaded parts of the windlass may not exceed 90 % of the yield strength of the respective parts and the windlass brake is not allowed to slip.

### **7.3.12 Connection with deck**

The windlass, the foundation and the stoppers have to be connected efficiently and safely to the deck.

## **7.4 Power and design**

### **7.4.1 Driving power**

- a) Depending on the grade of the chain cable, windlasses shall be capable of exerting the following nominal pulls at a speed of at least 0,15m/s:
- $$Z_1 = 28 \cdot d^2 \text{ for grade } Q_1$$
- $$Z_2 = 32 \cdot d^2 \text{ for grade } Q_2$$
- $$Z_i = \text{pull [N]}$$
- $$d = \text{diameter of anchor chain [mm]}$$
- b) The nominal output of the power units shall be such that the conditions specified above can be met for 30 minutes without interruption. In addition, the power units shall be capable of developing a maximum torque equal to 1.5 times the rated torque for at least two minutes at a correspondingly reduced lifting speed.
- c) At the maximum torque specified in b), a short time overload of up to 20 % is allowed in the case of internal combustion engines.
- d) An additional reduction gear stage may be fitted in order to achieve the maximum torque.
- e) With manually operated windlasses, steps are to be taken to ensure that the anchor can be hoisted at a mean speed of 0,033 m/s with the pull specified in a). This is to be achieved without exceeding a manual force of 150 N applied to a crank radius of about 350 mm with the hand crank turned at about 30 rev./min.

#### 7.4.2 Design of transmission elements

The basis for the design of the load-transmitting components of windlasses is given by the anchors and chain cables specified in the rules for equipment, see Rules for Hull-Inland Waterways (Part 2 Vol. I), Section 7, D.

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

The dimensional design of those parts of the windlass which are subjected to the chain pull when the cable lifter is disengaged (cable lifter, main shaft and braking equipment, bed frame and deck fastening) is to be based on a theoretical pull equal to 80 % of the nominal breaking load specified in the BKI Rules for Material for the chain in question.

The design of the main shaft is to take account of the braking forces, and the cable lifter brake shall not slip when subjected to this load.

The design of all other windlass components is to be based upon a force acting on the cable lifter pitch circle and equal to 1.5 times the nominal pull specified in a) of 7.4.1.

At the theoretical pull, the force exerted on the brake hand wheel shall not exceed 500 N

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

The foundations and pedestals of windlasses and chain stoppers shall be adequate designed to withstand the forces and loads as specified in 7.3.11 and in paragraphs here above.

### 7.5 Testing in the manufacturer's works

#### 7.5.1 Testing of driving engines

The power units are required to undergo test on a test stand. The relevant works test certificates are to be presented at the time of the final inspection of the windlass.

For electric motors, see Rules for rotating machines in Section 2, C.

Hydraulic pumps are to be subjected to pressure and operational tests.

### **7.5.2 Pressure and tightness tests**

Pressure components are to undergo a pressure test at pressure:

$$p_{ST} = 1,5 \cdot p$$

$p_{ST}$  = test pressure [bar]

$p$  = maximum allowable working pressure or pressure at which the relief valves open [bar]

For working pressures above 200 bar, the test pressure need not exceed  $p + 100$ .

For pressure testing of pipes, their valves and fittings, and also of hose assemblies, see C.

Tightness tests are to be performed on components to which this is appropriate.

### **7.5.3 Final inspection and operational testing**

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

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

## **8. Hydraulic system**

### **8.1 General**

#### **8.1.1 Scope**

The Rules contained in the following apply to hydraulic systems used, for example, to operate closing appliances in the vessel's shell, landing ramps and hoists. The Rules are to be applied in analogous manner to vessel's other hydraulic systems.

#### **8.1.2 Documents for review/approval**

The diagram of the hydraulic system together with drawings of the cylinders containing all the data necessary for assessing the system, e.g. operating data, descriptions, materials used etc., are to be submitted to BKI for review/approval. To facilitate a smooth and efficient approval process, the drawings could be submitted in electronic format. In specific cases and following prior agreement with BKI, they can also be submitted in paper form in triplicate.

#### **8.1.3 Dimensional design**

For the design of pressure vessels, see D.1., for the dimensions of pipes, see, C.

### **8.2 Materials**

#### **8.2.1 Approved materials**



Components fulfilling a major function in the power transmission system shall normally be made of steel or cast steel in accordance with the BKI Rules for Material and Welding. The use of other materials is subject to special agreement with BKI.

Cylinders are preferably to be made of steel, cast steel or nodular cast iron (with a predominantly ferritic matrix).

Pipes are to be made of seamless or longitudinally welded steel tubes.

The pressure-loaded walls of valves, fittings, pumps, motors, etc., are subject to the requirements of C.

### **8.2.2 Testing of materials**

The materials of pressure casings and pressure oilines shall possess mechanical characteristics in conformity with the Rules for Material and Welding. Evidence of this may take the form of a certificate issued by the steelmaker which contains details of composition and the results of the tests prescribed in the Rules for Material and Welding

## **8.3 Design and equipment**

### **8.3.1 Control**

Hydraulic systems may be supplied either from a common power station or from a number of power stations, each serving a particular system.

Where the supply is from a common power station and in the case of hydraulic drives whose piping system is connected to other hydraulic systems, a second pump set is to be provided.

Hydraulic systems shall not be capable of being initiated merely by starting the pump. The movement of the equipment is to be controlled from special operating stations. The controls are to be so arranged that, as soon as they are released, the movement of the hoist ceases immediately.

Local controls, inaccessible to unauthorized persons, are to be fitted. The movement of hydraulic equipment should normally be visible from the operating stations. If the movement cannot be observed, audible and/or visual warning devices are to be fitted. In addition, the operating stations are then to be equipped with indicators for monitoring the movement of the hoist.

In or immediately at each power unit (ram or similar) used to operate equipment which moves vertically or rotates about a horizontal axis, suitable precautions shall be taken to ensure a slow descent following a pipe rupture.

### **8.3.2 Pipes**

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

Pipes are to be installed at a sufficient distance from the vessel's shell. As far as possible, pipes should not pass through cargo spaces. The piping system is to be fitted with relief valves to limit the pressure to the maximum allowable working pressure.

Pipes are to be so installed that they are free from stress and vibration. The piping system is to be fitted with filters for cleaning the hydraulic fluid.

Equipment is to be provided to enable the hydraulic system to be vented.

The hydraulic fluids shall be suitable for the intended ambient and service temperatures.

Where the hydraulic system includes accumulators, the accumulator chamber shall be permanently connected to the safety valve of the associated system. The gas chamber of the accumulators shall only be filled with inert gases. Gas and hydraulic fluid are to be separated by accumulator bags, diaphragms or similar devices.

### **8.3.3 Oil level indicators**

Tanks within the hydraulic system are to be equipped with oil level indicators.

An alarm located in the wheelhouse is to be fitted for the lowest permissible oil level.

### **8.3.4 Hose lines**

Hose assemblies comprise hoses and their fittings in a fully assembled and tested condition.

High-pressure hose assemblies are to be used if necessary for flexible connections. These hose assemblies shall meet the requirements of C. or an equivalent standard. The hose assemblies shall be properly installed and suitable for the relevant operating media, pressures, temperatures and environmental conditions. In systems important to the safety of the vessel and in spaces subjected to a fire hazard, the hose assemblies are to be flame-resistant or to be protected correspondingly.

## **8.4 Testing in the manufacturer's works**

### **8.4.1 Testing of power units**

The power units of hydraulic systems are required to undergo test on a test stand. The relevant works test certificates are to be presented at time to the final inspection of the hydraulic system.

For electric motors, see Section 2, C.

Hydraulic pumps are to be subjected to pressure and operational tests.

### **8.4.2 Pressure and tightness tests**

Pressure components are to undergo a pressure test at pressure

$$p_{ST} = 1,5 \cdot p$$

$p_{ST}$  = test pressure [bar]

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

For pressure testing of pipes, their valves and fittings, and also of hose assemblies, see C.

Tightness tests are to be performed on components to which this is appropriate.

## **C. Pipes, Valves, Fittings and Pumps**

### **1. General**

#### **1.1 Scope**

These Rules apply to piping systems, including valves, fittings and pumps, which are necessary for the operation of the main propulsion plant together with its auxiliaries and equipment. They also apply to piping systems used in the operation of the vessel whose failure could directly or indirectly impair the safety of vessel or cargo, and to piping systems which are dealt with in other parts of the Rules.

Cargo pipelines on ship for the carriage of chemicals in bulk are additionally subject to the provisions of the Rules For Additional Requirements of Notations – Inland waterways (Part 2, Vol V), Section 3, A. and Section 3, B.

Cargo and process pipelines on ships for the carriage of liquefied gases in bulk are additionally subject to the provisions of the Rules For Additional Requirements of Notations – Inland waterways (Part 2, Vol V)

## **1.2 Documents for review / approval**

The following drawings/documents are to be submitted for approval in triplicate 1). To facilitate a smooth and efficient approval process, the drawings could be submitted in electronic format.

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

- steam systems
- boiler feed and condensate systems
- fuel systems (bunkering, transfer and supply systems)
- lubricating oil systems
- cooling water systems
- compressed air systems
- bilge systems
- thermal oil systems
- air, sounding and overflow systems
- drinking water and Sanitary sewage systems
- systems for remotely controlled valves
- hose assemblies and compensators

Hoses and expansion joints made of non-metallic materials are to be clearly indicated.

## **1.3 Classes of pipes**

Pipes are subdivided into two classes as indicated in Table 1.11.

## **2. Materials, quality assurance, pressure tests**

### **2.1 General**

Materials shall be suitable for the proposed application and shall comply with the BKI Rules for Materials vol V and Welding VI. In the case of especially corrosive media, BKI may impose special requirements on the materials used. For welds, see the BKI Rules for Welding VI. For the materials used for pipes and valves for steam boilers, see D.1.2.

## **2.2 Materials**

### **2.2.1 Pipes, valves and fittings of steel**

Pipes belonging to class II shall be either seamless drawn or produced by a welding procedure approved by BKI.

### **2.2.2 Pipes, valves and fittings of copper and copper alloys**

Pipes of copper and copper alloys shall be of seamless drawn material or produced by a method approved by BKI. Class II copper pipes shall be seamless.

In general, copper and copper alloys pipe lines shall not be used for media having temperatures above the limits given in Table 1.10.

### **2.2.3 Pipes, valves and fittings of cast iron with spheroidal or nodular graphite (GGG)**

Pipes, valves and fittings of nodular ferritic cast iron according to the BKI Rules for Materials Vol. V and Welding Vol. VI may be accepted for bilge, ballast and cargo pipes within double bottom tanks and cargo tanks and for other purposes approved by BKI at temperatures up to 350 °C.

### **2.2.4 Pipes, valves and fittings of cast iron with lamellar graphite (grey cast iron) (GG)**

Pipes, valves and fittings of grey cast iron may be accepted by BKI for class III. Pipes of grey cast iron may be used for cargo and ballast pipelines within cargo tanks of tankers. Grey cast iron is not allowed for clean ballast lines to forward ballast tanks through cargo oil tanks.

Pipes, valves and fittings of grey cast iron may also be accepted for cargo lines on tankers intended to carry flammable liquids with a flash point  $\leq 60$  °C. Tough materials shall be used for cargo hose connections and distributor headers.

This applies also to the hose connections of fuel and lubricating oil filling lines. Grey cast iron may not be used for cargo lines in cargo systems of ships carrying chemicals (see Rules Additional Requirements for Notations – Inland waterways (Part 2, Vol.V) Section 3, A. and Section 3, B.).

Grey cast iron is not allowed for pipes, valves and fittings for media having temperatures above 220 °C and for pipelines subject to water hammer, excessive strains and vibrations.

Grey cast iron is not allowed for river valves and pipes fitted on the vessel sides and for valves fitted on the collision bulkhead.

Valves on fuel tanks subject to static head may be made of grey cast iron only if they are adequately protected against damage.

The use of grey cast iron for other services will be subject to special consideration by BKI.

### **2.2.5 Plastic pipes**

Plastic pipes may be used after special approval by BKI.

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

Pipe penetrations through watertight bulkheads and decks as well as through fire divisions are to be approved by BKI. Plastic pipes are to be continuously and permanently marked with the following particulars:

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

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

### **2.2.6 Aluminium and aluminium alloys**

Aluminium and aluminium alloys shall comply with the BKI Rules for Materials vol V and may in individual cases, with the agreement of BKI, be used for temperatures up to 200 °C. They are not acceptable for use in fire-extinguishing lines.

### **2.2.7 Application of materials**

For the pipe classes named in 1.3 materials shall be applied according to Table 1.12.

Quality assurance

**2.3.1** The proof of the quality of materials for pipe class II is to be in the form of an inspection certificate 3.1 according to EN 10.204 or equivalent. For this purpose, the manufacturer of the material shall have been accepted by BKI.

**2.3.2** For components in pipe class III a works certificate issued by the manufacturer of the material is sufficient.

**2.3.3** Welded joints in pipelines of class II are to be tested in accordance with the BKI Rules for Materials and Welding (II-3).

## **2.4 Hydraulic tests on pipes**

### **2.4.1 Definitions**

a) Maximum allowable working pressure, PB [bar] formula symbol:  $p_{e,zul}$

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

b) Nominal pressure, PN [bar]

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

c) Test pressure, PP [bar] formula symbol:  $p_p$

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

d) Design pressure, PR [bar] formula symbol:  $p_c$

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

#### **2.4.2 Pressure tests of piping before assembly on board**

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

$$p_p = 1,5 \cdot p_c$$

$p_c$  = design pressure defined in 2.4.1

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

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

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

#### **2.4.3 Pressure tests of piping after assembly on board**

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

In particular the following applies:

- Heating coils in tanks and fuel lines shall be tested to not less than 1,5 PB but in no case less than 4 bar.
- Liquefied gas process piping systems are to be leak tested (by air, halides, etc.) to a pressure depending on the leak detection method applied.

### **2.5 Hydrostatic tests of valves**

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

- a) Valves of Pipe class II to 1,5 PR
- b) Valves mounted on the vessel's side not less than 5 bar

The valves specified under a) and b) shall also undergo a tightness test at 1.0 times the nominal pressure.

For the valves of steam boilers, see D.2.

**Table 1.10 Medium limit temperature**

<b>Material</b>	<b>Medium limit temperature</b>
Copper and aluminium brass	200 °C
Copper nickel alloys	300 °C
High-temperature bronze	230 °C

**Table 1.11 Classification of pipes into "pipe classes"**

<b>Medium conveyed by the piping system</b>	<b>Design pressure PR [bar] Design temperature t [°C]</b>	
Toxic media Inflammable media with service temperature above the flash point Inflammable media with a flash point below 60 °C Liquefied gases (LPG, LNG, LG) Corrosive media	all	not applicable
steam, thermal oil	PR < 16 and t < 300	PR < 7 and t < 170
Air, gas Lubricating oil, hydraulic oil Boiler feed water, condensate Seawater and fresh water for Cooling	PR < 40 and t < 300	PR < 16 and t < 200
Liquid fuels	PR < 16 and t < 150	PR < 7 and t < 60
Cargo pipelines for tankers	not applicable	All
Open-ended pipelines (without shut-off), e.g. drains, venting pipes, overflow lines and boiler blow down lines	not applicable	all
Pipe class	II	III

**Table 1.12 Approved materials**

Material or application		Pipe classes	
		II	III
Steel	Pipes	Pipes for general applications, below -10 °C pipes made of steels with high low-temperatures toughness, stainless steel pipes for chemicals	Steel not subject to any special quality specification, weldability in accordance with the BKI Rules for Welding
	Forgings, plates, flanges	Steels suitable for the corresponding loading and processing conditions, for temperatures below -10 °C steels with high low-temperature toughness	
	Bolts, nuts	Bolts for general machine construction, below -10 °C steels with high low- temperature toughness	Bolts for general machine construction
Castings valves, fittings, pipes)	Cast steel	Cast steel for general applications, below -10 °C cast steel with high low- temperature toughness, for aggressive media stainless castings	Cast steel for general applications
	Spheroidal/Nodular cast iron	Only ferritic grades, elongation A <sub>5</sub> at least 12 %	
	Cast iron with lamellar graphite (grey cast iron) (GG)	Not applicable	At least GG-20 for Pipe Class III up to 220 °C not permitted in: - ballast lines of ballast tanks outside cargo are through cargo tanks - valves on vessel's side, collision bulk-head and fuel tanks
Non-ferrous metals (valves, fittings, pipes)	Copper, copper alloys	In cargo lines on tank ships carrying chemicals only with special approval low- temperature copper nickel alloys by special agreement	For seawater and alkaline water only corrosion-resistant copper and copper alloys
	Aluminium, aluminium alloy	In cargo and processing lines on gas tank vessels	Only with the agreement of the Society up to 200 °C, not permitted in fire-extinguishing systems
Non-metallic	Plastics	Not applicable	On special approval see 2.2.5

### 3. Pipe wall thicknesses

#### 3.1 Minimum wall thickness

**3.1.1** The pipe thicknesses given in Table 1.13 and Table 1.14 are the assigned minimum thicknesses

$d_a$  = outside diameter of pipe [mm]

$s$  = minimum wall thickness [mm]



**3.1.2** Air pipes, sounding pipes, overflow pipes and pipes carrying media which is different to that in the tanks may not be routed through tanks for drinking water, feed water or lubricating oil. If this cannot be avoided, the arrangement of the pipes in the tanks is to be agreed with BKI.

**Table 1.13 Steel pipes**

<b>d<sub>a</sub></b>	<b>s</b>	<b>d<sub>a</sub></b>	<b>s</b>
up to 10,2	1,6	from 114,3	3,2
from 13,5	1,8	from 133,0	3,6
from 20,0	2,0	from 152,4	4,0
from 48,3	2,3	from 177,8	4,5
from 70,0	2,6	from 244,5	5,0
from 88,9	2,9	from 298,5	5,6

**Table 1.14 Copper and copper alloy pipes**

<b>Copper pipes</b>		<b>Copper alloy pipes</b>	
<b>d<sub>a</sub></b>	<b>s</b>	<b>d<sub>a</sub></b>	<b>s</b>
up to 12,2	1,0	up to 22,0	1,0
from 14,0	1,5	from 25,0	1,5
from 44,5	2,0	from 76,0	2,0
from 60,0	2,5	from 108,0	2,5
from 108,0	3,0	from 219,0	3,0
from 159,0	3,5		

## **4. Principles for the construction of pipes, valves, fittings and pumps**

### **4.1 General principles**

**4.1.1** Piping systems are to be constructed and manufactured on the basis of standards generally used in vessel building.

**4.1.2** Welded connections instead of detachable connections should be used for pipelines carrying toxic media and inflammable liquefied gases.

**4.1.3** Expansion in piping systems due to heating and shifting of their suspensions caused by deformation of the vessel are to be compensated by bends, compensators and flexible pipe connections. The arrangement of suitable fixed points is to be taken into consideration

### **4.2 Pipe connections**

#### **4.2.1 Dimensions and calculation**

The dimensions of flanges and bolting are to comply with recognized standards.

#### **4.2.2 Pipes connections**

The following pipe connections may be used:

- fully penetrating butt welds with/without provision to improve the quality of the root

- socket welds with suitable fillet weld thickness and possibly in accordance with recognized standards
- screw connections of approved type

For the use of these pipe connections, see Table 1.15.

**Table 1.15 Pipe connections**

Types of connections	Pipe class	Nominal diameter
Welded butt-joints with spacial provisions for root side	II, III	all
Welded butt-joints without all spacial provisions for root side	II, III	
Welded sockets	III	
Screwed sockets	for subordinate systems see 4.2.2	< 50

Screwed socket connections and similar connections are not permitted for pipes of classes II and III. Screwed socket connections are allowed only for subordinate systems (e.g. sanitary and hot-water heating systems) operating at low pressures. Screwed pipe connections and pipe coupling may be used subject to special approval.

Steel flanges may be used under considering the allowed pressures and temperatures as stated in the corresponding standards.

Flanges made of non-ferrous metals may be used in accordance with the relevant standards and within the limits laid down in the approvals. Flanges and brazed or welded collars of copper and copper alloys are subject to the following requirements:

- a) Welding neck flanges according to standard up to 200 °C or 300 °C for all Pipe classes
- b) Loose flanges with welding collar; as for a)
- c) Plain brazed flanges: only for Pipe class III up to a nominal pressure of 16 bar and a temperature of 120 °C

Approved pipe couplings are permitted in the following piping systems outside engine rooms :

- bilge and ballast systems
- fuel and oil systems
- fire-extinguishing and deck washing systems
- cargo oil pipes
- air, filling and sounding pipes
- sanitary drain pipes

- drinking water pipes

These couplings may only be used inside machinery spaces if they have been approved by BKI as flame resistant.

The use of pipe couplings is not permitted in:

- fuel and seawater lines inside cargo spaces
- bilge lines inside fuel tanks and ballast tanks

### **4.3 Layout, marking and installation**

**4.3.1** Piping systems shall be adequately identified according to their purpose based on recognized standard. Valves are to be permanently and clearly marked

**4.3.2** Pipes leading through bulkheads and tank walls shall be water and oil tight. Bolts through bulkheads are not permitted. Holes for set screws may not be drilled in the tank walls.

**4.3.3** Piping systems close to electrical switchboards shall be so installed or protected that possible leakage cannot damage the electrical installation.

**4.3.4** Piping systems are to be so arranged that they can be completely emptied, drained and vented. Piping systems in which the accumulation of liquids during operation could cause damage shall be equipped with special drain arrangements.

### **4.4 Shut-off devices**

**4.4.1** Shut-off devices shall comply with a recognized standard. Valves with screwed-on covers are to be secured to prevent unintentional loosening of the cover.

**4.4.2** Hand-operated shut-off devices are to be closed by turning in the clockwise direction.

**4.4.3** Indicators are to be provided showing the open/closed position of valves unless their position is shown by other means.

**4.4.4** Change-over devices in piping systems in which a possible intermediate position of the device could be dangerous in service shall not be used.

### **4.5 Outboard connections**

**4.5.1** Valves may only be mounted on the vessel's side by means of reinforcing flanges or thick-walled connecting pipes.

**4.5.2** Vessel's side valves shall be easily accessible. Water inlet and outlet valves shall be capable of being operated from above the floor plates. Cocks on the vessel's side shall be so arranged that the handle can only be removed when the cock is closed

**4.5.3** Where discharge pipes without shutoff devices may be connected to the vessel's hull below the freeboard deck, the wall thickness of the pipes to the nearest shut-off device shall be equal to that of the shell plating at the ends of the vessel, but need not to exceed 8 mm.

**4.5.4** Outboard connections are to be fitted with shut-off valves.

Cooling water discharge lines may be provided with loops led at a minimum height of 0,3 m above the maximum draft.

## **4.6 Remote controlled valves**

### **4.6.1 Scope**

These Rules apply to hydraulically, pneumatically or electrically operated valves in piping systems and sanitary discharge pipes.

### **4.6.2 Construction**

Remote controlled bilge valves and valves important to the safety of the vessel are to be equipped with an emergency operating arrangement.

For the emergency operation of remote controlled valves in cargo piping systems, see the Rules Additional for Class Notations (Part 2, Vol V), Section 3, A.3.2.

### **4.6.3 Arrangement of valves**

The accessibility of the valves for maintenance and repairing is to be taken into consideration.

Valves in bilge lines and sanitary pipes shall always be accessible.

Bilge lines valves and control lines are to be located as far as possible from the bottom and sides of the vessel.

The requirements stated here above also apply here to the location of valves and control lines.

Where remote controlled valves are arranged inside the ballast tanks, the valves should always be located in the tank adjoining that to which they relate.

Remote-controlled valves mounted on high and wing fuel tanks shall be capable of being closed from outside the compartment in which they are installed.

Where remote controlled valves are arranged inside cargo tanks, valves should always be fitted in the tank adjoining that to which they relate. A direct arrangement of the remote controlled valves in the tanks concerned is allowed only if each tank is fitted with two suction lines each of which is provided with a remote controlled valve.

### **4.6.4 Control stands**

The control devices of remote controlled valves are to be arranged together in one control stand.

The control devices are to be clearly and permanently identified and marked.

It shall be recognized at the control stand whether the valves are open or closed.

In the case of bilge valves and valves for changeable tanks, the closed position is to be indicated by limitposition indicators approved by BKI as well as by visual indicators at the control stand.

On passenger vessels, the control stand for remote controlled bilge valves is to be located outside the machinery spaces and above the bulkhead deck.

The control devices of valves for changeable tanks are to be interlocked to ensure that only the valve relating to the tank concerned can be operated. The same also applies to the valves of cargo holds and tanks, in which dry cargo and ballast water are carried alternately.

#### **4.6.5 Power units**

Power units are to be equipped with at least two independent sets for supplying power for remote controlled valves.

The energy required for the closing of valves which are not closed by spring power is to be supplied by a pressure accumulator.

Pneumatically operated valves can be supplied with air from the general compressed air system.

Where the quick-closing valves of fuel tanks are closed pneumatically, a separate pressure accumulator is to be provided. This is to be of adequate capacity and is to be located outside the engine room. Filling of this accumulator by a direct connection to the general compressed air system is allowed. A non return valve is to be arranged in the filling connection of the pressure accumulator.

The accumulator is to be provided either with a pressure control device with a visual and acoustic alarm or with a hand-compressor as a second filling appliance.

The hand-compressor is to be located outside the engine room.

#### **4.6.6 After installation on board, the entire system is to be subjected to an operational test.**

### **4.7 Pumps**

**4.7.1** Displacement pumps shall be equipped with sufficiently dimensioned relief valves without shut-off to prevent any excessive overpressure in the pump housing.

**4.7.2** Rotary pumps shall be capable of being operated without damage even when the delivery line is closed.

**4.7.3** Pumps mounted in parallel are to be protected against overloading by means of non-return valves fitted at the outlet side.

### **4.8 Protection of piping systems against**

The following piping systems are to be fitted with safety valves to avoid unallowable overpressures:

- piping systems and valves in which liquids can be enclosed and heated
- piping systems which may be exposed in service to pressures in excess of the design pressure

Safety valves shall be capable of discharging the medium at a maximum pressure increase of 10 %. Safety valves are to be fitted on the low-pressure side of reducing valves.

## **5. Steam systems**

### **5.1 Laying out of steam systems**

**5.1.1** Steam systems are to be so installed and supported that expected stresses due to thermal expansion, external loads and shifting of the supporting structure under both normal and interrupted service conditions will be safely compensated.

**5.1.2** Steam lines are to be so installed that water pockets will be avoided.

**5.1.3** Means are to be provided for the reliable drainage of the piping system.

**5.1.4** Pipe penetrations through bulkheads and decks are to be insulated to prevent heat conduction.

**5.1.5** Steam lines are to be effectively insulated to prevent heat losses.

At points where there is a possibility of contact, the surface temperature of the insulated steam systems may not exceed 80 °C.

Wherever necessary, additional protection arrangements against unintended contact are to be provided.

The surface temperature of steam systems in the pump rooms of tankers may nowhere exceed 220 °C.

It is to be ensured that the steam lines are fitted with sufficient expansion arrangements.

Where a system can be entered from a system with higher pressure, the former is to be provided with reducing valves and relief valves on the low-pressure side.

Welded connections in steam systems are subject to the requirements specified in the BKI Rules for Welding Vol. VI.

## **5.2 Steam strainers**

Wherever necessary, machines and apparatus in steam systems are to be protected against foreign matter by steam strainers.

## **5.3 Steam connections**

Steam connections to equipment and pipes carrying oil, e.g. steam atomizers or steam out arrangements, are to be so secured that fuel and oil cannot penetrate into the steam systems.

# **6. Boiler feed water and circulating arrangement, condensate recirculation**

## **6.1 Feed water pumps**

**6.1.1** At least two feed water pumps are to be provided for each boiler installation.

**6.1.2** Feed water pumps are to be so arranged or equipped that no backflow of water can occur when the pumps are at a standstill.

**6.1.3** Feed water pumps are to be used only for feeding boilers.

## **6.2 Capacity of feed water pumps**

**6.2.1** Where two feed water pumps are provided, the capacity of each is to be equivalent to at least 1.25 times the maximum permitted output of all the connected steam producers.

**6.2.2** Where more than two feed water pumps are installed, the capacity of all other feed water pumps in the event of the failure of the pump with the largest capacity is to comply with the requirements of 6.2.1.

**6.2.3** For continuous flow boilers the capacity of the feed water pumps is to be at least 1.0 times the maximum steam output.

## **6.3 Delivery pressure of feed water pumps**

Feed water pumps are to be so laid out that the delivery pressure can satisfy the following requirements:

- The required capacity according to 6.2 is to be achieved against the maximum allowable working pressure of the steam producer
- The safety valves shall have a capacity equal 1.0 times the approved steam output at 1.1 times the allowable working pressure.

The resistances to flow in the piping between the feed water pump and the boiler are to be taken into consideration. In the case of continuous flow boilers the total resistance of the boiler shall be taken into account.

#### **6.4 Power supply to feed water pumps**

For electric drives, a separate lead from the common bus-bar to each pump motor is sufficient.

#### **6.5 Feed water systems**

##### **6.5.1 General**

Feed water systems may not pass through tanks which do not contain feed water.

##### **6.5.2 Feed water systems for boilers**

- a) Each boiler is to be provided with a main and an auxiliary feed water systems.
- b) Where 2 adequately sized main boilers are provided the feed water to each of the boilers may be supplied by a single feed water line.
- c) Each feed water system is to be fitted with a shut-off valve and a check valve at the boiler inlet. Where the shut-off valve and the check valve are not directly connected in series, the intermediate pipe is to be fitted with a drain.
- d) Each feed water pump is to be fitted with a shut- off valve on the suction side and a screw-down non-return valve on the delivery side. The pipes are to be so arranged that each pump can supply each feed water system.
- e) Continuous flow boilers need not to be fitted with the valves required in b) provided that the heating of the boiler is automatically switched off should the feed water supply fail and that the feed water pump supplies only one boiler.

#### **6.6 Boiler water circulating systems**

**6.6.1** Each forced-circulation boiler is to be equipped with two circulating pumps powered independently of each other. Failure of the circulating pump in operation is to be signaled by an alarm. The alarm may only be switched off if a circulating pump is started or when the boiler firing is shut down.

**6.6.2** The provision of only one circulating pump for each boiler is sufficient if:

- a common stand-by circulating pump is provided which can be connected to any boiler or
- the burners of oil-fired auxiliary boilers are so arranged that they are automatically shut-off should the circulating pump fail and the heat stored in the boiler does not cause any unacceptable evaporation of the water present in the boiler.

#### **6.7 Condensate recirculation**

The condensate of all heating systems used to heat oil (fuel, lubricating, cargo oil, etc.) is to be led to condensate observation tanks. These tanks are to be fitted with air vents.

## **7. Fuel oil systems**

### **7.1 Storage of liquid fuels**

#### **7.1.1 General safety precautions for liquid fuel**

Tanks and fuel pipes are to be so located and equipped that fuel cannot spread either inside the vessel or on deck and cannot be ignited by hot surfaces or electrical equipment. Tanks are to be fitted with air and overflow pipes to prevent excessive pressure (see 13.).

#### **7.1.2 Distribution and location of fuel tanks**

The fuel supply is to be stored in several tanks so that, even in event of damage to one tank, the fuel supply will not be entirely lost. (At least 1 storage tank and 1 service/settling tank).

### **7.2 Fuel tank fittings and mountings**

**7.2.1** For fuel filling and suction systems see 7.6; for air, overflow and sounding pipes, see 13.

**7.2.2** Service tanks are to be so arranged that water and residues can settle out despite the movement of the vessel.

**7.2.3** Free discharge and drainage lines shall be fitted with self-closing shut-off valves.

#### **7.2.4 Tank gauges**

The following tank gauges are permitted:

- sounding pipes
- oil level indicating devices
- oil gauges with flat glasses and self-closing shut-off valves at the connections to the tank and protected against external damage

For fuel storage tanks, the provision of sounding pipes is sufficient. Such sounding pipes need not be fitted to tanks equipped with oil level indicating devices which have been type-tested by BKI.

Fuel service tank supplying the main propulsion unit, important auxiliaries and the driving engines for bow thrusters are to be fitted with low level alarm which has been type-approved by BKI.

The low level alarm shall be fitted at a height which enables the vessel to reach a safe location in accordance with the class notation without refilling the service tank.

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

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

## **7.3 Attachment of mountings and fittings to fuel tanks**

**7.3.1** Only appliances, mountings and fittings forming part of the fuel tank equipment may generally be



fitted to tank surfaces.

- 7.3.2** Valves and pipe connections are to be attached to strengthening flanges welded to the tank surfaces. Holes for attachment bolts shall not be drilled in the tank surfaces. Instead of strengthening flanges, short, thick pipe flange connections may be welded into the tank surfaces.

#### **7.4 Hydraulic pressure test**

See 2.4.

#### **7.5 Filling and delivery system**

The filling of fuels is to be effected from the open deck through permanently installed lines.

#### **7.6 Tank filling and suction systems**

- 7.6.1** Filling and suction lines terminating below the oil level in tanks shall be fitted with remote controlled shut-off valves. The shut-off valves shall be directly at the tanks.
- 7.6.2** The remote-controlled shut-off valves shall be capable of being operated from a permanently accessible open deck.
- 7.6.3** Air and sounding pipes shall not be used to fill fuel tanks.
- 7.6.4** The inlet openings of suction pipes shall be located above the drain pipes.
- 7.6.5** Service tanks of up to 50 litres capacity mounted directly on diesel engines need not be fitted with remote controlled shut-off valves.

#### **7.7 Pipe layout**

- 7.7.1** Fuel lines may not pass through tanks containing feed water, drinking water or lubricating oil.
- 7.7.2** Fuel lines may not be laid in the vicinity of hot engine components, boilers or electrical equipment. The number of detachable pipe connections is to be limited. Shut-off valves in fuel lines shall be operable from above the floor plates in machinery spaces.

Glass and plastic components are not permitted in fuel systems.

- 7.7.3** Shut-off valves in fuel spill lines to servicetanks are not permitted

#### **7.8 Filters**

Fuel supply lines to continuously operating engines are to be fitted with duplex filters with a changeover cock or with self-cleaning filters. By-pass arrangements are not permitted.

### **8. Lubricating oil systems**

#### **8.1 Storage of lubricating oil**

##### **8.1.1 Tank arrangement**

For the arrangement of the tanks, requirements of the Rules for Hull-Inland Waterways (Part 2, Vol.II), section 11, E.7 are to be applied.

#### **8.2 Tank fittings and mountings**

**8.2.1** Oil level glasses are to be connected to the tanks by means of self-closing shut-off valves.

**8.2.2** The requirements set out under 2.4 apply likewise to the mounting of appliances and fittings on these tanks.

### **8.3 Capacity and construction of tanks**

**8.3.1** Lubricating oil circulating tanks should be sufficiently large to ensure that the dwelling time of the oil is long enough for the expulsion of air bubbles, the settling out of residues, etc. The tanks shall be large enough to hold at least the lubricating oil contained in the entire circulation system.

**8.3.2** Measures, such as the provision of baffles or limber holes are to be taken to ensure that the entire contents of the tank remain in circulation. Limber holes should be located as near the bottom of the tank as possible. Lubricating oil drain pipes from engines are to be submerged closed to the tank bottom at their outlet ends. Suction pipe connections should be placed as far as is practicable from oil drain pipes so that neither air nor sludge can be sucked up irrespective of the inclination of the vessel.

**8.3.3** Lubricating oil drain tanks are to be equipped with sufficient vent pipes.

### **8.4 Hydraulic pressure test**

See 2.4.

### **8.5 Lubricating oil piping**

**8.5.1** Lubricating oil systems are to be constructed to ensure reliable lubrication over the whole range of speed and during run-down of the engines and to ensure adequate heat transfer.

#### **8.5.2 Priming pumps**

Where necessary, priming pumps are to be provided for supplying lubricating oil to the engines.

### **8.6 Lubricating oil pumps**

The suction connections of lubricating oil pumps are to be located as far as possible from drain pipes.

### **8.7 Filters**

Change-over duplex filters or automatic back-flushing filters are to be mounted in lubricating oil lines on the delivery side of the pumps.

### **8.8 Pipe Fittings**

For allowable pipe fittings in lubrication oil system see. Rules for Machinery Installation (Part 1, Vol.III), Section 11.

## **9. Cooling water systems**

### **9.1 Cooling water intakes, river chest**

**9.1.1** Each river chest is to be provided with an air pipe which can be shut-off and which shall extend above the bulkhead deck. The inside diameter of the air pipe shall be compatible with the size of the river chests and shall not be less than 30 mm.

**9.1.2** Where compressed air is used to blow through river chests, the pressure shall not exceed 2 bar.

## **9.2 Cooling water intake valves**

Two valves are to be provided for main propulsion plants. The cooling water pumps of important auxiliaries should be connected to the river chests over separate valves.

## **9.3 Filters**

The suction lines of cooling water pumps for main engines are to be fitted with filters which can be cleaned in service.

## **9.4 Expansion tanks of fresh water cooling**

The fresh water cooling system is to be provided with expansion tanks located at a sufficient height. The tanks are to be fitted with a filling connection, a water level indicator and an air pipe. A venting shall connect the highest point of the cooling water common pipe to the expansion tank.

In closed circuits, the expansion tanks are to be fitted with overpressure/ under pressure valves.

## **9.5 Fresh water coolers**

For fresh water coolers forming part of the vessel's shell plating and for special outboard coolers, provision shall be made for satisfactory de-aeration of the cooling water. Drawings of the cooler and the cooler arrangement are to be submitted for review/approval.

# **10. Compressed air systems**

## **10.1 General**

**10.1.1** Pressure lines connected to air compressors are to be fitted with non-return valves at the compressor outlet.

**10.1.2** Efficient oil and water traps are to be provided in the filling lines of compressed air receivers.

The air discharge from relief valves in the compressed air receivers installed in the engine rooms shall lead to the open air.

**10.1.3** Starting air lines may not be used as filling lines for air receivers.

**10.1.4** The starting air line to each engine is to be fitted with a non-return valve and a drain.

**10.1.5** Typhoons are to be connected to at least two compressed-air receivers.

**10.1.6** A safety relief valve is to be fitted down-stream of each pressure-reducing valve.

**10.1.7** Pressure water tanks and other tanks connected to the compressed air system are to be considered as pressure vessels and shall comply with the requirements in D.1.

## **10.2 Compressed air connections for blowing**

For compressed air connections for blowing through river chests refer to 9.1.2.

## **10.3 Compressed air supply to pneumatically**

For the compressed air supply to pneumatically operated valves refer to 4.6.

# **11. Bilge systems**

## **11.1 General**

The equipment of vessels with oil-separating facilities is to conform to national and international Regulations.

## **11.2 Bilge lines**

### **11.2.1 Layout of bilge lines**

Bilge lines and bilge suction are to be so arranged that the bilges can be completely pumped even under disadvantageous trim conditions.

Bilge suction are normally to be located on both sides of the vessel. For compartments located fore and aft in the vessel, one bilge suction may be considered sufficient provided that it is capable of completely draining the relevant compartment.

Spaces located forward of the collision bulkhead and aft of the stern tube bulkhead and not connected to the general bilge system are to be drained by other suitable means of adequate capacity.

The collision bulkhead may be pierced by a pipe for filling and draining of the fore peak, provided that a screw-down valve capable of being remotely operated from above the open deck is fitted at the collision bulkhead within the fore peak. Where the fore peak is directly adjacent to a permanently accessible room which is separated from the cargo space, this shut-off valve may be fitted directly at the collision bulkhead inside this room without provision for remote control.

### **11.2.2 Pipes led through tanks**

Bilge pipes may not be led through tanks for lubricating oil, thermal oil, drinking water or feed water.

### **11.2.3 Bilge suction and strums**

Bilge suction are to be so arranged as not to impede the cleaning of bilges and bilge wells. They are to be fitted with easily detachable, corrosion-resistant strums.

### **11.2.4 Bilge valves**

Valves in connecting pipes between the bilge and the river water and ballast water system, as well as between the bilge connections of different compartments, are to be so arranged that even in the event of faulty operation or intermediate positions of the valves, penetration of river water through the bilge system will be safely prevented.

Bilge discharge pipes are to be fitted with shut-off valves at the vessel's side.

Bilge valves are to be arranged so as to be always accessible irrespective of the ballast and loading condition of the vessel.

### **11.2.5 Pipe connections**

To prevent water penetration, each of the branch bilge pipes from the individual compartments is to be connected to the main bilge pipe by a screw-down non-return valve. In the case of small vessels with only one cargo hold, the branch bilge pipes serving the various spaces can also be connected to the bilge pumps over changeover or three-way angle cocks.

Where a bilge pump is also to be used for pumping water over the vessel's side and from ballast water tanks, the main bilge pipe shall be connected to the suction line of the pump by a non-return device to

prevent raw or ballast water from penetrating the bilge system.

Such non-return devices include three -way cocks with L plugs, three-way angle cocks and changeover gate valves. Instead of these changeover devices, a screw-down non-return valve may also be fitted between the pump and the main bilge pipe, so that two non-return valves will then be connected in series.

A direct suction from the engine room shall be connected to the largest of the specified bilge pumps. Its diameter shall not be less than that of the main bilge pipe.

However, the direct suction in the engine room need be fitted with only one screw-down non-return valve.

Where the direct suction is connected to a centrifugal pump which can also be used for cooling water, ballast water or fire-extinguishing, a screw-down non-return valve is to be fitted in the discharge pipe of the pump.

### 11.3 Calculation of pipe diameters

#### 11.3.1 Tankers

The inside diameter of the main bilge pipe in the main engine rooms of tankers is calculated by applying the formula:

$$d_H = 3,0 \cdot \sqrt{(B+D) \cdot l_1} + 25$$

$l_1$  = total length [m] of spaces between cofferdam or cargo bulkhead and stern tube bulkhead.

Other terms as stated under 11.3.2.

Branch bilge pipes are to be dimensioned in accordance with 11.3.2.

#### 11.3.2 Other vessels

a) Main bilge pipes

$$d_H = 1,5 \cdot \sqrt{(B+D) \cdot L} + 25$$

b) Branch bilge pipes

$$d_Z = 2,0 \cdot \sqrt{(B+D) \cdot l} + 25$$

Where

$d_H$  = inside diameter of main bilge pipe [mm]

$d_Z$  = inside diameter of branch bilge pipe [mm]

$l$  = length of watertight compartment [m]

$L$  = Length defined in Rules for Hull-Inland Waterways (Part 2, Vol.II) [m]

$B$  = Breadth defined in Rules for Hull -Inland Waterways (Part 2, Vol.II) [m]

$D$  = Draught defined in Rules for Hull -Inland Waterways (Part 2, Vol.II) [m]

### 11.4 Bilge pumps

#### 11.4.1 Capacity of independent pumps

Each bilge pump shall be capable of delivering:

$$Q = 5,75 \cdot 10^{-3} \cdot d_H^2$$

$Q$  = minimum capacity [ $\text{m}^3/\text{h}$ ]

$d_H$  = calculated inside diameter of main bilge pipe [mm]

**11.4.2** Where centrifugal pumps are used for bilge pumping, they shall be self-priming or connected to an air extracting device.

#### **11.4.3 Capacity of attached bilge pumps**

Bilge pumps having a smaller capacity than that specified in 11.4.1 are acceptable provided that the independent pumps are designed for a correspondingly larger capacity.

#### **11.4.4 Use of other pumps for bilge pumping**

Ballast pumps, general service pumps and similar units may also be used as independent bilge pumps provided they are of the required capacity according to 11.4.1.

Oil pumps may not be connected to the bilge system.

#### **11.4.5 Number of bilge pumps**

Vessels with a propulsion power of up to 225 kW shall have one bilge pump, which may be driven from the main engine. Where the propulsion power is greater than 225 kW, a second bilge pump driven independently of the main propulsion plant shall be provided.

On passenger vessels further bilge pumps may be required according to size and propulsion power.

### **11.5. Bilge Pump for Various Space**

#### **11.5.1 Machinery Space**

The bilges of every main machinery space shall be capable of being pumped as follows:

- a) through the bilge suction connected to the main bilge system and
- b) through one direct suction connected to the largest independent bilge pump.

#### **11.5.2 Fore and after peaks**

Connection of the fore and after peaks to the general bilge system is not permitted. Where the peak tanks are not connected to the ballast system, separate means of pumping are to be provided. Where the after peak terminates at the engine room, it may be drained to the engine room bilge through a pipe fitted with a shut-off valve. Similar emptying of the fore peak into an adjoining space is not permitted.

#### **11.5.3 Spaces above peak tanks**

These spaces may either be connected to the bilge system or be pumped by means of hand-operated bilge pumps. Spaces above the after peak may be drained to the machinery space, provided that the drain line is fitted with a self-closing shut-off valve at a clearly visible and easily accessible position. The drain pipes shall have an inside diameter of at least 40 mm.

#### **11.5.4 Cofferdams and void spaces**

Bilge pumping arrangements are to be provided for cofferdams and void spaces.

### **11.5.5 Chain lockers**

Chain lockers may be connected to the main bilge system or drained by a hand pump. Draining to the forepeak tank is not permitted.

## **12. Thermal oil systems**

### **12.1 General**

Thermal oil systems shall be installed in accordance with D.2.

### **12.2 Pumps**

#### **12.2.1 Circulating pumps**

One circulating pump is to be provided; as the second circulating pump, a complete spare pump stored on board can be accepted.

With the owner's confirmation, the spare pump on board may be omitted.

#### **12.2.2 Transfer pumps**

A transfer pump is to be installed for filling the expansion tank.

**12.2.3** The pumps are to be so mounted that any oil leakage can be safely disposed of.

**12.2.4** For emergency stopping, see H.2.3.

### **12.3 Valves**

**12.3.1** Only valves made of ductile materials may be used.

**12.3.2** Valves shall be designed for a nominal pressure of PN 16.

**12.3.3** Valves are to be mounted in accessible positions.

**12.3.4** Non-return valves are to be fitted in the pressure lines of the pumps.

**12.3.5** Valves in return pipes are to be secured in the open position.

### **12.4 Piping**

**12.4.1** The material of the sealing joints is to be suitable for permanent operation at the design temperature and resistant to the thermal oil.

**12.4.2** Provision is to be made for thermal expansion by an appropriate pipe layout and the use of suitable compensators.

**12.4.3** The pipe lines are to be preferably connected by means of welding. The number of detachable pipe connections is to be minimized.

**12.4.4** The laying of pipes through accommodation, public or service spaces is not permitted.

**12.4.5** Pipelines passing through cargo holds are to be installed in such a way that no damage can be caused.

**12.4.6** Pipe penetrations through bulkheads and decks are to be insulated against conduction of heat.

**12.4.7** The venting is to be so arranged that air/oil mixtures can be carried away without danger.

## **12.5 Tightness and operational testing**

### **12.5.1 Location and equipment of thermal tanks**

After installation, the entire arrangement is to be subjected to tightness and operational testing under the supervision of BKI.

## **12.6 Location and equipment of thermal oil tanks**

For the location and equipment of thermal oil tanks, see D.3.

## **12.7 Design pressure and test pressure**

For design pressure and test pressure, see D.3.

## **13. Air, sounding and overflow pipes**

### **13.1 Air / overflow pipes**

#### **13.1.1 Tank equipment in general**

All tanks, void spaces, etc. are to be fitted at their highest point with air pipes which shall normally terminate above the open deck.

The height of air and overflow pipes above deck shall be at least 0,45 m, for fuel oil tanks of tankers 0,5 m, (see Rules for Additional Requirements of Notations – Inland Waterways (Part 2 Vol. V) , Section 3, A.3.5.1).

Air and overflow pipes are to be laid vertically. Air and overflow pipes passing through cargo holds are to be protected against damage.

Where tanks are filled by pumping through permanently installed pipelines, the inside cross-section of the air pipes shall equal at least 125 % that of the corresponding filling pipe.

Air pipes of lubricating oil storage tanks may terminate in the engine room. Air pipes of the lubricating oil storage tanks which form part of the vessel's shell are to terminate in the engine room casing above the freeboard deck.

It is necessary to ensure that no leaking oil can spread on to heated surfaces where it may ignite.

The air pipes of lubricating oil tanks, gear and engine crankshaft casings shall not be led to a common line.

Cofferdams and void spaces with bilge connections shall be provided with air pipes terminating above the open deck.

## **13.2 Sounding pipes**

### **13.2.1 General arrangement**

Sounding pipes are to be provided for tanks, void spaces, cofferdams and bilges (bilge wells) in spaces which are not accessible at all times. As far as possible, sounding pipes are to be laid straight and are to extend as near as possible to the bottom of the tank.



Sounding pipes which terminate below the deepest load waterline are to be fitted with self-closing shut-off devices. Such sounding pipes are only permissible in spaces which are accessible at all times. All other sounding pipes are to be extended to the open deck. The sounding pipe openings shall always be accessible and fitted with watertight closures.

Sounding pipes of tanks are to be provided close to the top of the tank with holes for equalizing the pressure.

A striking pad is to be fitted under every sounding pipe. Where sounding pipes are connected to the tanks over a lateral branch pipe, the branch-off under the sounding pipe is to be adequately reinforced.

### **13.2.2 Sounding pipes for fuel and lubricating oil**

Where sounding pipes cannot be extended above the open deck, they shall be provided with self-closing shut-off devices as well as with self-closing test valves.

The openings of sounding pipes shall be located at a sufficient distance from boilers, electrical equipment and hot components.

Sounding pipes shall not terminate in accommodation or service spaces. They are not to be used as filling pipes.

## **13.3 Overflow pipes**

### **13.3.1 Liquid fuel tanks**

Where an overflow pipe is provided for liquid fuel tanks, the discharge is generally to be led to an over-flow tank of appropriate capacity.

Overflows from service tanks are generally to be led back either to the fuel bunkers, or to an overflow tank of appropriate capacity.

Where filling of a tank is performed by a power pump, it is recommended to fit on the overflow pipe an alarm or a sight glass to indicate when the tank is full.

### **13.3.2 Design of overflow systems.**

Where overflows from service tanks intended to contain the same liquid or different ones are connected to a common main, provision is to be made to prevent any risk of intercommunication between the various tanks in the course of movements of liquid when emptying or filling.

### **13.3.3 Construction**

Overflow pipes are normally to be made of the same material as the pipes serving the corresponding compartments

In each compartment which can be pumped up, the total cross-section of overflow pipes is not to be less than required in 13.1.1.

## **14. Hose assemblies and compensators**

### **14.1 Scope**

**14.1.1** The following Rules are applicable for hose assemblies and compensators made of non-metallic and metallic materials.

**14.1.2** Hose assemblies and compensators made of non-metallic and metallic materials may be used according to their suitability in fuel, lubricating oil, hydraulic oil, bilge, ballast, fresh water cooling, river water cooling, compressed air, auxiliary steam, exhaust gas and thermal oil systems as well as in secondary piping systems.

**14.1.3** Compensators made of non-metallic materials are not approved for the use in cargo lines of tankers.

## **14.2 Definitions**

**14.2.1** Hose assemblies consist of metallic or non-metallic hoses completed with end fittings ready for installation.

Compensators consist of bellows with end fittings as well as anchors for absorption of axial loads where angular or lateral flexibility is to be ensured. End fittings may be flanges, welding ends or approved pipe unions.

Burst pressure is the internal static pressure at which a hose assembly or compensator will be destroyed.

### **14.2.2 High-pressure hose assemblies made of non-metallic materials**

Hose assemblies or compensators which are suitable for use in systems with predominantly static load characteristics.

### **14.2.3 Low-pressure hose assemblies and compensators**

Hose assemblies or compensators which are suitable for use in systems with predominantly static load characteristics.

### **14.2.4 Maximum allowable working pressure respectively nominal pressure of hose assemblies and compensators made of non-metallic materials**

The maximum allowable working pressure of high-pressure hose assemblies is the maximum dynamic internal pressure permitted to be imposed on the components.

The maximum allowable working pressure respectively nominal pressure for low-pressure hose assemblies and compensators is the maximum static internal pressure permitted to be imposed on the components.

### **14.2.5 Test pressure**

For non-metallic high -pressure hose assemblies the test pressure is 2 times the maximum allowable working pressure.

For non-metallic low-pressure hose assemblies and compensators the test pressure is 1.5 times the maximum allowable working pressure or 1.5 times the nominal pressure.

For metallic hose assemblies and compensators the test pressure is 1.5 times the maximum allowable working pressure or 1.5 times the nominal pressure.

### **14.2.6 Burst pressure**

For non-metallic as well as metallic hose assemblies and compensators the burst pressure is to be at least 4 times the maximum allowable working pressure or 4 times the nominal pressure. Excepted hereof are non metallic hose assemblies and compensators with a maximum allowable working pressure or nominal pressure of not more than 20 bar. For such components the burst pressure has to be at least three times the maximum allowable working pressure or three times the nominal pressure. For hose assemblies and

compensators in process and cargo piping for gas and chemical tankers the burst pressure is required to be at least 5 times the maximum allowable working pressure.

### **14.3 Requirements**

**14.3.1** Hoses and compensators used in the systems mentioned in 14.1.2 are to be of approved type.

**14.3.2** Manufacturers of hose assemblies and compensators shall be recognized by BKI.

**14.3.3** Hose assemblies and compensators including their couplings are to be suitable for media, pressures and temperatures they are designed for.

**14.3.4** The selection of hose assemblies and compensators is to be based on the maximum allowable working pressure of the system concerned. A pressure of 5 bar is to be considered as the minimum working pressure.

**14.3.5** Hose assemblies and compensators for the use in fuel-, lubricating oil-, hydraulic oil-, bilge- and river water systems are to be flame-resistant

### **14.4 Installations**

**14.4.1** Non-metallic hose assemblies shall only be used at locations where they are required for compensation of relative movements. They shall be kept as short as possible under consideration of the installation instructions of the hose manufacturer.

**14.4.2** The minimum bending radius of installed hose assemblies shall not be less than specified by the manufacturers.

**14.4.3** Non-metallic hose assemblies and compensators are to be located at visible and accessible positions.

**14.4.4** In fresh water systems with a working pressure of  $\leq 5$  bar and in charging and scavenging air lines, hoses may be fastened to the pipe ends with double clips.

**14.4.5** Where hose assemblies and compensators are installed in the vicinity of hot components they shall be provided with approved heat-resistant sleeves.

### **14.5 Tests**

Hose assemblies and compensators are to be subjected in the manufacturer's works to a pressure test in accordance with 2.4 under the supervision of BKI.

### **14.6 Vessel cargo hoses**

**14.6.1** Vessel cargo hoses for cargo-handling on chemical tankers and gas tankers shall be type approved.

Mounting of end fittings is to be carried out only by approved manufacturers.

**14.6.2** Vessel cargo hoses are to be subjected to final inspection at the manufacturer under supervision of a BKI Surveyor as follows:

- visual inspection
- hydrostatic pressure test with 1.5 times the maximum allowable working pressure or 1.5 times the nominal pressure. The nominal pressure shall be at least 10 bar

- measuring of the electrical resistance between the end fittings. The resistance shall not exceed 1 k $\Omega$

#### **14.7 Marking**

Hose assemblies and compensators shall be permanently marked with the following particulars:

- manufacturer's mark or symbol
- date of manufacturing
- type
- nominal diameter
- maximum allowable working pressure respectively nominal pressure
- test certificate number and sign of the responsible BKI inspection

### **D. Pressure Vessels and Heat Exchangers, Boilers and Thermal Oil Heaters**

#### **1. Pressure vessels and heat exchangers**

##### **1.1 General**

##### **1.1.1 Scope**

The following Rules apply to pressure vessels for the operation of the main propulsion plant and its auxiliary machinery. They also apply to pressure vessels and equipment necessary for the operation of the inland waterway vessel and to independent cargo tanks if these are subjected to internal or external pressure in service.

Cargo tanks and containers with design temperatures of  $< 0\text{ }^{\circ}\text{C}$  are subject to the Rules for Additional Requirements of Notations – Inland Waterways (Part 2, Vol.V), Section 3, C.

These Rules do not apply to pressure vessels with permitted working pressures of up to 1,0 bar and with a total capacity, without deducting the volume of internal fittings, of not more than 1000 litres, nor to pressure vessels with working pressures of  $> 1$  bar where the product of pressure [bar] multiplied capacity [litres] is  $\leq 200$ .

Pressure vessels manufactured according to recognized standards can be accepted if they have been demonstrated in the manufacturer's works to tests conforming to the standard.

##### **1.1.2 Division into classes**

Pressure vessels are to be assigned to classes in accordance with the operating conditions indicated in Table 1.16.

Pressure vessels filled partly with liquids and partly with air or gases or which are blown out with air or gases, such as pressure tanks in drinking water or sanitary systems and reservoirs, are to be classified as pressure vessels containing air or gas.

##### **1.1.3 Documents for review/approval**

Drawings of pressure vessels, heat exchangers and pressurized equipment containing all the data necessary for their safety assessment are to be submitted to BKI in triplicate. In specific cases and following prior

agreement with BKI, they can also be submitted in paper form in triplicate. The following details, in particular, are to be specified:

- intended use, substances to be contained in the vessel
- maximum allowable working pressure and temperatures; if necessary, secondary loads and the volume of the individual pressure spaces
- design details of the pressurized parts
- substance to be contained in the pressure vessel, working pressures and temperatures
- materials to be used, welding details, heat treatment

**Table 1.16 Pressure vessel classes**

Operating medium	Design pressure $p_c$ [bar] Design temperature $t$ [°C]		
Liquefied gases (propane, butane, etc.), toxic and corrosive media	all	NA	NA
Steam, compressed air, gases, thermal oil	$p_c > 16$ or $t > 300$	$p_c \leq 16$ and $t \leq 300$	$p_c \leq 7$ and $t \leq 170$
Liquid fuels, lubricating oils, flammable hydraulic fluids	$p_c > 16$ or $t > 150$	$p_c \leq 16$ and $t \leq 150$	$p_c \leq 7$ and $t \leq 60$
Water, non flammable hydraulic fluids	$p_c > 40$ or $t > 300$	$p_c \leq 40$ and $t \leq 300$	$p_c \leq 16$ and $t \leq 200$
Pressure vessel class	I	II	III
NA = not applicable			

## 1.2 Materials

### 1.2.1 General requirements

The materials of pressure-containing parts shall be suitable for the intended use and shall comply with the Rules for Materials (Part 1, Vol V).

Parts such as gussets, girders, lugs, brackets etc. welded directly to pressure vessel walls are to be made of a material compatible with the basic material and of guaranteed weldability.

Welded structures are also subject to the Rules for Welding (Part 1, Vol VI).

### 1.2.2 Testing of materials

Tests in accordance with the BKI Rules for Materials (Part 1, Vol V) are prescribed for materials belonging to pressure vessel classes I and II used for:

- a) All surfaces under pressure with the exception of small parts such as welded pads, reinforcing discs, branch pieces and flanges of nominal diameter  $\leq DN 32$  mm, together with forged or rolled steel valve heads for compressed air receivers
- b) Forged flanges for service temperatures  $> 300$  °C and for service temperatures  $\leq 300$  °C if the product of the maximum allowable working pressure,  $P_B$  [bar] by the nominal diameter,  $DN$  [mm] is  $< 2500$  or the nominal diameter  $DN$  is  $> 250$

- c) Bolts and nuts of size M 30 (30 mm diameter metric thread) and above made of steels with a tensile strength of more than 500 N/mm<sup>2</sup>, or more than 600 N/mm<sup>2</sup> in the case of nuts, and alloy or heat-treated steel bolts above M 16.

**1.2.3** For class II parts subject to mandatory testing, proof of material quality may take the form of Manufacturer Inspection Certificates<sup>5</sup> provided that the test results certified therein comply with the BKI Rules for Materials (Part 1, Vol V).

Manufacturer inspection certificates may also be recognized for series-manufactured class I parts made of unalloyed steels, e.g. hand- and manhole covers, and for branch pipes where the product of  $PB \times DN \leq 2500$  and the nominal bore  $DN \leq 250$  mm for service temperatures of  $< 300$  °C.

**1.2.4** For all parts not subject to testing of materials by BKI, alternative proof of the characteristics of the material is to be provided, e.g. a works certificate or manufacturer's guarantee as to the properties of the materials used.

### **1.3 Manufacturing principles**

#### **1.3.1 Manufacturing processes applied to materials**

Manufacturing processes shall be compatible with the materials concerned. Materials whose grain structure has been adversely affected by hot or cold working are to undergo heat treatment in accordance with the Rules for Materials (Part 1, Vol V) Section 6, A.

#### **1.3.2 Welding**

The execution of welding work, the approval of welding shops and the qualification testing of welders are to be in accordance with the Rules for Welding (Part 1, Vol VI) Section 14.

#### **1.3.3 Reinforcement of openings**

Due account is to be taken of the weakening of walls caused by openings and, where necessary, reinforcement is to be provided.

#### **1.3.4 End plates**

The flanges of dished ends may not be unduly hindered in their movement by any kind of fixtures, e.g. fastening plates or stiffeners. Supporting legs may only be attached to dished ends which have been adequately dimensioned for this purpose.

Where covers or ends are secured by hinged bolts, the latter are to be safeguarded against slipping off.

#### **1.3.5 Branch pipes**

The wall thickness of branch pipes shall be so dimensioned as to enable additional external stresses to be safely absorbed. The wall thickness of welded-in branch pipes should be appropriate to the wall thickness of the part into which they are welded. The walls shall be effectively welded together.

Pipe connections in accordance with C. are to be provided for the attachment of piping.

#### **1.3.6 Tube plates**

Tube holes shall be carefully drilled and deburred. Bearing in mind the tube-expansion procedure and the

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<sup>5</sup> See Part 1 Seagoing Ships, Rules for Materials, Volume V, Principles Covering the Manufacture and Testing of Materials, Section 1

combination of materials involved, the ligament width shall be such as to ensure the proper execution of the expansion process and the sufficient anchorage of the tubes. The expanded length should not be less than 12 mm.

### **1.3.7 Compensation for expansion**

The design of pressure vessels and equipment is to take account of possible thermal expansion, e.g. between the shell and nest of heating tubes.

### **1.3.8 Corrosion protection**

Pressure vessels and equipment exposed to accelerated corrosion owing to the medium which they contain shall be protected in a suitable manner.

### **1.3.9 Cleaning and inspection**

Pressure vessels and equipment are to be provided with inspection and access openings which should be as large as possible and conveniently located. For the minimum dimensions of these, see 2.3.

Pressure vessels over 2,0 m long shall have inspection openings at each end at least. Where the pressure vessel can be entered, one access opening is sufficient.

Pressure vessels with an inside diameter of more than 800 mm shall be capable of being entered.

In order to provide access with auxiliary or protective gear, a manhole diameter of at least 600 mm is generally required. The diameter may be reduced to 500 mm where the pipe socket height to be traversed does not exceed 250 mm.

Inspection openings may be dispensed with where experience has proved the unlikelihood of corrosion or deposits, e.g. in steam jackets.

Where pressure vessels and equipment contain dangerous substances (e.g. liquefied or toxic gases), the covers of inspection and access openings shall not be secured by crossbars but by bolted flanges.

Special inspection and access openings are not necessary where internal inspection can be carried out by removing or dismantling parts.

### **1.3.10 Mountings**

Wherever necessary, strengthening elements are to be fitted at mountings and supports to prevent excessive stress increases in the pressure vessel shell due to vibration.

### **1.3.11 Identification and marking**

Each pressure vessel is to be provided with a plate or permanent inscription indicating the manufacturer, the serial number, the year of manufacture, the capacity, the maximum allowable working pressure of the pressurized parts and the identification of the inspection body. In case the service temperature of pressure vessel more than 50°C or less than -10°C the maximum allowable temperature of the pressurized parts is to be provided. On smaller items of equipment, an indication of the working pressures is sufficient.

## **1.4 Design**

Design calculations are to be performed according to existing BKI Rules or to international codes such as ISO, ASME or other standards accepted by BKI, taking into consideration the special requirements for pressure vessels installed on inland waterway vessels.

Applicable statutory requirements of the Flag State Authority are to be observed additionally.

## **1.5 Equipment and installation**

### **1.5.1 Shut-off devices**

Shut-off devices shall be fitted in pressure lines as close as possible to the pressure vessel. Where several pressure vessels are grouped together, it is not necessary that each pressure vessel should be capable of being shut-off individually and means need only be provided for shutting off the group. In general, not more than three pressure vessels should be grouped together. Starting air receivers and other pressure vessels which are opened in service shall be capable of being shut off individually. Devices incorporated in piping, e.g. water and oil separators, do not require shut-off devices.

### **1.5.2 Pressure gauges**

Each pressure vessel which can be shut-off and every group of pressure vessels with a shutoff device shall be equipped with a pressure gauge, also capable of being shut-off, suitable for the medium contained in the pressure vessels. The measuring range and calibration shall extend to the test pressure with a red mark to indicate the maximum working pressure.

Equipment need only be fitted with pressure gauges when these are necessary for its operation.

### **1.5.3 Safety equipment**

**1.5.3.1** Each pressure vessel which can be shut-off or every group of pressure vessels with a shut-off device shall be equipped with a spring-loaded safety valve which cannot be shut-off and which closes again reliably after blow-off.

Appliances for controlling pressure and temperature are no substitute for relief valves.

**1.5.3.2** Safety valves shall be designed and set in such a way that the max. allowable working pressure cannot be exceeded by more than 10 %. Means shall be provided to prevent the unauthorized alteration of the safety valve setting. Valves cones shall be capable of being lifted at all times.

**1.5.3.3** Means of drainage which cannot be shut-off are to be provided at the lowest point on the discharge side of safety valves for gases, steam and vapours. Facilities shall be provided for the safe disposal of hazardous gases, vapours or liquids discharging from safety valves. Heavy oil flowing out shall be drained off via an open funnel.

**1.5.3.4** Steam-filled spaces are to be fitted with a safety valve if the steam pressure inside them is liable to exceed the maximum allowable working pressure. If vacuum will occur, e.g. by condensating, an appropriate safety device is necessary.

**1.5.3.5** Heated spaces which can be shut off on both the inlet and the outlet side are to be fitted with a safety valve which will prevent an inadmissible pressure increase should the contents of the space undergo dangerous thermal expansion or the heating elements fail.

**1.5.3.6** Pressure water tanks are to be fitted with a safety valve on the water side. A safety valve on the air side may be dispensed with if the air pressure supplied to the tank cannot exceed its maximum allowable working pressure.

**1.5.3.7** Calorifiers are to be fitted with a safety valve at the cold water inlet.

**1.5.3.8** Rupture disks are permitted only with the consent of BKI in application where their use is specially justified. They must be designed that the maximum allowable working pressure PB cannot be exceeded by more than 10 %.



Rupture disks are to be provided with a guard to catch the fragments of the rupture element and shall be protected against damage from outside. The fragments of the rupture element shall not be capable of reducing the necessary section of the discharge aperture.

**1.5.3.9** Pressure relief devices can be dispensed with in the case of accumulators in pneumatic and hydraulic control and regulating systems provided that the pressure which can be supplied to these accumulators cannot exceed the maximum allowable working pressure and that the pressure-volume product is  $PB \text{ [bar]} \times \text{capacity [litres]} \leq 200$ .

Electrically heated equipment has to be equipped with a temperature limiter besides of a temperature controller.

**1.5.3.10** Oil-fired warm water generators are to be equipped with limiters for temperature and pressure above a specified threshold. Additionally, a low water level limiter, a limiter for minimum pressure or a low flow limiter is to be provided. The actuation of the limiters shall shut-down and interlock the oil burner.

Warm water generators heated by exhaust gases are to be equipped with the corresponding alarms.

**1.5.3.11** The equipment on pressure vessels has to be suitable for the use on inland navigation vessels. The limiters for e.g. pressure, temperature and flow are safety devices and have to be type-approved and have to be provided with appropriate type approval certificates. For type approval of safety valves, the test requirements outlined in BKI Guidelines for Test Requirement for Mechanical Components and ISO/ EN 4196 shall be observed.

#### **1.5.4 Liquid level indicators and feed equipment for heated pressure vessels**

**1.5.4.1** Heated pressure vessels in which a fall of the liquid level can result in unacceptably high temperatures in the vessel walls are to be fitted with a device for indicating the level of the liquid.

**1.5.4.2** Pressure vessels with a fixed minimum liquid level are to be fitted with feed equipment of adequate size.

**1.5.4.3** Warm water generating plants are to be designed as closed systems with external pressure generation and membrane expansion vessel. Water shall be circulated by forced circulation.

#### **1.5.5 Sight glasses**

Sight glasses in surfaces subject to pressure are allowed only if they are necessary for the operation of the plant and other means of observation cannot be provided. They shall not be larger than necessary and shall preferably be round. Sight glasses are to be protected against mechanical damage, e.g. by wire mesh. With combustible, explosive or poisonous media, sight glasses shall be fitted with closable covers.

#### **1.5.6 Draining and venting**

Pressure vessels and equipment shall be capable of being depressurized and completely emptied or drained. Particular attention is to be given to the adequate drainage facilities of compressed air pressure vessels.

Suitable connections and a vent at the uppermost point shall be provided for the execution of hydraulic pressure tests.

#### **1.5.7 Installation**

Pressure vessels and equipment are to be installed in such a way as to provide for maximum allround visual inspection and to facilitate the execution of periodic tests. Where necessary, ladders or steps are to be fitted inside pressure vessels.

Wherever possible, horizontal compressed air receivers should be installed at an angle and parallel to the fore-and aft line of the inland waterway vessel. The angle should be at least 10° (with the valve head at the top.) Where pressure vessels are installed athwartships, the angle should be greater.

Where necessary, compressed air receivers are to be so marked on the outside that they can be installed on board inland waterway vessels in the position necessary for complete venting and drainage.

### 1.5.8 Cargo tanks for liquefied gases

For the equipment and installation of cargo tanks for liquefied gases, see the Rules for Additional Class Notation-Inland Waterways (Part 1, Vol.V), Section 3 C.

## 1.6 Tests

### 1.6.1 Constructional test and pressure tests

On completion, pressure vessels and equipment are to undergo constructional and hydrostatic tests. No permanent deformation of the walls may result from these tests.

During the hydrostatic test, the loads specified in Table 1.17 may not be exceeded.

**Table 1.17 Loads during hydrostatic tests**

For materials with a definite yield point		For materials without a definite yield point
$R_{eH}, 20 / 1,1$		$R_m, 20 / 2,0$
$R_{eH}, 20$	=	guaranteed yield strength or minimum value of the 0,2 % proof stress at room temperature
$R_m, 20$	=	guaranteed minimum tensile strength [N/mm <sup>2</sup> ] at room temperature

For Group I pressure vessels and equipment, the test pressure is generally 1.5 times the permitted working pressure subject to a minimum of  $p + 1$  bar.

For pressure vessels and equipment of Groups II and III, the test pressure is 1.3 times the permitted working pressure subject to a minimum of  $p + 1$  bar. For working pressures below atmospheric pressure, the test pressure is 2 bar excess pressure.

Air coolers (e.g. charge air coolers) are to be tested on the water side at 1.5 times the permitted working pressure subject to a minimum of 4 bar.

In special cases the use of media other than water for the pressure tests may be agreed.

### 1.6.2 Tightness tests

Where pressure vessels and equipment contain hazardous substances (e.g. liquefied gases), BKI reserves the right to call for a special test of gastightness.

### 1.6.3 Certification of tests

The constructional test and the pressure test are to be performed in the manufacturer's works in the presence of a Surveyor. For pressure vessels and equipment of Group II and III the manufacturer's test certificates are acceptable if the permitted working pressure  $PB < 1$  bar or if the product of the pressure [bar] x capacity [litres]  $PB \times l \leq 200$ .

#### 1.6.4 Testing after installation on board

After installation on board the fittings of pressure vessels and equipment and the arrangement and settings of the safety devices are to be checked and, wherever necessary, subjected to a functional test.

## 2. Steam boilers

### 2.1 General

#### 2.1.1 Scope

For the purpose of these Rules the term "steam boiler" includes all closed pressure vessels and piping systems used for:

- a) generating steam with a pressure above atmospheric pressure (steam generators) - the generated steam is to be used in a system outside of the steam generators or
- b) raising the temperature of water above the boiling point corresponding to atmospheric pressure (hot water generators) - the generated hot water is to be used in a system outside of the hot water generators.

The term "steam boiler" also includes any equipment directly connected to the aforementioned pressure vessels or piping systems in which the steam is, for example, superheated or cooled, as well as external drums, and the circulating lines and the casings of circulating pumps serving forced-circulation boilers.

For warm water generators having a maximum allowable discharge temperature of not more than 120 °C and steam or for hot water generators which are heated solely by steam or hot liquids 1. applies.

#### 2.1.2 Other Rules

As regards their construction and installation, steam boiler plants are also required to comply with the applicable statutory requirements and regulations of the inland waterway vessel's country of registration.

#### 2.1.3 Definitions

Steam boiler walls are the walls of the steam and water spaces located between the boiler isolating devices. The bodies of these isolating devices form part of the boiler walls.

The maximum allowable working pressure PB (design pressure) is the approved steam pressure in bar (gauge pressure) in the saturated steam space prior to entry into the superheater. In once-through forced flow boilers, the maximum allowable working pressure is the pressure at the superheater outlet or, in the case of continuous flow boilers without a superheater, the steam pressure at the steam generator outlet.

The heating surface is that part of the boiler walls through which heat is supplied to the system, i.e.:

- a) the area [m<sup>2</sup>] measured on the side exposed to fire or exhaust gas, or
- b) in the case of electrical heating, the equivalent heating surface [m<sup>2</sup>]:

$$H = \frac{860 \cdot P}{18000} \text{ [m}^2\text{]}$$

P = electrical power [kW]

The allowable steam output is the maximum hourly steam quantity which can be produced continuously by the steam generator operating under the design steam conditions.

The "dropping time" is the time taken by the water level under conditions of interrupted feed and allowable steam production, to drop from the lowest water level (LWL) to the level of the highest flue (HF).

$$T = \frac{V}{D \cdot v'} \text{ [min]}$$

T = dropping time [min]

V = volume [m<sup>3</sup>] of water between the lowest water level and the highest flue

D = allowable steam output [kg/min]

v' = specific volume of water at saturation temperature [m<sup>3</sup>/kg]

The lowest water level is to be set so that the dropping time is not less than 5 minutes.

#### 2.1.4 Manual operation

For steam boilers which are operated automatically means for operation and supervision are to be provided which allow manual operation with the following minimum requirements by using an additional control level.

At boilers with a defined highest flue at their heating surface (e.g. oil-fired steam boilers and exhaust gas boilers with temperature of the exhaust gas > 400 °C) at least the water level limiters, and at hot water generators the temperature limiters, have to remain active.

The monitoring of the oil content of the condensate or of the ingress of foreign matters into the feeding water may not lead to a shut-down of the feeding pumps during manual operation.

The safety equipment not required for manual operation may only be deactivated by means of a key-operated switch. The actuation of the key-operated switch is to be indicated.

For detailed requirements in respect of manual operation of the oil firing system, see 4.

Manual operation demands constant and direct supervision of the steam boiler plant.

#### 2.1.5 Documents for review/approval

The following documents are to be submitted for approval. To facilitate a smooth and efficient approval process, the drawings could be submitted in electronic format. In specific cases and following prior agreement with BKI, they can also be submitted in paper form in triplicate.

- drawings of all steam boiler parts subject to pressure, such as shells, drums, headers, tube arrangements, manholes and inspection covers etc.,
- drawings of the expansion vessel and other pressure vessels for hot water generating plants
- equipment and functional diagrams with description of the steam boiler plant
- circuit diagrams of the electrical control system and, as applicable, monitoring and safety devices with limiting values.

These drawings shall contain all the data necessary for strength calculations and design assessment, such as maximum allowable working pressure, heating surfaces, lowest water level, allowable steam production, steam conditions, superheated steam temperatures, as well as materials to be used and full details of welds.

Further the documents shall contain information concerning the equipment of the steam boiler as well as a description of the boiler plant with the essential boiler data, information about the installation location in

relation to the longitudinal axis of the ship and data about feeding and oil firing equipment.

## **2.2 Materials**

### **2.2.1 General requirements**

With respect to their workability during manufacture and their characteristics in subsequent operation, materials used for the manufacture of steam boilers shall satisfy the technical requirements, particularly those relating to high-temperature strength and, where appropriate, weldability.

### **2.2.2 Approved materials**

The requirements specified in 2.2.1 are recognized as having been complied with if the materials shown in Table 1.19 are used.

Materials not specified in the BKI Rules for Materials may be used provided that proof is supplied of their suitability and mechanical properties.

### **2.2.3 Material testing**

The materials of boiler parts subject to pressure shall be tested under supervision of BKI in accordance with the BKI Rules for Materials (see Table 1.19). For these materials, an A-Type Certificate is to be issued.

Material testing under supervision of BKI may be waived in the case of:

- a) small boiler parts made of unalloyed steels, such as stay bolts, stays of  $\leq 100$  mm diameter, reinforcing plates, handhole, headhole and manhole closures, forged flanges up to DN 150 and nozzles up to DN150 and
- b) smoke tubes (tubes subject to external pressure).

For the parts mentioned in a) and b), the properties of the materials are to be attested by Manufacturer Inspection Certificates.

If the design temperature is 450 °C or higher or the design pressure is 32 bar or higher, pipes shall be non-destructively tested in accordance with the BKI Rules for Materials.

Special agreements may be made regarding the testing of unalloyed steels to recognized standards.

The materials of valves and fittings shall be tested under supervision of BKI in accordance with the data specified in Table 1.18. For these materials, an A- Type Certificate<sup>6</sup> needs to be issued.

Parts not subject to material testing, such as external supports, lifting brackets, pedestals, etc. shall be designed for the intended purpose and shall be made of suitable materials.

## **2.3 Principles applicable to manufacture**

### **2.3.1 Manufacturing processes applied to boiler materials**

Materials are to be checked for defects during the manufacturing process. Care is to be taken to ensure that different materials cannot be confused. During the course of manufacture care is likewise required to ensure that marks and inspection stamps on the materials remain intact or are transferred in accordance with regulations.

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<sup>6</sup>See BKI Rules for Materials, Volume V Section I

Steam boiler parts whose microstructure has been adversely affected by hot or cold forming are to be subjected to heat treatment and testing in accordance with the BKI Rules for Materials.

**Table 1.18 Testing of materials for valves and fittings**

Type of material <sup>1)</sup>	Service temperature	Testing required for
Steel, cast steel	> 300	DN > 32
Steel, cast steel Nodular cast iron	≤300	P <sub>zul</sub> x DN > 2500 <sup>2)</sup> or DN > 250
Copper alloys	≤225	P <sub>zul</sub> x DN > 1500 <sup>2)</sup>
P <sub>zul</sub> = working pressure [bar] DN = nominal diameter [mm]  <sup>1)</sup> No tests are required for grey cast iron <sup>2)</sup> Testing may be dispensed with, if the nominal DN is ≤ 32		

**Table 1.19 Approved materials**

Material and product form	Limits of application	Material grade in accordance with the BKI Rules for materials
Steel plates and strips	NA	Steel plates for steam boilers and pressure vessels
Steel tubes	NA	Steel pipes for high temperatures service
Steel forgings and formed	NA	Steel forgings for steam boilers and pressure
Steel castings	NA	Steel castings for steam boilers and pressure
Nodular cast iron	≤300 °C ≤ 40 bar ≤DN 175 for valves and fittings	Nodular graphite iron castings
Lamellar (grey) cast iron: boiler parts only for unheated surfaces and not for thermal oil heaters  valves and fittings	≤200 °C ≤10 bar Φ≤ 200  ≤ 200 °C ≤ 10 bar ≤DN 175	Grey iron castings
Bolts and nuts	NA	Bolts and nuts for elevated temperature
Valves and fittings of copper alloy castings	≤225 °C ≤ 25 bar	Copper alloy castings
Φ = diameter [mm] NA = not applicable		

### 2.3.2 Welding

Steam boilers are to be manufactured by welding.

The execution of welds, the approval of welding shops and the qualification testing of welders are to be in accordance with the BKI Rules.

### 2.3.3 Tube expansion

Tube holes shall be carefully drilled and deburred. Sharp edges are to be chamfered. Tube holes should be as close as possible to the radial direction, particularly in the case of small wall thicknesses.

Tube ends to be expanded are to be cleaned and checked for size and possible defects. Where necessary, tube ends are to be annealed before being expanded.

Smoke tubes with welded connections between tube and tube plate at the entry of the second path shall be roller-expanded before and after welding.

### 2.3.4 Stays, stay tubes and stay bolts

Stays, stay tubes and stay bolts are to be so arranged that they are not subjected to undue bending or shear forces.

Stress concentrations at changes in cross-section, in threads and at welds are to be minimized by suitable component geometry.

Stay bars and stay bolts are to be welded preferably by full penetration. Any vibrational stresses are to be considered for longitudinal stays.

Stay bars and stay bolts are to be drilled at both ends in such a way that the holes extend at least 25 mm into the water or steam space. Where the ends have been upset, the continuous shank shall be drilled to a distance of at least 25 mm.

The angle made by gusset stays and the longitudinal axis of the boiler shall not exceed 30°. Stress concentrations at the welds of gusset stays are to be minimized by suitable component geometry. Welds are to be executed as full penetration welds. In fire tube boilers, gusset stays are to be located at least 200 mm from the fire tube.

Where flat surfaces exposed to flames are stiffened by stay bolts, the distance between centres of the said bolts shall not generally exceed 200 mm.

### 2.3.5 Stiffeners, straps and lifting eyes

Where flat end surfaces are stiffened by profile sections or ribs, the latter shall transmit their load directly (i.e. without welded-on straps) to the boiler shell.

Doubling plates may not be fitted at pressure parts subject to flame radiation.

Where necessary to protect the walls of the boiler, strengthening plates are to be fitted below supports and lifting brackets.

### 2.3.6 Welding of flat unrimmed ends to boiler shells

Flat unrimmed ends (disc ends) on shell boilers are only permitted as socket-welded ends with a shell projection of  $\geq 15$  mm. The end/shell wall thickness ratio  $s_B/s_M$  shall not be greater than 1,8. The end is to be welded to the shell with a full penetration weld.

### 2.3.7 Nozzles and flanges

Nozzles and flanges are to be of rugged design and properly welded, preferably by full penetration to the shell. The wall thickness of nozzles shall be sufficiently large to safely withstand additional external loads. The wall thickness of welded-in nozzles shall be appropriate to the wall thickness of the part into which

they are welded.

Welding-neck flanges shall be made of forged material with favourable grain orientation.

### 2.3.8 Cleaning and inspection, openings, cutouts and covers

Steam boilers are to be provided with openings through which the space inside can be cleaned and inspected. Especially critical and high-stressed welds, parts subjected to flame radiation and areas of varying water level shall be sufficiently accessible to inspection. Boiler shells with an inside diameter of more than 1200 mm, and those measuring over 800 mm in diameter and 2000 mm in length, are to be provided with means of access. Parts inside drums shall not obstruct internal inspection or shall be capable of being removed.

Inspection and access openings are required to have the following minimum dimensions (see Table 1.20):

**Table 1.20 Opening dimensions**

<b>Manholes</b>	300 x 400 mm or 400 mm diameter where the annular height is > 150 mm, the opening is to measure 320 x 420 mm.
<b>Holes for the head</b>	220 x 320 mm or 320 mm diameter
<b>Handholes</b>	87 x 103 mm
<b>Sight holes</b>	are required to have a diameter of at least 50 mm; they should, however, be provided only when the design of the equipment makes a handhole impracticable.

The edges of manholes and other openings, e.g. for domes, are to be effectively reinforced if the plate has been unacceptably weakened by the cutouts. The edges of openings closed with covers are to be reinforced by welded on edge-stiffeners.

Cover plates, manhole frames and crossbars shall be made of ductile material (not grey or malleable cast iron). Grey cast iron (at least GG-20) may be used for handhole cover crossbars of headers and sectional headers, provided that the crossbars are not located in the heating gas flow.

Unless metal packings are used, cover plates shall be provided on the external side with a rim or spigot to prevent the packing from being forced out. The gap between this rim or spigot and the edge of the opening is to be uniform round the periphery and may not exceed 2 mm for boilers with a working pressure of less than 32 bar, or 1 mm where the pressure is 32 bar or over. The height of the rim or spigot shall be at least 5 mm greater than the thickness of the packing.

Only continuous rings may be used as packing. The materials used shall be suitable for the given operating conditions.

## 2.4 Design

Design calculations are to be performed according to existing BKI Rules or to international codes accepted by BKI such as AD-Merkblätter, ASME, CODAP, British standards or harmonized European standards, taking into consideration the special requirements for steam boilers installed on inland waterway vessels.



Applicable statutory requirements of the Flag State Authority are to be observed additionally.

## **2.5 Equipment and installation**

### **2.5.1 Feed and circulating equipment**

Each boiler shall generally be provided with two feed-water pumps, each of which shall be capable of supplying a quantity of water equivalent to 1.25 times the boiler output.

One feedwater pump is sufficient for boilers which are not needed to keep the machinery in operation, provided that the following conditions are met:

- a) The steam pressure and the water level shall be automatically controlled.
- b) After the firing has been shut-down, the heat stored in the boiler may not cause any inadmissible lowering of the water level.
- c) In the event of a failure of the power supply to the feedwater pump drive, the firing system shall shutdown automatically.
- d) The boiler shall be fitted with a water-level limiting device independent of the water-level control.

In the case of continuous-flow boilers a pump delivery rate equal to 1.0 times the boiler output is sufficient.

The feedwater system shall be capable both of supplying the required quantity of feedwater against the maximum allowable working pressure and of delivering the quantity of feedwater corresponding to the steaming capacity against 1.1 times the maximum allowable working pressure.

For electrically driven feedwater pumps, each motor is to be supplied via a separate line from the busbar. Each feedwater pump shall be independently capable of being isolated from the suction and delivery lines.

Each boiler feed line shall be equipped with a shut-off device and a non-return valve. If the shut-off device and the non-return valve are not mounted in immediate conjunction, the intervening length of pipe shall be fitted with a pressure relief device.

Continuous-flow boilers require no shut-off device or non-return valve provided that the feed system serves only one boiler.

The feed devices are to be fitted to the steam generator in such a way that it cannot be drained lower than 50 mm above the highest flue when the non-return valve is not tight.

The feedwater is to be fed into the steam generator in such a way as to prevent damaging effects to the boiler walls and to heated surfaces.

Each forced-circulation boiler shall generally be equipped with two independently driven circulating pumps. Failure of the circulating unit in service shall trip an alarm.

One circulating pump is sufficient for continuous-flow boilers.

Should the power supply to the circulating pump drive fail, the firing shall shut-down automatically.

### **2.5.2 Shut-off devices**

Each steam boiler shall be capable of being shut off from all connected pipes. The shut-off devices are to be installed as close as possible to the boiler shell and are to be operated without risk.

### **2.5.3 Scum removal, sludge removal, drain, venting and sampling devices**

Steam boilers and external steam drums are to be fitted with devices to allow them to be drained and vented and the sludge to be removed. Where necessary, steam generators are to be fitted with a scum removal device.

Drain devices and their connections are to be protected from the effects of the heating gases and shall be capable of being operated without risk. Self-closing sludge removal valves shall be lockable when closed or, alternatively, an additional shut-off device is to be fitted in the pipe.

With the exception of once-through forced-flow steam generators, devices for taking samples from the water contained in the steam generator are to be fitted to the generator.

Scum removal, sludge removal, drain, venting and sampling devices are to be capable of safe operation. The media being discharged are to be drained away safely.

### **2.5.4 Safety valves**

Each steam boiler which has its own steam space is to be equipped with at least two type-approved, spring-loaded safety valves. At least one safety valve is to be set to respond if the maximum allowable working pressure is exceeded.

In combination, the safety valves are to be capable of discharging the maximum quantity of steam which can be produced by the steam generator during continuous operation without the maximum allowable working pressure being exceeded by more than 10 %.

The closing pressure of the safety valves shall be not more than 10 % below the response pressure.

The minimum flow diameter of the safety valves shall be at least 15 mm.

The safety valves are to be fitted to the saturated steam part or, in the case of steam boilers which do not have their own steam space, to the highest point of the boiler or in the immediate vicinity.

The steam may not be supplied to the safety valves through pipes in which water may collect.

A drain which cannot be shut off is to be fitted at the lowest point at the discharge side of the safety valve.

### **2.5.5 Water level indicators**

Each steam with a free surface is to be equipped with at least two indicators giving a direct reading of the water level

Cylindrical glass water level gauges are not permitted.

The water level indicators are to be fitted so that a reading of the water level is possible when the ship is heeling and during the motion of the inland waterway vessel when it is at sea. The limit for the lower visible range shall be at least 30 mm above the highest flue, but at least 30 mm below the lowest water level. The lowest water level shall not be above the centre of the visible range.

Water level indicators shall be separately and individually connected to the boiler. The connecting lines shall be free from sharp bends so as to avoid water and steam pockets, and shall be safeguarded against the effects of the heated gases and against cooling.

The connection pipes shall have an inner diameter of at least 20 mm. Where water level indicators are linked by means of common connection pipes or where the connection pipes on the water side are longer than 750 mm, the inside diameter of these pipes shall be at least 40 mm.

Water level indicators are to be connected to the water and steam space of the steam boiler by means of quick-acting shut-off devices that are easily accessible and simple to control.

The devices used for blowing through the water level indicators are to be designed so that they are safe to operate and so that blow-through can be monitored. The discharged media are to be drained away safely.

In place of water level indicators, once-through forced flow boilers are to be fitted with two mutually independent devices which trip an alarm as soon as water flow shortage is detected. An automatic device to shut down the oil burner may be provided in place of the second warning device.

#### **2.5.5.1 Lowest water level**

The lowest water level (LWL) has to be located at least 150 mm above the highest flue, even when the ship heels 4° to either side.

The highest flue (HF) shall remain wetted even when the ship is at the static heeling angles laid down in Table 1.1.

The height of the water level is crucial to the response of the water level limiters.

The lowest specified water level is to be indicated permanently on the boiler shell by means of a water level pointer. The location of the pointer is to be included in the documentation for the operator. Reference plates are to be attached additionally beside or behind the water level gauges pointing at the lowest water level.

The highest flue (HF)

- is the highest point on the side of the heating surface which is in contact with the water and which is exposed to flame radiation, and
- is to be defined by the boiler manufacturer in such a way that, after shut-down of the burner from full-load condition or reduction of the heat supply from the engine, the flue gas temperature or exhaust gas temperature, as applicable, is reduced to a value below 400 °C at the level of the highest flue, before, under the condition of interrupted feedwater supply, the water level has dropped from the lowest water level to a level 50 mm above HF

The highest flue on water tube boilers with an upper steam drum is the top edge of the highest gravity tubes. The requirements relating to the highest flue do not apply to:

- water tube boiler risers up to 102 mm outer diameter
- flues in which the temperature of the heating gases does not exceed 400 °C at maximum continuous power
- once-through forced flow boilers
- superheats

The heat accumulated in furnaces and other heated boiler parts may not lead to any inadmissible lowering of the water level due to subsequent evaporation when the oil burner is switched off.

This requirement with regard to an inadmissible lowering of the water level is met for example, if it has been demonstrated by calculation or trial that, after shut-down of the burner from full-load condition or reduction of the heat supply from the engine, the flue gas temperature or exhaust gas temperature, as applicable, is reduced to a value below 400 °C at the level of the highest flue, before, under the condition of interrupted feed water supply, the water level has dropped from the lowest water level LWL to a level 50 mm above the highest flue HF.

The water level indicators have to be arranged in such a way that the distance 50 mm above HF can be identified.

#### **2.5.6 Pressure indicators**

Each steam boiler is to be fitted with at least one pressure gauge directly connected to the steam space. The maximum allowable working pressure is to be marked on the dial by means of a permanently and easily visible red mark. The indicating range of the pressure gauge shall include the test pressure.

At least one additional pressure indicator having a sensor independent from the pressure gauge has to be located at the machinery control station or at some other appropriate site.

The pipe to the pressure gauge shall have a water trap and shall be provided with a blow-through connection. A connection for a test gauge is to be installed close to the pressure gauge.

In the case of pressure gauges which are at a lower position, the test connection shall be provided close to the pressure gauge and close to the connection piece of the pressure gauge pipes.

Pressure gauges are to be protected against radiant heat and shall be well illuminated.

#### **2.5.7 Name plate**

A name plate is to be permanently affixed to each steam boiler, displaying the following information:

- manufacturer's name and address
- serial number and year of construction
- maximum allowable working pressure [bar]
- allowable steam production [kg/h] or [t/h ]

The name plate is to be attached to the largest part of the boiler or to the boiler frame so that it is visible.

#### **2.5.8 Special requirements for low capacity boilers**

In the case of boilers with a water volume of not more than 150 litres and a permitted working pressure of up to 10 bar and where the volume of water in liters multiplied by the max. allowable working pressure in bar does not exceed 500 bar x L, the second feed pump and the second water level indicator, or for continuous-flow boilers the second warning device, may be dispensed with.

#### **2.5.9 Special requirements for automatically controlled steam boilers not under permanent supervision**

With the exception of steam boilers which are heated by exhaust gas, steam boilers are to be operated with rapid-control, automatic oil burners.

After the oil burner has been shut down, the heat stored in the firebox and the heating gas paths may not cause any inadmissible evaporation of the water contained in the steam generator.

The control system shall be capable of adapting the boiler to changes in the operating load without actuating the safety devices.

The steam pressure shall be automatically regulated by controlling the supply of heat. The steam pressure of boilers heated by exhaust gas may also be regulated by condensing the excess steam.

In the case of steam generators which have a specified minimum water level, the water level is to be regulated automatically by controlling the supply of feedwater.

In the case of forced-circulation steam generators whose heating surface consists of a steam coil and of once-through forced flow steam generators, the supply of feedwater may be regulated as a function of fuel supply.

Fired steam generators are to be equipped with a pressure limiter which cuts out and interlocks the oil burner before the maximum allowable working pressure is reached.

In steam generators on whose heating surfaces a highest flue is specified, two mutually independent water level limiters have to respond to cut out and interlock the oil burner when the water falls below the specified minimum water level.

In the case of forced-circulation steam generators with a specified lowest water level, two mutually independent safety devices are to be fitted in addition to the requisite water level limiters, which will cut out and interlock the oil burner in the event of any unacceptable reduction in water circulation.

In the case of forced-circulation steam generators where the heating surface consists of a single coil and once-through steam generators, two mutually independent safety devices are to be fitted in place of the water level limiters in order to provide a sure means of preventing any excessive heating of the heating surfaces by cutting out and interlocking the oil burner.

Where there is a possibility of oil or grease getting into the steam, condensate or hot water system, a suitable automatic and continuously operating unit is to be installed which trips an alarm and cuts off the feedwater supply or the circulation resp. if the concentration at which boiler operation is put at risk is exceeded. The control device for oil or grease ingress may be waived for a dual circulation system.

Where there is a possibility of acid, lye or seawater getting into the steam, condensate or hot water system, a suitable automatic and continuously operating unit is to be installed which trips an alarm and cuts off the feedwater supply or the circulation, as applicable, if the concentration at which boiler operation is put at risk is exceeded. The control device for acid, lye or seawater ingress may be waived for a dual circulation system.

The controls for steam pressure and water level and any additional safety devices (trips) shall take the form of mutually independent units.

The safety devices have to trip visual and audible alarms at the steam boiler control panel.

The electrical devices associated with the limiters are to be designed in accordance with the closed-circuit principle so that, even in the event of a power failure, the limiters will cut out and interlock the systems unless an equivalent degree of safety is achieved by other means.

The electrical interlocking of the oil burner following tripping by the safety devices is only to be cancelled out at the oil burner control panel itself.

The receptacles for water level limiters located outside the steam boiler are to be connected to the steam boiler by means of lines which have a minimum inner diameter of 20 mm. Shut-off devices in these lines shall have a nominal diameter of at least 20 mm and have to indicate their open or closed position. Where water level limiters are connected by means of common connection lines, the connection pipes on the water side are to have an inner diameter of at least 40 mm.

Operation of the oil burner shall only be possible when the shut-off devices are open or else, after closure, the shut-off devices are reopening automatically and in a reliable manner.

Water level limiter receptacles which are located outside the steam boiler are to be designed in such a way that a compulsory and periodic blow-through of the receptacles and lines is carried out.

Emergency shut-down of the oil burner shall be possible from the burner control platform.

If an equivalent level of safety cannot be achieved by the self-monitoring of the equipment, the functional testing of the safety devices shall be practicable even during operation. In this case, the operational testing of the water level limiters shall be possible without dropping the surface of the water below the lowest water level (LWL).

#### **2.5.10 Design and testing of valves and fittings**

Valves and fittings for boilers are to be made of ductile materials as specified in Table 1.19 and all their components shall be able to withstand the loads imposed in operation, in particular thermal loads and possible stresses due to vibration. Grey cast iron may be used within the limits specified in Table 1.19, but shall not be employed for valves and fittings which are subjected to dynamic loads, e.g. safety valves and blow-off valves.

Testing of materials for valves and fittings is to be carried out as specified in Table 1.18. Care is to be taken to ensure that the bodies of shut-off gate valves cannot be subjected to unduly high pressure due to heating of the enclosed water. Valves with screw-on bonnets shall be safeguarded to prevent unintentional loosening of the bonnet.

All valves and fittings are to be subjected to a hydrostatic pressure test at 1.5 times the nominal pressure before they are fitted. Valves and fittings for which no nominal pressure has been specified are to be tested at twice the maximum allowable working pressure. In this case, the safety factor in respect of the 20 °C yield strength value shall not fall below 1.1. The sealing efficiency of the closed valve is to be tested at the nominal pressure or at 1.1 times the maximum allowable working pressure, as applicable.

Safety valves are to be subjected to a test of the set pressure. After the test the tightness of the seat is to be checked at a pressure 0.8 times the set pressure. The setting is to be secured against unauthorized alteration.

#### **2.5.11 Installation of boilers**

Steam boilers are to be installed in the inland waterway vessel with care and have to be secured to ensure that they cannot be displaced by any of the circumstances arising when the inland waterway vessel is at sea. Means are to be provided to accommodate the thermal expansion of the boiler in service. Boilers and their seatings are to be well accessible from all sides or shall be easily made accessible.

Safety valves and shut-off mechanisms shall be capable of being operated without danger. Wherever necessary, permanent steps, ladders or platforms shall be fitted. Water level indicator cocks and valves, except safety valves, which cannot be directly reached by hand from the floor plates or a platform shall be fitted with draw rods or chains enabling them to be operated from the boiler control platform. Cocks shall be so arranged that they are open when the draw rod is in its lowest position.

### **2.6 Testing of boilers**

#### **2.6.1 Manufacturing test**

After completion, steam boilers are to undergo a constructional check.

The constructional check includes verification that the steam boiler complies with the approved drawings and is of satisfactory construction. For this purpose, all parts of the boiler shall be accessible to allow

adequate inspection. If necessary, the constructional check is to be performed at separate stages of manufacture.

The following documents are to be presented: material test certificates covering the materials used, reports on the non-destructive testing of welds and, where applicable, the results of tests of workmanship and proof of the heat treatment applied.

### **2.6.2 Hydrostatic pressure tests**

A hydrostatic pressure test is to be carried out on the steam boiler before refractory insulation and casing are fitted. Where only some of the component parts are sufficiently accessible to allow proper visual inspection, the hydrostatic pressure test may be performed in stages. Steam boiler surfaces have to withstand the test pressure without leaking or suffering permanent deformation.

The test pressure is generally required to be at least 1.5 times the maximum allowable working pressure, subject to a minimum of  $p_{zul} + 1$  bar.

In the case of once-through forced flow boilers, the test pressure shall be at least 1.1 times the water inlet pressure when operating at the maximum allowable working pressure and maximum steam output. In the event of danger that parts of the boiler might be subjected to stresses exceeding 0.9 of the yield strength, the hydrostatic test may be performed in separate sections. The maximum allowable working pressure is then deemed to be the pressure for which the particular part of the boiler has been designed.

## **2.7 Hot water generators**

### **2.7.1 Design**

In respect of the materials used and the strength calculations, hot water generators heated by solid, liquid or gaseous fuels, by waste gases or by electrical means are to be treated in a manner analogous to that applied to steam generators. The materials and strength calculations for hot water generators which are heated solely by steam or hot liquids only are subject to the requirements in 1.

### **2.7.2 Equipment**

The safety equipment of hot water generators is subject to the requirements contained in recognized standards accepted by BKI with due regard for the special conditions attaching to shipboard operation.

### **2.7.3 Testing**

Each hot water generator is to be subjected to a constructional test and to a hydrostatic pressure test at least 1.5 times the maximum allowable working pressure, subject to a minimum of 4 bar.

## **3. Thermal oil heaters**

### **3.1 General**

#### **3.1.1 Scope**

The following Rules apply to the components in thermal oil systems in which organic liquids (thermal oils) are heated by oil burners or electricity to temperatures below their initial boiling point at atmospheric pressure.

Thermal oil heaters to which thermal energy is supplied by engine exhaust gases can also be approved. The safety equipment is subject, as applicable, to the BKI Rules.

#### **3.1.2 Definitions**

The "maximum allowable working pressure" is the maximum pressure which may occur in the individual parts of the equipment under service conditions.

The "thermal oil temperature" is the temperature of the thermal oil at the centre of the flow cross-section.

The "discharge temperature" is the temperature of the thermal oil immediately at the heater outlet.

The "return temperature" is the temperature of the thermal oil immediately at the heater inlet.

The "film temperature" is the wall temperature on the thermal oil side. In the case of heated surfaces, this may differ considerably from the temperature of the thermal oil.

### **3.1.3 Documents for review/approval**

The following documents are to be submitted for approval. To facilitate a smooth and efficient approval process, the drawings could be submitted in electronic format. In specific cases and following prior agreement with BKI they can also be submitted in paper form in triplicate.

- a description of the system stating the discharge and return temperatures, the maximum allowable film temperature, the total volume of the system and the physical and chemical characteristics of the thermal oil
- drawings of the heaters, the expansion vessel and other pressure vessels
- circuit diagrams of the electrical control system and monitoring and safety devices with limiting values respectively
- a functional diagram with information about the safety and monitoring devices and valves provided.

If specially requested, mathematical proof of the maximum film temperature in accordance with a recognized standard, accepted by BKI, is to be submitted.

### **3.1.4 Construction and manufacture**

Design calculation, materials, manufacture and testing are governed by:

- 2 for heaters
- 1 for expansion and pressure vessels
- 4 for oil firing systems (the cut-out conditions for trips are as stated in 3.2.2 and 3.3.2)
- C. for pipes, pumps, valves and fittings

However, grey cast iron is not permitted for components of the hot thermal oil circuit.

Welded structures are subject to the BKI Rules for Materials and Welding (II-3).

### **3.1.5 Thermal oils**

The thermal oil has to remain serviceable for at least 1 year at the specified thermal oil temperature. Its suitability for further use is to be verified at appropriate intervals, but at least once a year.



Thermal oils may only be used within the limits set by the manufacturer. A safety margin of about 50 °C is to be maintained between the discharge temperature and the maximum allowable film temperature specified by the manufacturer.

Precautions are to be taken to protect the thermal oil from oxidation.

Copper and copper alloys, which due to their catalytic effect lead to an increased ageing of the thermal oil are to be avoided or oils with specific additives are to be used.

### **3.1.6 Manual operation**

For thermal oil heaters which are operated automatically, means for operation and supervision are to be provided which allow a manual operation with the following minimum requirements by using an additional control level:

At least the temperature limiter on the oil side and the flow limiter shall remain operative at the oil-fired heater.

The safety equipment not required for manual operation may only be deactivated by means of a key-operated switch. The actuation of the key-operated switch is to be indicated.

For details of requirements in respect of the manual operation of the oil firing equipment, see 4.

Manual operation requires constant and direct supervision of the system.

## **3.2 Heaters**

### **3.2.1 Design**

The heater is to be equipped with an automatic, rapidly controllable heating system.

Heaters are to be designed thermodynamically and by construction in a way that neither the surfaces nor the thermal oil become excessively heated at any point. The flow of the thermal oil is to be ensured by forced circulation.

The surfaces which come into contact with the thermal oil are to be designed for the maximum allowable working pressure, subject to a minimum gauge pressure of 10 bar.

Oil-fired heaters are to be provided with inspection openings for the examination of the combustion chamber.

Sensors for the temperature measuring and monitoring devices are to be introduced into the system through welded-in immersion pipes.

Heaters are to be fitted with devices enabling them to be completely drained.

### **3.2.2 Equipment and safety devices**

Temperature-indicating devices are to be fitted at the discharge and return line as well as in the flue gas outlet of the heater.

The outlet of the circulating pump is to be equipped with a pressure gauge. The maximum allowable working pressure PB is to be indicated on the scale by a red mark which is permanently fixed and well visible. The indicating range has to include the test pressure.

For automatic control of the discharge temperature, oil- fired heaters are to be equipped with an automatic and rapidly adjustable heat supply in accordance with 4.

If the allowable discharge temperature is exceeded for oil-fired heaters, the oil burner is to be switched off and interlocked by a temperature limiter.

Parallel-connected heating surfaces are to be monitored individually at the discharge side of each coil. At the oil-fired heater, the oil burner is to be switched off and interlocked by a temperature limiter in case the allowable discharge temperature is exceeded in at least one coil. An additional supervision of the allowable discharge temperature of the heater is not necessary.

A flow monitor switched as a limiter is to be provided at the oil-fired heater. If the flow rate falls below a minimum value, the oil burner has to be switched off and interlocked.

**3.2.3** Start-up of the oil burner is to be prevented by interlocks if the circulating pump is at standstill.

If the specified flue gas temperature is exceeded, the heating shall be switched off by a temperature limiter.

Electrical equipment items are subject to Section 2 and in particular to Section 2, M.

### **3.3 Pressure vessels**

**3.3.1** All pressure vessels, including those open to the atmosphere, are to be designed for a pressure of at least 2 bar, unless provision has to be made for a higher working pressure.

Drains shall be self-closing.

#### **3.3.2 Expansion vessel**

An expansion vessel is to be placed at a high level in the system. The space provided for expansion shall be such that the increase in the volume of the thermal oil at the maximum thermal oil temperature can be safely accommodated. The following are to be regarded as minimum requirements: 1.5 times the increase in volume for charges up to 1000 litres, and 1.3 times the increase for charges over 1000 litres. The volume is the total quantity of thermal oil contained in the system up to the lowest liquid level in the expansion vessel. The expansion vessel shall be equipped with a liquid level gauge with a mark indicating the lowest allowable liquid level.

Level gauges made of glass, plexiglass or plastic are not allowed.

A limit switch is to be fitted which shuts down and interlocks the oil burner and switches off the circulating pumps if the liquid level falls below the allowable minimum.

Additionally, an alarm for low liquid level is to be installed, e.g. by means of an adjustable level switch on the level indicator, in order to give an early warning of a falling liquid level in the expansion vessel (e.g. in case of a leakage).

An alarm is also to be provided for the maximum liquid level.

The expansion vessel is to be provided with an overflow line leading to the drainage tank.

For rapid drainage in case of danger, a quick-opening valve is to be fitted directly to the expansion vessel with remote control from outside the space in which the equipment is installed.

The quick drainage line may be routed jointly with the overflow line to the drainage tank.

The opening of the quick drainage valve shall activate an alarm. At the same time, a non-safety related shutdown of the oil burner at the oil-fired heater should be carried out.

Where the expansion vessel is installed outside the engine room, the quick drainage valve may be replaced by an emergency shut-off device which, in the event of danger, prevents the egress of large quantities of thermal oil.

A safety expansion line shall connect the system to the expansion vessel. This shall be installed with a continuous positive gradient and shall be dimensioned in a way that a pressure increase of more than 10 above the maximum allowable working pressure in the system is avoided.

The dimensions of the expansion, overflow, drainage and venting pipes shall comply with Table 1.21.

All parts of the system in which thermal oil can expand due to the absorption of heat from outside are to be safeguarded against excessive pressure. Any thermal oil emitted is to be safely drained off.

**Table 1.21 Nominal diameter of expansion, overflow, drainage and venting pipes depending on the output of the heaters**

<b>Total output of heaters [kW]</b>	<b>Expansion and overflow pipes nominal diameter DN</b>	<b>Drainage and venting pipes nominal diameter DN</b>
≤ 600	25	32
≤ 900	32	40
≤ 1200	40	50
≤ 2400	50	65
≤ 6000	65	80

### **3.3.3 Pre-pressurized systems**

Pre-pressurized systems are to be equipped with an expansion vessel, which content is blanketed with an inert gas. The inert gas supply to the expansion vessel has to be guaranteed and monitored for minimum pressure.

The pressure in the expansion vessel shall be indicated and safeguarded against overpressure.

A pressure limiter which gives an alarm and shuts down and interlocks the oil burner at a set-pressure below the set-pressure of the safety valve is to be provided at the expansion vessel.

### **3.3.4 Drainage tanks**

At the lowest point of the system, a drainage tank is to be located, the capacity of which is sufficient to hold the volume of the largest isolatable system section.

In exceptional cases, approval may be given for the drainage tank and the storage tank to be combined. Combined storage/drainage tanks are to be dimensioned in a way that in addition to the stock of thermal oil, there is volume for the content of the largest isolatable system section.

For air ducts and drains, see **3.3.1**.

For sounding pipes, see **C. 13**.

## **3.4 Fire precautions**

See **H.4.3**.

## **3.5 Testing**

After completion of installation on board, the system including the associated monitoring equipment is to be subjected to pressure, tightness and functional tests in the presence of the BKI Surveyor.

#### **4. Oil burners and oil firing equipment**

##### **4.1 General**

###### **4.1.1 Scope**

The following Rules apply to oil burners and oil firing equipment that are to be used for the burning of liquid fuels and installed in auxiliary steam boilers, thermal oil heaters and hot water generators, these being referred to as heat generators in the following.

The oil firing equipment of automatically controlled auxiliary steam boilers and thermal oil heaters is subject to the Rules in 4.2.

The following general requirements of this Section are mandatory for all installations and appliances.

###### **4.1.2 Documents for review/approval**

The following documents are to be submitted for approval. To facilitate a smooth and efficient approval process, the drawings could be submitted in electronic format. In specific cases and following prior agreement with BKI, they can also be submitted in paper form in triplicate.

- General drawings of the oil burner
- Piping and equipment diagram of the burner including parts list
- Description of function
- Electrical diagrams
- List of equipment regarding electrical control and safety

###### **4.1.3 Approved fuels**

See A.2.6

###### **4.1.4 Equipment of the heat generators and burner arrangement**

Oil burners are to be designed, fitted and adjusted in such a manner as to prevent flames from causing damage to the boiler surfaces or tubes which border the combustion space. Boiler parts which might otherwise suffer damage are to be protected by refractory lining.

The firing system shall be so arranged as to prevent flames from blowing back into the boiler or engine room and to allow unburnt fuel to be safely drained.

Observation openings are to be provided at suitable points on the heat generator or burner through which the ignition flame, the main flame and the lining can be observed.

The functioning of explosion doors or rupture disks may not endanger personnel or important items of equipment in the boiler room.

Fuel leaking from potential leak points is to be safely collected in oiltight trays and to be drained away.

#### **4.1.5 Simultaneous operation of oil burners and internal combustion machinery**

The operation of oil burners in spaces containing other plants with a high air consumption, e.g. internal combustion engines or air compressors, is not to be impaired by variations in the air pressure.

### **4.2 Oil firing equipment for boilers and thermal oil heaters**

#### **4.2.1 Preheating of fuel oil**

The equipment has to enable the heat generators to be started up with the facilities available on board. Where only steam-operated preheaters are present, fuel which does not require preheating has to be available to start up the boilers.

Any controllable heat source may be used to preheat the fuel oil. Preheating with open flame is not permitted.

The fuel oil supply temperature is to be selected so as to avoid excessive foaming, the formation of vapour or gas and also the formation of deposits on the heating surface.

Temperature or viscosity control shall be done automatically. For monitoring purposes, a thermometer or viscosimeter is to be fitted to the fuel oil pressure line in front of the burners.

Should the oil temperature or viscosity deviate above or below the permitted limits, an alarm system has to signal this fact to the heat generator control panel.

When a change is made from heavy to light oil, the light oil shall not be passed through the heater or be excessively heated (alarm system).

The dimensional and constructional design of pressurized fuel oil preheaters is subject to the rules set out in 1.

Electrically heated continuous-flow heaters are to be equipped with temperature safety trips in accordance with 1.5.3.

#### **4.2.2 Pumps, pipelines, valves and fittings**

Fuel oil service pumps may be connected only to the fuel system.

Pipelines shall be permanently installed and joined by oiltight welds, oiltight threaded connections of approved design or with flanged joints. Flexible hoses may be used only immediately in front of the burner or to enable the burner to swivel. They shall be installed with adequate bending radii and shall be protected against undue heating. For non-metallic flexible pipes and expansion compensators, see C.14.

Suitable devices, e.g. relief valves, shall be fitted to prevent any excessive pressure increase in the fuel oil pump or pressurized fuel lines.

By means of a hand-operated, quick-closing device mounted at the fuel oil manifold, it shall be possible to isolate the fuel supply to the burners from the pressurized fuel lines. Depending on the design and method of operation, a quick-closing device may also be required directly in front of each burner.

#### **4.2.3 Safety equipment**

The correct sequence of safety functions when the burner is started up or shut down is to be ensured by means of a burner control box.

Two automatic quick-closing devices have to be provided at the fuel oil supply line to the burner.

For the fuel oil supply line to the ignition burner, one automatic quick-closing device will be sufficient, if the fuel oil pump is switched off after ignition of the burner.

The automatic quick-closing devices shall not release the oil supply to the burner during start-up and shall interrupt the oil supply during operation (automatic restart possible) if one of the following faults occurs:

- failure of the required pressure of the atomizing medium (steam and compressed-air atomizers)
- failure of the oil pressure needed for atomization (pressure atomizers) or
- insufficient rotary speed of spinning cup or primary air pressure too low (rotary cup atomizers)
- failure of combustion air supply
- failure of control power supply
- failure of induced-draught fan or insufficient opening of exhaust gas register
- burner not in operating position

The fuel oil supply has to be interrupted by closing the automatic quick-closing devices and interlocked by means of the burner control box if

- the flame does not develop within the safety period following start-up
- the flame is extinguished during operation and an attempt to restart the burner within the safety period is unsuccessful, or
- limit switches are actuated

Every burner is to be equipped with a safety device for flame monitoring suitable for the particular fuel oil (spectral range of the burner flame is to be observed) in use. This appliance has to comply with the following safety periods on burner start-up or when the flame is extinguished in operation:

- on start-up 5 seconds
- in operation 1 second.

Where it is justified, longer safety periods may be permitted for burners with an oil throughput of up to 30 kg/h. Measures are to be taken to ensure that the safety period for the main flame is not prolonged by the action of the igniters (e.g. ignition burners).

"Safety period" is the maximum permitted time during which fuel oil may be supplied to the combustion space in the absence of a flame.

Oil firing equipment with electrically operated components shall also be capable of being shut down by an emergency switch located outside the space in which the equipment is installed.

In an emergency, it shall be possible to close the automatic quick-closing devices from the heat generator control platform and - where applicable - from the engine control room.

#### **4.2.4 Design and construction of burners**

The type and design of the burner and its atomizing and air turbulence equipment shall ensure virtually complete combustion.

Oil burners shall be so designed and constructed that personnel cannot be endangered by moving parts. This applies particularly to blower intake openings. The latter shall also be protected to prevent the entry of drip water.

Oil burners are to be so constructed that they can be retracted or pivoted out of the operating position only when the fuel oil supply has been cut-off. The high- voltage ignition system shall be automatically disconnected when this occurs. A catch is to be provided to hold the burner in the swung out position. Burners that can be retracted or pivoted are to be provided with a catch to hold the burner in the swung-out position.

Steam atomizers shall be fitted with appliances to prevent fuel oil entering the steam system.

Where dampers or similar devices are fitted in the air supply duct, care shall be taken to ensure that air for purging the combustion space is always available unless the oil supply is positively interrupted.

Every burner shall be equipped with an igniter. The ignition is to be initiated immediately after purging. In the case of low-capacity burners of monobloc type (permanently coupled oil pump and fan) ignition may begin with start-up of the burner unless the latter is located in the roof of the chamber.

Where dampers or similar devices are mounted in the air supply line, care shall be taken to ensure that air is available in all circumstances for purging the combustion space.

Pivoted oil burners shall be so constructed that they can be swivelled out only after the fuel oil has been cut off. The high-voltage ignition equipment shall likewise be disconnected when this happens.

The plant shall also be capable of being shut down by means of an emergency switch located outside the space in which the plant is installed.

#### **4.2.5 Purging of combustion chamber and flues, exhaust gas ducting**

The combustion chamber and flues are to be adequately purged with air prior to every burner start-up. A warning sign is to be mounted to this effect.

A threefold renewal of the total air volume of the combustion chamber and the flue gas duct up to the funnel inlet is considered sufficient. Normally, purging shall be performed with the total flow of combustion air for at least 15 seconds. It shall, however, in any case be performed with at least 50 % of the volume of combustion air needed for the maximum heating power of the firing system.

Bends and dead corners in the exhaust gas ducting are to be avoided.

Dampers in uptakes and funnels should be avoided. Any dampers which may be fitted shall be so installed that no oil supply is possible when the cross-section of the purge line is reduced below a certain minimum value. The position of the damper shall be indicated at the boiler control platform.

Where an induced-draught fan is fitted, an interlocking system shall prevent start-up of the burner equipment before the fan has started. A corresponding interlocking system is also to be provided for any covers which may be fitted to the funnel opening.

#### **4.2.6 Electrical equipment**

Electrical equipment and its degree of protection has to comply with the BKI Rules in Section 2.

Safety appliances and flame monitors shall be self- monitoring and shall be connected in such a way as to prevent the supply of oil in the event of a break in the circuitry of the automatic oil burning system.

The equipment in the oil firing system has to be suitable for the use in oil firing systems and on ships. The proof of the suitability of the limiters and the alarm transmitters for e.g. burner control box, flame monitoring device and automatic quick-closing device is to be demonstrated by a type approval examination according to the requirements of BKI Rules.

High-voltage igniters shall be adequately protected against unauthorized interference.

#### **4.2.7 Manual operation**

For oil burners at heat generators that are operated automatically, means for operation and supervision are to be provided which allow a manual operation with the following minimum requirements by using an additional control level.

**4.2.8** Flame monitoring shall remain active.

**4.2.9** The safety equipment not required for manual operation may only be set out of function by means of a key-operated switch. The actuation of the key-operated switch is to be indicated.

**4.2.10** Manual operation requires constant and direct supervision of the system.

#### **4.2.11 Testing**

Test at the manufacturer's workshop.

For burners of heat generators, the following examinations have to be performed at the manufacturer's shop and documented by a BKI approval certificate:

- visual inspection and completeness check
- pressure test of the oil preheater, if available and required according to this Section
- pressure test of the burner
- insulation resistance test
- high voltage test
- functional test of the safety-related equipment

#### **4.2.12 Tests on board**

After installation, a pressure and tightness test of the fuel system, including fittings, has to be performed. The system, including the switchboard installed at the heat generator on board the vessel, has to be functionally tested as follows; in particular, the required purging time has to be identified and manual operation has to be demonstrated.

- completeness check for the required components of the equipment
- functional test of all safety-relevant equipment
- functional test of the burner control box
- identification of maximum and minimum burner power
- identification of flame stability on start-up, at maximum and at minimum burner power, under consideration of combustion chamber pressure (unspecified pressure changes are not permitted)



- proof regarding required purging of flues and safety times
- in case the oil burner is operated with different fuel oils, the proper change-over to another fuel oil quality and especially the safe operation of the flame monitoring, the quick-closing devices and the preheater, if existing, are to be checked
- proof regarding combustion properties, e.g. volumetric content of CO<sub>2</sub> (and possibly O<sub>2</sub> and CO) and soot number at minimum, mean and maximum power, in case of statutory requirements

The correct combustion at all settings as well as the function of safety equipment has to be verified. A BKI approval Certificate of the oil burner regarding examination at the manufacturer's shop is to be presented to BKI during functional testing.

Burners for warm water generators are to be delivered with a test protocol issued by the manufacturer.

## **E. Steering Gears**

### **1. Symbols**

$d_T$  = theoretical rudder stock diameter [mm] based on ahead run in accordance with the BKI Rules for Hull(Part 1,Vol.II), Section 14

$d$  = minimum actual rudder stock diameter [mm]

$k_1 = \left(\frac{235}{R_{eH}}\right)^{n_1}$

$R_{eH}$  = yield stress [N/mm<sup>2</sup>] of the steel used, and not exceeding the lower of 0,7-R<sub>m</sub> and 450 N/mm<sup>2</sup>

$R_m$  = minimum ultimate tensile strength [N/mm<sup>2</sup>]of the steel used,

$n_1$  = coefficient

= 0,75 for  $R_{eH} > 235 \text{ N/mm}^2$

= 1,00 for  $R_{eH} \leq 235 \text{ N/mm}^2$

### **2. General**

#### **2.1 Scope**

The following Rules apply to the steering gear, the steering station and all transmission elements from the steering station to the steering gear.

For the rudder and manoeuvring arrangement, see the Rules for Hull – Inland waterways (Part 2, Vol. 2), Section 7, A.

For the purposes of these Rules, steering gears comprise all the equipment used to operate the rudder from the rudder actuator to the steering station including the transmission elements.

This section is to be applied in analogous manner to rudder propellers in their function as steering gears.

#### **2.2 Documents for review/approval**

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

The drawings and other documents are to contain all the information relating to materials, working pressures, pump delivery rates, drive motor ratings etc. necessary to enable the documentation to be checked. To facilitate a smooth and efficient approval process, the drawings could be submitted in electronic format.

### **3. Materials**

#### **3.1 Approved materials**

As a rule, important load transmitting components of the steering gear (e.g. tiller, hydraulic cylinder, plunger, rotary vane, bolts, keys and so on) should be made of steel or cast steel complying with the Rules for Materials and Welding seagoing ship.

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

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

For welded structures, the BKI Rules for Materials and Welding seagoing ship are to be observed.

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

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

**3.1.3** High pressure hose lines may be used for short connections subject in compliance with B.7.

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

#### **3.2 Testing of materials**

The materials of important force - transmitting components of the steering gear as well as of the pressurized casings of hydraulic steering gears are to be tested under the supervision of BKI in accordance with the Rules for Materials (Part 1, Vol. V).

For pressurized oil pipes the requirements according to Section 1.C, Table 1.12 are to be observed.

For welded pressurized casings, the Rules for Welding (Part 1, Vol. VI), are to be considered. Evidence of this may take the form of manufacturer's acceptance test certificate.

### **4. Design and equipment**

#### **4.1 Number of steering gears**

Every ship shall be equipped with at least one main and one auxiliary steering gear. Each steering gear shall be able to operate the rudder on its own and independently of the other system. BKI may agree to components being used jointly by the main and auxiliary steering gear. For the electrical part of steering gear systems, see Rules Electrical Installation - Inland waterways (Part 2, Vol. IV) Section 2, H.

## 4.2 Main steering gear

**4.2.1** Main steering gears shall, with the rudder fully immersed in calm water, be capable of putting the rudder from 35° port to 35° starboard and vice versa and the ship travelling at full speed, see the Rules for Hull – Inland waterways (Part 2, Vol. II), Section 7, A. The time required to put the rudder over shall not exceed 20 seconds.

The main steering gear shall normally be power- operated.

**4.2.2** Manual operation is acceptable for rudder stock diameters up to 150 mm calculated for torsional loads in accordance with the Rules for Hull – Inland waterways (Part 2, Vol. II) Section 7, A.3.1.1. In the case of multi-surface rudders controlled by a common steering gear, the specified diameter is to be determined by applying the formula:

$$d_T = \sqrt[3]{\sum d_{Ti}^3}$$

Not more than 30 turns of the handwheel shall be necessary to put the rudder from one hard over position to the other. Taking account of the efficiency of the system, the force required to operate the hand- wheel should generally not exceed 200 N.

The manual wheel shall not be driven by a powered drive unit.

Regardless of rudder position, a kick-back of the wheel shall be prevented when the manual drive is engaged automatically.

## 4.3 Auxiliary steering gear

Auxiliary steering gears shall be designed to ensure continued adequate manoeuvrability with the rudder fully immersed and the ship travelling at reduced speed.

Manual operation of auxiliary steering gear systems is permitted where the size of the system allows this.

## 4.4 Power unit

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

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

**4.4.3** In the event of a loss of hydraulic oil, it shall be possible to isolate the damaged system in such a way that the second control system remains fully serviceable and may take over in not more than 5 sec.

**4.4.4** If the second drive unit or manual drive is not placed in service automatically, it shall be possible to do so immediately by means of a single operation by the helmsman that is both simple and quick.

**4.4.5** Hydraulic pumps should be protected by means of non-return valves mounted at the discharge part.

**4.4.6** The second drive unit or manual drive shall ensure the manoeuvrability required by the Rules for Hull – Inland waterways (Part 2, Vol. II), Section 7, A.3.1 as well.

## 4.5 Rudder angle limitation

The rudder angle of power-operated steering gears is to be limited to the specified maximum amount by devices fitted to the steering gear (e.g. limit switches).

Deviations from this requirements are permitted only with the consent of BKI.

#### **4.6 End position limitation**

**4.6.1** For limitation of end positions, stoppers are to be provided. Where necessary, a mechanical safety device at the end position is to be supplied.

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

#### **4.7 Locking equipment**

Steering gear systems are to be equipped with a locking system effective in all rudder positions.

For hydraulic plants shut-off valves directly at the cylinder are accepted instead.

#### **4.8 Overload protection**

**4.8.1** Power-operated steering gear systems are to be fitted with overload protection (slip coupling, relief valve) to ensure that the driving torque is limited to the maximum permissible value. Means shall be provided for checking the setting while in service.

**4.8.2** The pressurized casings of hydraulic steering gears which also fulfil the function of the locking equipment mentioned in 4.7 are to be fitted with relief valves unless they are so designed that the pressure generated when the elastic limit torque is applied to the rudder stock cannot cause rupture or permanent deformation of the pressurized casings.

**4.8.3** In the case of hydraulic steering gears, the torque transmitted by the rudder as a result of grounding, e.g., shall in addition, be limited by safety valves.

#### **4.9 Controls**

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

Alarm for oil high temperature has to be provided for.

#### **4.10 Rudder angle indication**

**4.10.1** The rudder position shall be clearly indicated in the bridge and at all steering stations. Where the steering gear is operated electrically or hydraulically, the rudder angle shall be signalled by a device (rudder position indicator) which is actuated either by the rudder stock itself or by parts which are rigidly connected to it.

**4.10.2** The rudder position at any moment shall also be indicated at the steering gear itself.

#### **4.11 Piping**

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

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

Pipes are to be so installed that they are free from stress and vibration.

Hydraulic hoses are:

- a) only permissible if vibration absorption or freedom of movement of components makes their use inevitable;
- b) to be designed for at least the maximum service pressure;
- c) to be renewed at the latest every eight years.

Hydraulic cylinders, hydraulic pumps and hydraulic motors as well as electric motors shall be examined at the latest every eight years by a specialized firm and repaired if required.

**4.11.2** The pipes of main and auxiliary steering gear systems are normally to be laid independently of each other. With BKI consent, the joint use of pipes for the main and auxiliary steering gear systems may be permitted.

In such cases, the design pressure for pipes and joints shall be 1.5 times the maximum permissible working pressure.

**4.11.3** No other power consumers may be connected to the hydraulic steering gear drive unit. Where there are two independent drive units such a connection to one of the two systems is however acceptable if the consumers are connected to the return line and may be disconnected from the drive unit by means of an isolating device.

**4.11.4** For the design and dimensions of pressure vessels, pipes, valves, fittings, etc., see D. and C.

#### **4.12 Oil level indicators, filters, etc.**

**4.12.1** Tanks with the hydraulic system are to be fitted with oil level indicators.

**4.12.2** The lowest permissible oil level is to be alarmed.

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

**4.12.4** Hydraulic tanks shall be equipped with a warning system that monitors for any dropping of the oil level below the lowest content level needed for safe operation.

#### **4.13 Arrangement**

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

### **5. Power and design**

#### **5.1 Power of steering gears**

**5.1.1** The power of the steering gear is governed by the requirements set out in 4.2 and 4.3. The minimum requirement with regard to the maximum effective torque ( $M_{TR}$ ) [N·m] for which the steering gear including piping is to be designed is to be calculated according to the following formula:

$$M_{TR} = \frac{d_T^3}{74 \cdot k_1}$$

For the determination of the pertinent working pressure (maximum pressure), the frictional losses in the steering gear including piping are to be considered.

The relief valves are to be set at this pressure value.

**5.1.2** Electrical drive motors are also subject to the Rules for Electrical Installations – Inland waterways (Part 2, Vol. IV) Section 1, H.1

## 5.2 Design of transmission components

**5.2.1** The design calculations for those parts of the steering gear which are not protected against overload are to be based on the elastic limit torque of the rudder stock. The elastic limit torque [N-m] is:

$$M_F = \frac{26,6 \cdot d^3}{1000 \cdot k_1}$$

where, the value used for the minimum actual rudder stock diameter,  $d$ , need not be larger than  $1,145 \cdot d_T$ .

In the case of multi-surface rudders, the diameter of only one rudder stock, i.e. the largest, is to be taken into account.

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

### 5.2.2 Tiller and rotary vane hubs

Tiller and rotary vane hubs made of material with tensile strength of up to  $500 \text{ N/mm}^2$  shall satisfy the following conditions in the area where the force is applied (see Fig. 1.5).

Height of hub [mm]:  $H_0 \geq d$

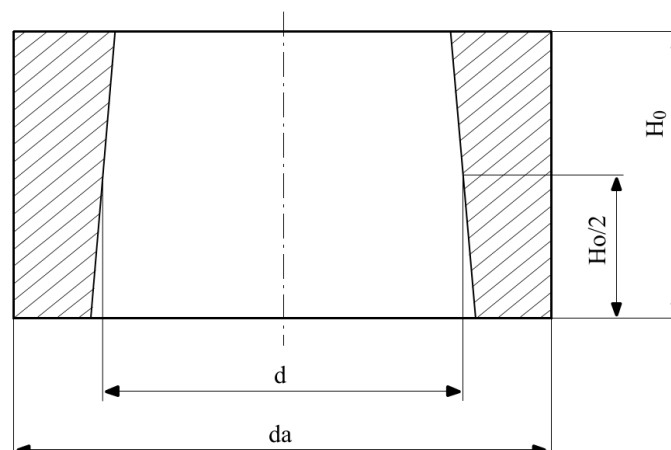
Outside diameter [mm]:  $d_a \geq 1,8 \cdot d$

In special cases the outer diameter may be reduced to:

$d_a \geq 1,7 \cdot d$

but the height of the hub shall then be at least:

$H_0 \geq 1,145 \cdot d$



**Fig. 1.5 Hub dimensions**

### 5.2.3 Tillers, tiller arms, quadrants and key ways

a) The scantling of the tiller is to be determined as follows:

the section modulus of the tiller arm in way of the end fixed to the boss is not to be less than the value [cm<sup>3</sup>] calculated from the following formula:

$$z_b = \frac{0,147 \cdot d^3}{1000} \cdot \frac{L'}{L} \cdot \frac{R_e}{R_e'}$$

L = distance from the centreline of the rudder stock to the point of application of the load on the tiller (see Fig. 1.6)

L' = distance between the point of application of the above load and the root section of the tiller arm under consideration (see Fig. 1.6)

R<sub>e</sub> = value of the minimum specified yield strength of the material at ambient temperature [N/mm<sup>2</sup>]

R<sub>e</sub>' = design yield strength [N/mm<sup>2</sup>] determined by the following formula:

$$= R_e, \text{ where } R \geq 1,4 \cdot R_e$$

$$= 0,417 \cdot (R_e + R) \text{ where } R < 1,4 \cdot R_e$$

R = value of the minimum specified tensile strength of the material at ambient temperature [N/mm<sup>2</sup>]

The width and thickness of the tiller arm in way of the point of application of the load are not to be less than one half of those required by the above formula.

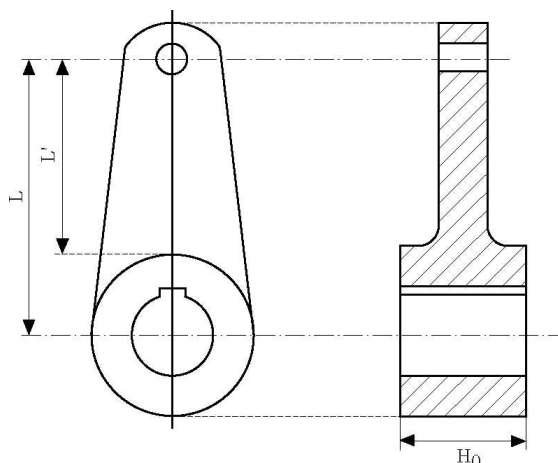
In the case of double arm tillers, the section modulus of each arm is not to be less than one half of the section modulus required by the above formula.

b) The scantling of the quadrants is to be determined as specified in a) for the tillers. When quadrants having two or three arms are provided, the section modulus of each arm is not to be less than one half or one third, respectively, of the section modulus required for the tiller.

Arms of loose quadrants not keyed to the rudder stock may be of reduced dimensions to the satisfaction of BKI, and the depth of the boss may be reduced by 10 percent.

c) Keys should be designed according to the following provisions:

- the key is to be made of steel with a yield stress not less than that of the rudder stock and that of the tiller boss or rotor without being less than 235 N/mm<sup>2</sup>
- the width of the key is not to be less than 0,25·d
- the thickness of the key is not to be less than 0,10·d
- the ends of the keyways in the rudder stock and in the tiller (or rotor) are to be rounded and the keyway root fillets are to be provided with small radii of not less than 5 percent of the key thickness
- the permissible surface pressure of the key and keyway should not exceed 90 % of the materials yield strength.



**Fig. 1.6 Tiller arm**

**5.2.4** Where materials with a tensile strength greater than 500 N/mm<sup>2</sup> are used, the section of the hub may be reduced by 10 %.

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

For the elastic limit torque according to formula given in 5.2.1, the thread root diameter, in mm, of the bolts can be determined by applying the following formula:

$$d_B = 9,76 \cdot d \cdot \sqrt{\frac{1}{z \cdot R_{eh} \cdot k_1}}$$

$z$  = total number of bolts

**5.2.6** Split hubs of clamped joints shall be joined together with at least four bolts.

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

## **6. Tests in the manufacturer's works**

### **6.1 Testing of power units**

The power units are required to undergo test on a test stand. The relevant manufacturer's works test certificates are to be presented at the time of the final inspection of the steering gear.

For electric motors, see Rules for Electrical Installation – Inland waterways (Part 2, Vol IV) Section 1,C

Hydraulic pumps are to be subjected to pressure and operational tests. Where the drive power of the hydraulic pump is 50 kW or more, these tests are to be carried out in presence of a BKI Surveyor.

### **6.2 Pressure and tightness tests**

Pressure components are to undergo a pressure test, using the following testing pressure:

$$P_{ST} = 1,5 \cdot p$$

$P_{ST}$  = testing pressure [bar]



$p$  = maximum allowable working pressure or pressure at which the relief valve is open  
however, for working pressures above 200 bar, the testing pressure need not exceed  $p + 100$  bar

For pressure testing of pipes, their valves and fittings and also for hose assemblies, see C.

Tightness tests are to be performed on components to which this is appropriate.

### **6.3 Final inspection and operational test**

Following testing of the individual components and after completion of assembly, the steering gear is required to undergo final inspection and an operational test in the presence of BKI Surveyor. The overload protection is to be adjusted at this time.

## **F. Lateral Thrust Units**

### **1 General**

#### **1.1 Scope**

**1.1.1** The following requirements apply to the lateral thrust unit, the control station and all the transmission elements from the control station to the lateral thrust unit.

#### **1.2 Documents for review/approval**

**1.2.1** Assembly and sectional drawings together with detail drawings of the gear mechanism and propellers containing all the necessary data and calculations are to be submitted to BKI for review/approval.

### **2. Material**

**2.1** Materials are subject, as appropriate, to the provisions of B.2.2 and B.3.2.

### **3. Thruster tunnel**

#### **3.1 Scantlings and arrangements**

**3.1.1** The scantlings and arrangements of the thruster tunnel are to be in compliance with the BKI Rules for Hull-Inland Waterways (Part 2, Vol.II), Section 6, A.7-8.

## **4. Machinery and systems**

### **4.1 Dimensions and design**

**4.1.1** The dimensional design of the driving mechanisms of lateral thrust units is to be in compliance with B.3. and B.4.

The dimensional design of the propellers is to comply with B.5.

The free end of the driving shaft from the non drive end bearing to the propeller is to be dimensionally designed as a propeller shaft in accordance with B.3.

**4.1.2** The pipes for drive systems of lateral thrust units are to be of seamless or longitudinally welded steel tubes. The use of cold-drawn, unannealed tubes is not permitted.

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

Hose lines comprise hoses and their fittings in a fully assembled and tested condition.

High pressure hose lines are to be used if necessary for flexible connections. These hose lines shall meet the requirements of C. or an equivalent standard. The hose lines shall be properly installed and suitable for the relevant operating media, pressures, temperatures and environmental conditions. In systems important to the safety of the vessel and in spaces subjected to a fire hazard, the hose lines are to be flame resistant or to be protected correspondingly.

**4.1.3** Lateral thrust units shall be capable of being operated independently of other connected systems.

## **4.2 Steering thruster control**

Controls for steering thrusters are to be provided from the bridge, machinery control station and locally.

Means are to be provided to stop any running thruster at each of the control stations.

A thruster angle indicator is to be provided at each steering control station. The angle indicator is to be independent of the control system.

## **5 Electrical installations**

### **5.1 General**

**5.1.1** Electrical installations of lateral thrust units are to comply with Section 2, H.2.

### **5.2 Cables**

The cables are to be intended to supply a short-time load for up to one hour service.

### **5.3 Auxiliary machinery**

#### **5.3.1 Thruster auxiliary plants**

The thruster auxiliary plants are to be supplied directly from the main switchboard or from the main distribution or from a distribution board reserved for such circuits, at the auxiliary rated voltage.

## **6 Test in the manufacturer's works**

### **6.1 Testing of power units**

The power units are required to undergo a test on a test stand. The relevant manufacturers test certificates are to be presented at the time of the final inspection of unit.

For electrical motors, see Section 2.

Hydraulic pumps are to be subjected to pressure and operational tests.

### **6.2 Pressure and tightness tests**

Pressure components are to undergo a pressure test, using the following testing pressure:

$$P_{ST} = 1,5 \cdot p$$

$P_{ST}$  = testing pressure [bar]

$p$  = maximum allowable working pressure or pressure at which the relief valve is open however, for working pressures above 200 bar, the testing pressure need not exceed  $p + 100$  bar

For pressure testing of pipes, their valves and fittings and also for hose assemblies, see C.

Tightness tests are to be performed on components to which this is appropriate.

### **6.3 Final inspection and operational test**

Following testing of the individual components and after completion of assembly, the steering gear is required to undergo final inspection and an operational test in the presence of BKI Surveyor. The overload protection is to be adjusted at this time.

## **G. Domestic Gas Installations**

### **1 General**

#### **1.1 Application**

**1.1.1** The following requirements apply to permanently installed domestic liquefied gas installations on vessels.

**1.1.2** Exceptions to these Rules are possible where they are permitted by the statutory Regulations in force in the area of service.

#### **1.2 General provisions**

**1.2.1** On vessels intended to carry dangerous goods, liquefied gas installations are to comply also with applicable requirements of the Rules For Additional Requirements of Notations - Inland Waterways (Part 2 Vol.V), Section 3, B., C. or D.

**1.2.2** Liquefied gas installations consist essentially of a supply unit comprising one or more gas receptacles, and of one or more reducing valves, a distribution system and a number of gas-consuming appliances.

**1.2.3** Such installations may be operated only with commercial propane.

#### **1.3 Documentation to be submitted**

Diagrammatic drawings including following information, are to be submitted to BKI:

- service pressure
- size and nature of materials for piping
- capacity and other technical characteristics for accessories
- generally, all information allowing the verification of the requirements of the present Section

### **2. Gas installations**

#### **2.1 General**

- 2.1.1** Liquefied gas installations shall be suitable throughout for use with propane and shall be built and installed in accordance with the state of the art.
- 2.1.2** A liquefied gas installation may be used only for domestic purposes in the accommodation and the wheelhouse, and for corresponding purposes on passenger vessels.
- 2.1.3** There may be a number of separate installations on board. A single installation may not be used to serve accommodation areas separated by a hold or a fixed tank.
- 2.1.4** No part of a liquefied gas installation shall be located in the engine room.

## **2.2 Gas receptacles**

- 2.2.1** Only receptacles with an approved content of between 5 and 35 kg are permitted.

In principle, in the case of passenger vessels, the use of receptacles with a larger content may be approved.

- 2.2.2** The gas receptacles shall be permanently marked with the test pressure.

## **2.3 Supply unit**

**2.3.1** Supply units shall be installed on deck in a freestanding or wall cupboard located outside the accommodation area in a position such that it does not interfere with movement on board. They shall not, however, be installed against the fore or aft bulwark plating. The cupboard may be a wall cupboard set into the superstructure provided that it is gastight and can only be opened from outside the superstructure. It shall be so located that the distribution pipes leading to the gas consumption points are as short as possible.

**2.3.2** No more receptacles may be in operation simultaneously than are necessary for the functioning of the installation. Several receptacles may be in operation only if an automatic reversing coupler is used. Up to four receptacles may be in operation per installation. The number of receptacles on board, including spare receptacles, shall not exceed six per installation.

**2.3.3** Up to six receptacles may be in operation on passenger vessels with galleys or canteens for passengers. The number of receptacles on board, including spare receptacles, shall not exceed nine per installation.

**2.3.4** The pressure reducer, or in the case of two- stage reduction the first pressure reducer, shall be fitted to a wall in the same cupboard as the receptacles.

**2.3.5** Supply units shall be so installed that any leaking gas can escape from the cupboard into the open without any risk of it penetrating inside the vessel or coming into contact with a source of ignition.

**2.3.6** Cupboards shall be constructed of fire- resistant materials and shall be adequately ventilated by apertures in the top and bottom. Receptacles shall be placed upright in the cupboards in such a way that they cannot be overturned.

**2.3.7** Cupboards shall be so built and placed that the temperature of the receptacles cannot exceed 50 °C.

## **2.4 Pressure reducers**

**2.4.1** Gas-consuming appliances may be connected to receptacles only through a distribution system fitted with one or more reducing valves to bring the gas pressure down to the utilization pressure. The pressure may be reduced in one or two stages. All reducing valves shall be set permanently at a pressure determined in accordance with 2.5.

**2.4.2** The final pressure reducers shall be either fitted with or immediately followed by a device to protect the pipe automatically against excess pressure in the event of a malfunctioning of the reducing valve. It shall be ensured that in the event of a breach in the airtight protection device any leaking gas can escape into the open without any risk of it penetrating inside the vessel or coming into contact with a source of ignition; if necessary, a special pipe shall be fitted for this purpose.

**2.4.3** The protection devices and vents shall be protected against the entry of water.

## **2.5 Pressure**

**2.5.1** Where two-stage reducing systems are used, the mean pressure shall be not more than 2,5 bar above atmospheric pressure.

**2.5.2** The pressure at the outlet from the last pressure reducer shall be not more than 0,05 bar above atmospheric pressure, with a tolerance of 10 %.

## **2.6 Piping and flexible tubes**

**2.6.1** Pipes shall consist of fixed steel or copper tubing, in compliance with requirements of C. However, pipes connecting with the receptacles shall be high-pressure flexible tubes or spiral tubes suitable for propane. Gas-consuming appliances may be connected by means of suitable flexible tubes not more than 1 m long.

**2.6.2** Pipes shall be able to withstand any stresses or corrosive action which may occur under normal operating conditions on board, and their characteristics and layout shall be such that they ensure a satisfactory flow of gas at the appropriate pressure to the gas-consuming appliances.

**2.6.3** Pipes shall have as few joints as possible. Both pipes and joints shall be gastight and shall remain gastight despite any vibration or expansion to which they may be subjected.

**2.6.4** Pipes shall be readily accessible, properly fixed and protected at every point where they might be subject to impact or friction, particularly where they pass through steel bulkheads or metal walls. The entire outer surface of steel pipes shall be treated against corrosion.

**2.6.5** Flexible pipes and their joints shall be able to withstand any stresses which may occur under normal operating conditions on board. They shall be unencumbered and fitted in such a way that they cannot be heated excessively and can be inspected over their entire length.

## **2.7 Distribution system**

**2.7.1** It shall be possible to shut off the entire distribution system by means of a valve which is at all times easily and rapidly accessible.

**2.7.2** Each gas-consuming appliance shall be supplied by a separate branch of the distribution system, and each branch shall be controlled by a separate closing device.

**2.7.3** Valves shall be fitted at points where they are protected from the weather and from impact.

**2.7.4** An inspection joint shall be fitted after each pressure reducer. It shall be ensured using a closing device that in pressure tests the pressure reducer is not exposed to the test pressure.

## **2.8 Gas-consuming appliances**

**2.8.1** The only appliances that may be installed are propane- consuming appliances equipped with devices that effectively prevent the escape of gas in the event of either the flame or the pilot light being

extinguished.

**2.8.2** Appliances shall be so placed and connected that they cannot overturn or be accidentally moved and as to avoid any risk of accidental wrenching of the connecting pipes.

**2.8.3** Heating and water-heating appliances and refrigerators shall be connected to a duct for evacuating combustion gases into the open air.

**2.8.4** The installation of gas-consuming appliances in the wheelhouse is permitted only if the wheelhouse is so constructed that no leaking gas can escape into the lower parts of the vessel, in particular through the control runs leading to the engine room.

**2.8.5** Gas-consuming appliances may be installed in sleeping quarters only if combustion takes place independently of the air in the quarters.

**2.8.6** Gas-consuming appliances in which combustion depends on the air in the rooms in which they are located shall be installed in rooms which are sufficiently large.

### **3 Ventilation system**

#### **3.1 General**

**3.1.1** In rooms containing gas-consuming appliances in which combustion depends on the ambient air, fresh air shall be supplied and combustion gases evacuated by means of ventilation apertures of adequate dimensions, with a clear section of at least 150 cm<sup>2</sup> per aperture.

**3.1.2** Ventilation apertures shall not have any closing device and shall not lead to sleeping quarters.

**3.1.3** Evacuation devices shall be so designed as to ensure the safe evacuation of combustion gases. They shall be reliable in operation and made of nonflammable materials. Their operation shall not be affected by the ventilators.

### **4 Tests and trials**

#### **4.1 Definition**

A piping shall be considered gastight if, after sufficient time has elapsed for thermal balancing, no drop in the test pressure is noted during the following 10 minutes.

#### **4.2 Testing conditions**

**4.2.1** The completed installation shall be subjected to tests defined in 4.2.2 to 4.2.8.

**4.2.2** Medium-pressure pipes between the closing device, referred to in 2.8.4, of the first reducing device and the valves fitted before the final pressure reducer:

- a) pressure test, carried out with air, an inert gas or a liquid at a pressure 20 bar above atmospheric pressure
- b) gastightness test, carried out with air or an inert gas at a pressure 3,5 bar above atmospheric pressure

**4.2.3** Pipes at the utilization pressure between the closing device, referred to in 2.7.4, of the single pressure reducer or the final pressure reducer and the valves fitted before the gas-consuming appliances:

- tightness test, carried out with air or an inert gas at a pressure of 1 bar above atmospheric pressure

**4.2.4** Pipes situated between the closing device, referred to in 2.7.4, of the single pressure reducer or the final pressure reducer and the controls of the gas- consuming appliance:

- leak test at a pressure of 0,15 bar above atmospheric pressure

**4.2.5** In the tests referred to in 4.2.2 (b), 4.2.3 and 4.2.4, the pipes are deemed gastight if, after sufficient time to allow for normal balancing, no fall in the test pressure is observed during the following 10 minutes.

**4.2.6** Receptacle connectors, piping and other fittings subjected to the pressure in the receptacles, and joints between the reducing valve and the distribution pipe:

- tightness test, carried out with a foaming substance, at the operating pressure

**4.2.7** All gas-consuming appliances shall be brought into service and tested at the nominal pressure to ensure that combustion is satisfactory with the regulating knobs in the different positions.

Flame failure devices shall be checked to ensure that they operate satisfactorily.

**4.2.8** After the test referred to in 4.2.7, it shall be verified, in respect of each gas-consuming appliance connected to a flue, whether, after five minutes' operation at the nominal pressure, with windows and doors closed and the ventilation devices in operation, any combustion gases are escaping through the damper.

If there is a more than momentary escape of such gases, the cause shall immediately be detected and remedied. The appliance shall not be approved for use until all defects have been eliminated.

## **H. Fire-Protection and Fire-Extinguishing**

### **1. General**

#### **1.1 Scope**

**1.1.1** These Rules apply to fire-protection and fireextinguishing.

**1.1.2** For fire detection, see Section 2, Table 2.16.

**1.1.3** For additional requirements on fire protection on passenger vessels, see the Rules For Additional Requirements of Notations - Inland Waterways (Part 2 Vol.V), Section 2, D.3

**1.1.4** For additional requirements on fire protection on tankers, see the Rules For Additional Requirements of Notations – Inland Waterways (Part 2 Vol.V), Section 3, E.

**1.1.5** For additional requirements on fire protection on dry cargo vessels carrying dangerous goods, see the Rules For Additional Requirements of Notations - Inland Waterways (Part 2 Vol.V), Section 3, E.

#### **1.2 Approval**

Hoses, nozzles, fire-extinguishers, fire-detection and alarm systems, fire-protection equipment and extinguishing media shall have been approved. Exceptions to the Rules compatible with the statutory Regulations of the vessel's country of registration may be agreed with BKI.

#### **1.3 Documents for review/approval**

Plans of the following equipment are to be submitted to BKI at least in triplicate, where applicable:

- general water fire-extinguishing systems

- CO<sub>2</sub> extinguishing systems
- other gas fire-extinguishing systems
- foam extinguishing systems
- fire-detection and alarm systems
- fire control plan

The plan shall clearly show for each deck the control stations, the various fire sections enclosed by class A and B divisions together with particulars of the fire-detection and alarm systems, the sprinkler installation, if any, the fireextinguishingappliances, means of access to thedifferent compartments and the ventilation systemincluding the location of fire dampers andfan control positions.

#### **1.4 Definitions**

**1.4.1** The term "Type Approval" is defined in the Rules for Classification and Surveys – Inland Waterways (Part 2, Vol. I), Section1, A.1.2.16.

#### **1.4.2 Non-combustible material**

Non-combustible material is a material which neitherburns nor gives off flammable vapours in sufficient quantity for self-ignition when heated to approximately750 °C (see Note).

*Note*

*Reference is made to the Fire Test Procedure Code,Annex 1, Part 1, adopted by IMO by Resolution MSC.61 (67).*

#### **1.4.3 A-class divisions**

A-class divisions are those divisions formed by bulkheadsand decks which comply with the following criteria:

- a) they are constructed of steel or other equivalent material
- b) they are suitably stiffened
- c) they are insulated with type approved non-combustible materials such that the average temperature of the unexposed side will not rise more than 140 °C above the original temperature, nor will the temperature, at any one point, including any joint, rise more than 180 °C above the original temperature, within the time listed below:
  - class A-60 60 min
  - class A-30 30 min
  - class A-0 0 min
- d) they are constructed as to be capable of preventingthe passage of smoke and flame to the end of the one-hour standard fire test (see Note)

*Note*

*Reference is made to the Fire Test Procedure Code, Annex 1, Part 3, adopted by IMO by Resolution*



MSC.61 (67).

#### 1.4.4 B-class divisions

B-class divisions are those divisions formed by bulkheads, decks, ceilings or linings which comply with the following criteria:

- a) they are constructed of approved non-combustible materials and all materials used in the construction and erection of B-class divisions are non-combustible, with the exception that surface materials may have low flame spread characteristics
- b) they have an insulation value such that the average temperature of the unexposed side will not rise more than 140 °C above the original temperature, nor will the temperature at any one point, including any joint, rise more than 225 °C above the original temperature, within the time listed below:
  - class B-15 15 min
  - class B-0 0 min
- c) they are so constructed as to be capable of preventing the passage of flame to the end of the first half hour of the standard fire test (see Note)

*Note*

*Reference is made to the Fire Test Procedure Code, Annex 1, Part3, adopted by IMO by Resolution MSC.61 (67)."*

#### 1.4.5 Low flame spread surface material

Low flame spread means that the surface thus described will adequately restrict the spread of flame (see Note).

*Note*

*Reference is made to the Fire Test Procedure Code, Annex 1, Part 5, adopted by IMO by Resolution MSC.61 (67).*

#### 1.4.6 Not readily ignitable material

Not readily ignitable materials means a material which will not give rise to smoke or toxic and explosive hazards at elevated temperatures (see Note).

*Note*

*Reference is made to the Fire Test Procedure Code, Annex 1, Part6, adopted by IMO by Resolution MSC.61 (67).*

## 2. Fire protection

### 2.1 Installation of boilers

Auxiliary and domestic boilers are to be arranged in such a way that other equipment is not endangered, even in the event of overheating. They shall, in particular, be placed as far away as possible from fuel tanks, lubricating oil tanks and hold bulkheads. Oiltight trays are to be located below oil-fired boilers.

### 2.2 Insulation of exhaust gas lines

See B.2.6.4.

### **2.3 Emergency stops, remotely operated**

Fuel pumps, fan motors and boiler fans are to be equipped with emergency stops. The outlet valves of fuel service tanks shall be fitted with remotely operated shut-off devices. Emergency stops and remotely operated shut-off devices shall be capable of being operated from permanently accessible open deck and protected from unauthorized use.

### **2.4 Means of closure**

Means shall be provided for the airtight sealing of boiler, engine and pump rooms. The air ducts to these spaces are to be fitted with closing appliances or equivalent devices made of non-combustible material which can be closed from the deck. Engine room skylights shall also be able to be closed from outside.

### **2.5 Escapes**

**2.5.1** Every engine room shall be provided with two means of escape as widely separated as possible. One of the means of escape shall be an emergency exit. If a skylight is permitted as an escape, it shall be possible to open it from the inside.

**2.5.2** The escape trunk shall have clear dimensions of at least 0,6 x 0,6 m.

**2.5.3** In case of engine rooms of less than 35 m<sup>2</sup> one means of escape may be accepted.

**2.5.4** At all levels of accommodation there shall be provided at least two widely separated means of escape from each restricted space or group of spaces.

## **3. Fixed fire-extinguishing system design**

### **3.1 Automatic pressure water spraying system (sprinkler system)**

#### **3.1.1 General**

Alternative systems complying with recognized standards may subject to approval be accepted.

#### **3.1.2 Pressure water tanks**

Pressure water tanks are to be fitted with a safety valve, connected directly without valves to the water compartment, with a water level indicator that can be shut-off and is protected against damage, and with a pressure gauge. Furthermore D. is to be applied.

The volume of the pressure water tank shall be equivalent to at least twice the specified pump delivery per minute.

The tank shall contain a standing charge of fresh water equivalent to at least the specified volume delivered by the pump in one minute.

The tank is to be fitted with a connection to enable the entire system to be refilled with fresh water.

Means are to be provided for replenishing the air cushion in the pressure water tank.

#### **3.1.3 Pressure water-spraying pumps**

The pressure pumps may only be used for supplying water to the pressure water-spraying systems.

In the event of a pressure drop in the system, the pump shall start up automatically before the fresh water charge in the pressure water tank has been exhausted. Suitable means of testing are to be provided.

The capacity of the pump shall be sufficient to cover the area of the greatest protected space. At a rate of application of at least  $5 \text{ l}/(\text{m}^2 \cdot \text{min})$ , this is equivalent to a minimum delivery rate of  $375 \text{ l}/\text{min}$ .

The pump is to be provided with a direct suction connection at the vessel's side. The shut-off device is to be secured in the open position. A suitable raw water filter is to be fitted, the mesh size of which is able to prevent coarse impurities from clogging the nozzles. The pump delivery is to be fitted with a test valve with connecting pipes, the cross-section of which is compatible with the pump capacity at the prescribed head.

#### **3.1.4 Location**

Pressure water tanks and pressure water pumps are to be located outside, and at a sufficient distance from, the rooms to be protected.

#### **3.1.5 Water supply**

The system shall be completely charged with fresh water when not in operation.

In addition to the water supply to the spraying equipment located outside the spaces to be protected, the system is also to be connected to the fire main via a screw-down non-return valve.

The equipment shall be kept permanently under pressure and shall be ready at all times for immediate, automatic operation. With the test valve at the alarm valve in the fully open position, the pressure at the level of the highest spray nozzles shall still be at least 1,75 bar.

#### **3.1.6 Power supply**

At least two mutually independent power sources shall be provided for supplying the pump and the automatic indicating and alarm systems. Each source shall be sufficient to power the equipment. Furthermore, the Rules for Electrical Installations (Part 1, Vol.IV) Section.7 shall be observed.

#### **3.1.7 Piping, valves and fittings**

Lines between suction connection, pressure water tank, shore connection and alarm valve are to comply with the dimensional requirements set out in C., Table 1.13. Lines shall be effectively protected against corrosion.

Check valves are to be fitted to ensure that raw water cannot penetrate into the pressure water tank nor water for fire-extinguishing be discharged overboard through pump suction lines.

Hose connections are to be provided at suitable points on the port and starboard sides for supplying the equipment with water from the shore. The connecting valves are to be secured against being opened unintentionally.

Each line leading to a section of the system is to be equipped with an alarm valve (see also 3.1.9).

Shut-off devices located between the pump delivery and the alarm valves are to be secured in the open position.

#### **3.1.8 Sprinklers**

The sprinklers are to be grouped into sections.

A sprinkler section may extend only over one main fire section or one watertight compartment and may

not include more than two vertically adjacent decks.

The sprinklers are to be so arranged in the upper deck area that a water volume of not less than 5  $\ell/(\text{m}^2 \cdot \text{min})$  is sprayed over the area to be protected.

Inside accommodation and service spaces the sprinklers shall be activated within a temperature range from 68 °C to 79 °C. This does not apply to spaces such as drying rooms with higher temperatures. Here the triggering temperature may be up to 30 °C above the maximum temperature in the deck head area.

The nozzles are to be made of corrosion-resistant material. Nozzles of galvanized steel are not allowed.

### **3.1.9 Indicating and alarm systems**

Every sprinkler section is to be equipped with an alarm valve which, when a nozzle is opened, actuates a visual and audible alarm at one or more suitable positions, at least one of which shall be permanently manned. In addition, each alarm valve is to be fitted with a pressure gauge and a test valve with an I.D. corresponding to a spray nozzle.

At the positions mentioned here above, an automatic indicating device is to be mounted which identifies the actuated sprinkler section.

The electrical installation shall be self-monitoring and shall be capable of being tested separately for each section.

## **3.2 Fixed gas fire-extinguishing systems**

### **3.2.1 General**

Fire-extinguishing systems, inert gas systems, CO<sub>2</sub> systems, etc. are to be installed after agreement with BKI in accordance with the BKI Rules.

Fire-extinguishing systems not dealt with in these Rules are to be in compliance with other BKI Rules.

### **3.2.2 Application**

The following requirements apply to fixed fire extinguishing systems for the engine room, boiler room, pump room and all spaces containing essential equipment (switchboards, compressors, etc.) for the refrigeration equipment, if any.

### **3.2.3 Extinguishing agents**

The following extinguishing agents are permitted:

- a) CO<sub>2</sub> (carbon dioxide)
- b) HFC 227 ea (heptafluoropropane) (FM 200)
- c) IG-541 (52 % nitrogen, 40 % argon, 8 % carbon dioxide) (INERGEN)
- d) FK-5-1-12 (dodecafluoro-2-methylpentan-3-one)

Other extinguishing agents are permitted only on the basis of recommendations by the Administrative Committee.

The fixed fire-extinguishing systems according to b) and c) here above shall be type-approved by the class society (based on the requirements laid down in IMO MSC/Circ. 848).

If other extinguishing agents will be permitted, these fixed fire-extinguishing systems are to be type-approved by the class society as well.

### 3.2.4 Ventilation, air extraction

- a) The combustion air required by the combustion engines which ensure propulsion should not come from spaces protected by permanently fixed fire-extinguishing systems. This requirement is not mandatory if the vessel has two independent main engine rooms with a gastight separation or if, in addition to the main engine room, there is a separate engine room installed with a bow thruster that can independently ensure propulsion in the event of a fire in the main engine room.
- b) All forced ventilation systems in the space to be protected shall be shut-down automatically as soon as the fire-extinguishing system is activated.
- c) All openings in the space to be protected which permit air to enter or gas to escape shall be fitted with devices enabling them to be closed quickly from outside the space to be protected. It shall be clear whether they are open or closed.
- e) Air escaping from the pressure-relief valves of the pressurized air tanks installed in the engine rooms shall be led from the pressure-relief valves to the open air.
- f) Overpressure or negative pressure caused by the diffusion of the extinguishing agent shall not cause an unacceptable over- or under pressure in the space concerned. It shall be possible to ensure the safe equalization of pressure.
- f) Protected spaces shall be provided with a means of extracting the extinguishing agent. If extraction devices are installed, it shall not be possible to start them up during extinguishing.

### 3.2.5 Fire-detection system

The space to be protected shall be monitored by an appropriate type-approved fire-detection system. The alarm signal shall be audible in the wheelhouse, the accommodation and the space to be protected.

### 3.2.6 Piping system

- a) The extinguishing agent shall be routed to and distributed in the space to be protected by means of a permanent piping system. Piping installed in the space to be protected and the reinforcements it incorporates shall be made of steel. This shall not apply to the connecting nozzles of tanks and compensators provided that the materials used are fire-resistant and type approved. Piping shall be protected against corrosion both internally and externally.
- b) The discharge nozzles shall be so arranged as to ensure the regular diffusion of the extinguishing agent, also below the floor plates.

### 3.2.7 Triggering device

- a) Automatically activated fire-extinguishing systems are not permitted.
- b) It shall be possible to activate the fire extinguishing system from outside the space to be protected.
- c) Triggering devices shall be so installed that they can be activated in the event of a fire and so that the risk of their breakdown in the event of a fire or an explosion in the space to be protected is reduced as far as possible.

Systems which are not mechanically activated shall be supplied from two energy sources independent of each other. These energy sources shall be located outside the space to be protected. The control lines located in the space to be protected shall be so designed as to remain capable of operating in the event of

a fire for a minimum of 30 minutes. The electrical installations are deemed to meet this requirement if they conform to the IEC 60331-21:1999 standard.

When the triggering devices are so placed as not to be visible, the component concealing them shall carry the "Fire-fighting system" symbol, each side being not less than 10 cm in length, with the following text in red letters on a white ground:

#### FIRE-EXTINGUISHING SYSTEM

- d) If the fire-extinguishing system is intended to protect several spaces, it shall comprise a separate and clearly marked triggering device for each space.
- e) The instructions shall be posted along side all triggering devices and shall be clearly visible and indelible. The instructions are to be at least in a language the master can read and understand and if this language is not English, French or Bahasa, they are to be at least in English, or Bahasa in addition. They shall include information concerning:
  - the activation of the fire-extinguishing system
  - the need to ensure that all persons have left the space to be protected
  - the correct behaviour of the crew in the event of activation
  - the correct behaviour of the crew in the event of the failure of the fire-extinguishing system to function properly
- f) The instructions shall mention that prior to the activation of the fire-extinguishing system, combustion engines installed in the space and aspirating air from the space to be protected shall be shut-down. All ventilation inlet and outlet openings shall be closed prior to the activation of the fire-extinguishing system.

#### **3.2.8 Alarm device**

- a) Permanently fixed fire-extinguishing systems shall be fitted with an audible and visual alarm device.
- b) The alarm device shall be activated automatically as soon as the fire-extinguishing system is first activated. The alarm device shall function for an appropriate period of time before the extinguishing agent is released; it shall not be possible to turn it off.
- c) Alarm signals shall be clearly visible in the spaces to be protected and their access points and be clearly audible under operating conditions corresponding to the highest possible sound level. It shall be possible to distinguish them clearly from all other sound and visual signals in the space to be protected.
- d) Sound alarms shall also be clearly audible in adjoining spaces, with the communicating doors shut, and under operating conditions corresponding to the highest possible sound level.
- e) If the alarm device is not intrinsically protected against short circuits, broken wires and drops in voltage, it shall be possible to monitor its operation.
- f) A sign with the following text in red letters on a white ground shall be clearly posted at the entrance to any space the extinguishing agent may reach:

WARNING, FIRE-EXTINGUISHING SYSTEM!  
LEAVE THIS SPACE IMMEDIATELY  
WHEN THE ... (DESCRIPTION) ALARM IS ACTIVATED!

#### **3.2.9 Pressurized tanks, fittings and piping**

- e) Pressurized tanks, fittings and piping shall conform to the requirements of the competent authority.

- f) Pressurized tanks shall be installed in accordance with the manufacturer's instructions.
- g) Pressurized tanks, fittings and piping shall not be installed in the accommodation.
- h) The temperature of cabinets and storage spaces for pressurized tanks shall not exceed 50 °C.
- i) Cabinets or storage spaces on deck shall be securely stowed and shall have vents so placed that in the event of a pressurized tank not being gastight, the escaping gas cannot penetrate into the vessel. Direct connections with other spaces are not permitted.

### 3.2.10 Quantity of extinguishing agent

If the quantity of extinguishing agent is intended for more than one space, the quantity of extinguishing agent available does not need to be greater than the quantity required for the largest of the spaces thus protected.

### 3.2.11 Fire-extinguishing system operating with CO<sub>2</sub>

In addition to the requirements contained in 3.2.1 to 3.2.10, fire-extinguishing systems using CO<sub>2</sub> as an extinguishing agent shall conform to the following provisions:

- a) Tanks of CO<sub>2</sub> shall be placed in a gastight space or cabinet separated from other spaces. The doors of such storage spaces and cabinets shall open outwards; they shall be capable of being locked and shall carry on the outside the symbol "Warning: danger", not less than 5 cm high and "CO<sub>2</sub>" in the same colours and the same size.
- b) Wherever possible, the CO<sub>2</sub> room to be situated on the open deck. Storage cabinets or spaces for CO<sub>2</sub> tanks located below deck shall only be accessible from the outside. These spaces shall have a mechanical ventilation system with extractor hoods and shall be completely independent of the other ventilation systems on board.
- c) The level of filling of CO<sub>2</sub> tanks shall not exceed 0,75 kg/l. The volume of depressurized CO<sub>2</sub> shall be taken to be 0,56 m<sup>3</sup>/kg.
- d) The concentration of CO<sub>2</sub> in the space to be protected shall be not less than 40 % of the gross volume of the space. 85 % of this quantity shall be released within 120 seconds. It shall be possible to monitor whether diffusion is proceeding correctly.
- e) The opening of the tank valves and the opening of the directional valve shall correspond to two different operations.
- f) The appropriate period of time mentioned in 3.2.8 b shall be not less than 20 seconds. A reliable installation shall ensure the timing of the diffusion of CO<sub>2</sub>.

### 3.2.12 Fire-extinguishing system operating with

HFC-227 ea (heptafluoropropane) – FM 200 In addition to the requirements of 3.2.1 to 3.2.10, fire extinguishing systems using HFC-227 ea as an extinguishing agent shall conform to the following provisions:

- a) Where there are several spaces with different gross volumes, each space shall be equipped with its own fire-extinguishing system.
- b) Every tank containing HFC-227 ea placed in the space to be protected shall be fitted with a device to prevent overpressure. This device shall ensure that the contents of the tank are safely diffused in the

space to be protected if the tank is subjected to fire, when the fire-extinguishing system has not been brought into service.

- c) Every tank shall be fitted with a device permitting control of the gas pressure.
- d) The level of filling of tanks shall not exceed 1,15 kg/l. The specific volume of depressurized HFC-227 ea shall be taken to be 0,1374 m<sup>3</sup>/kg.
- e) The concentration of HFC-227 ea in the space to be protected shall be not less than 8 % of the gross volume of the space. This quantity shall be released within 10 seconds.
- f) Tanks of HFC-227 ea shall be fitted with a pressure monitoring device which triggers an audible and visual alarm in the wheelhouse in the event of an unscheduled loss of propellant gas. Where there is no wheelhouse, the alarm shall be triggered outside the space to be protected.
- g) After discharge, the concentration in the space to be protected shall not exceed 10,5 % (volume).
- h) The fire-extinguishing system shall not comprise aluminium parts.

### **3.2.13 Fire-extinguishing system operating with IG- 541**

In addition to the requirements of 3.2.1 to 3.2.10, fire extinguishing systems using IG-541 as an extinguishing agent shall conform to the following provisions:

- a) Where there are several spaces with different gross volumes, every space shall be equipped with its own fire-extinguishing system.
- b) Every tank containing IG-541 placed in the space to be protected shall be fitted with a device to prevent overpressure. This device shall ensure that the contents of the tank are safely diffused in the space to be protected if the tank is subjected to fire, when the fire-extinguishing system has not been brought into service.
- c) Each tank shall be fitted with a device for checking the contents.
- d) The filling pressure of the tanks shall not exceed 200 bar at a temperature of +15 °C.
- e) The concentration of IG-541 in the space to be protected shall be not less than 44 % and not more than 50 % of the gross volume of the space. This quantity shall be released within 120 seconds.

### **3.2.14 Fire-extinguishing system operating with FK- 5-1-12**

In addition to the requirements of A. to I., fire extinguishing systems using FK-5-1-12 as an extinguishing agent shall conform to the following provisions:

- a) Where there are several spaces with different gross volumes, each space shall be equipped with its own fire-extinguishing system.
- b) Every tank containing FK-5-1-12 placed in the space to be protected shall be fitted with a device to prevent overpressure. This device shall insure that the contents of the tank are safely diffused in the space to be protected if the tank is subjected to fire, when the fire-extinguishing system has not been brought into service.
- c) Every tank shall be fitted with a device permitting control of the gas pressure.
- d) The level of filling of tanks shall not exceed 1,00 kg/l. The specific volume of depressurized FK-5-1-12 shall be taken to be 0,0719 m<sup>3</sup>/kg.



- e) The concentration of FK-5-1-12 in the space to be protected shall be not less than 5,5 % of the gross volume of the space. This quantity shall be released within 10 seconds.
- f) Tanks of FK-5-1-12 shall be fitted with a pressure monitoring device which triggers an audible and visual alarm in the wheelhouse in the event of an unscheduled loss of propellant gas. Where there is no wheelhouse, the alarm shall be triggered outside the space to be protected.
- g) After discharge, the concentration in the space to be protected shall not exceed 10,0 % (volume).

#### **4. General water fire-extinguishing system**

##### **4.1 Fire pumps**

**4.1.1** Self-propelled vessels are to be equipped with a power-driven pump suitable for use as a fire pump.

**4.1.2** The capacity of the fire pump, acting through fire mains and hoses, shall be sufficient to project a least one jet of water to any part of the vessel. This is to be based on a length of throw of 12 m from a 12 mm diameter nozzle. The minimum pump capacity shall be 10 m<sup>3</sup>/h.

**4.1.3** The pump shall have a drive independent of the main propulsion unit. On vessels with a gross volume (L · B · D) of up to 800 m<sup>3</sup> or with a propulsive power of up to 350 kW, a bilge pump or cooling water pump coupled to the main engine may also be used provided that the propeller shafting can be disengaged.

**4.1.4** Combined ballast pumps, bilge pumps or other pumps exclusively pumping water having a sufficient capacity may be accepted as fire pumps and shall be connected to the fire main by means of a non return valve.

**4.1.5** Fire pumps are to be located aft of the forward collision bulkhead.

**4.1.6** Outboard connections for fire pumps are to be located as deep as possible. Pump suction shall be safeguarded even in lightship condition.

##### **4.2 Fire mains and hoses**

**4.2.1** Fire mains are to be so arranged that a water jet can at all times be projected to any part of the vessel through a single length of hose not exceeding 20 m. At least three hydrants are to be provided.

For vessels less than 40 m in length, at least two hydrants are to be provided.

Deck-washing lines may be incorporated in the fire extinguishing system.

**4.2.2** Hoses shall be able to be connected to the fire mains via fire hydrants and quick couplings.

**4.2.3** At least two hoses with dual purpose nozzles are to be provided. These are to be stowed in hose boxes placed close to the hydrants.

Hose boxes are to be properly marked. Hose wrenches are to be provided in every hose box.

##### **4.3 Water fire-extinguishing systems for vessels without self-propulsion**

Where a water fire-extinguishing system is provided on a vessel without self-propulsion, the rules set out in 4.1 and 4.2 are to be applied as appropriate.

#### **5. Portable fire-extinguishers**

## **5.1 Extinguishing media and weights of charge**

**5.1.1** Fire-extinguishers shall have been type-approved, or approved by Authorities.

**5.1.2** In the case of water and foam extinguishers, the charge shall not be less than 9 ℓ and not more than 13,5ℓ.

The weight of the charge in dry powder extinguishers should be at least 6 kg. The maximum weight of a portable fire extinguisher ready for use shall not exceed 20 kg.

**5.1.3** The extinguishing agent shall be suitable at least for the class of fire most likely to occur in the space (or spaces) for which the fire-extinguisher is intended.

On vessels with electrical installations having an operating voltage greater than 50 V, the extinguishing agent shall also be suitable for fighting fire in electrical equipment.

On motor vessels and vessels with oil-fired equipment, engine rooms and accommodation spaces are to be provided with dry powder extinguishers covering class A, B and C fires.

**5.1.4** As extinguishing agent, fire-extinguishers may contain neither CO<sub>2</sub> nor agents capable of emitting toxic gases in use.

Nevertheless, CO<sub>2</sub> extinguishers may be used for galleys and electrical installations.

**5.1.5** Fire-extinguishers with charges which are sensitive to frost or heat are to be mounted or protected in such a way that their effectiveness is guaranteed at all times.

**5.1.6** Where fire-extinguishers are mounted under cover, the covering shall be properly marked.

## **5.2 Number of portable fire-extinguishers**

**5.2.1** One portable fire-extinguisher each is to be provided:

- in the wheelhouse
- at each entrance from the deck to accommodation areas
- at each entrance to spaces which are not accessible from the accommodation area and which contain heating, cooking or cooling equipment operated with solid or liquid fuels or with liquefied gas
- at each entrance to engine rooms
- at each entrance to spaces in which oil-fired auxiliary boilers or heating boilers are installed
- at each entrance to spaces in which materials presenting a fire hazard are stored

**5.2.2** In the part of machinery spaces situated below deck and containing internal combustion engines, additional fire extinguishers are to be mounted in such a way that an extinguisher is accessible in the immediate vicinity of any part of the room.

The number of additional fire-extinguishers shall be as indicated in Table 1.23.

**Table 1.22 Classification of extinguishing media**

<b>Fire class</b>	<b>Fire hazard</b>	<b>Extinguishing media</b>
A	Solid combustible materials of organic nature (e.g. wood, coal, fibre materials)	Water, dry powder, foam
B	Flammable liquids (e.g. oils, tars, petrol)	Dry powder, foam, carbon dioxide
C	Gases (e.g. acetylene, propane)	Dry powder, carbon Dioxide
D	Metals (e.g. aluminium, magnesium, sodium)	Special dry powder

**Table 1.23 Portable fire-extinguishers in machinery space**

<b>Total power [kW]</b>	<b>Number of fire extinguishers</b>
Over 100 up to 375	1
up to 750	2
over 750	1 further extinguisher for each additional 750 Kw or part thereof

**I. Test On Board****1 General****1.1 Application**

**1.1.1** The following covers onboard tests, both at the moorings and during river trials. Such tests are additional to the workshop tests required in the other Subsections.

**1.2 Purpose of onboard tests**

**1.2.1** Shipboard tests are intended to demonstrate that the main and auxiliary machinery and associated systems are functioning properly, in particular in respect of the criteria imposed by the Rules. The tests are to be witnessed in the presence of a BKI Surveyor.

**1.3 Documentation to be submitted**

**1.3.1** A comprehensive list of the shipboard tests intended to be carried out by the shipyard is to be submitted to BKI. For each test, the following information is to be provided:

- scope of the test
- parameters to be recorded

**2. General requirements for shipboard tests****2.1 Trials at the moorings**

Trials at the moorings are to demonstrate the following:

- a) satisfactory operation of the machinery in relation to the service for which it is intended
- b) quick and easy response to operational commands
- c) safety of the various installations, as regards:
  - the protection of mechanical parts
  - the safeguards for personnel
- d) accessibility for cleaning, inspection and maintenance

Where the above features are not deemed satisfactory and require repairs or alterations, BKI reserves the right to require the repetition of the trials at the moorings, either wholly or in part, after such repairs or alterations have been carried out.

## **2.2 River trials**

### **2.2.1 Scope of the tests**

River trials are to be conducted after the trials at the moorings and are to include the following:

- a) demonstration of the proper operation of the main and auxiliary machinery, including monitoring, alarm and safety systems, under realistic service conditions
- b) check of the propulsion capability when one of the essential auxiliaries becomes inoperative
- c) detection of dangerous vibrations by taking the necessary readings when required
- d) checks either deemed necessary for vessel classification or requested by the interested parties and which are possible only in the course of navigation

### **2.2.2 Exemptions**

Exemption from some of the river trials may be considered by BKI in the case of vessels having a sister ship for which the satisfactory behaviour in service is demonstrated.

Such exemption is, in any event, to be agreed upon by the interested parties and is subject to the satisfactory results of trials at the moorings to verify the safe and efficient operation of the propulsion system.

## **3 Shipboard tests for machinery**

### **3.1 Conditions of river trials**

#### **3.1.1 Displacement of the vessel**

Except in cases of practical impossibility, or in other cases to be considered individually, the river trials are to be carried out at a displacement as close as possible to the deadweight (full load) or to one half of the deadweight (half load).

#### **3.1.2 Power of the machinery**

- a) The power developed by the propulsion machinery in the course of the river trials is to be as close as possible to the power for which classification has been requested. In general, this power is not to exceed the maximum continuous power at which the weakest component of the propulsion system can be operated. In cases of diesel engines and gas turbines, it is not to exceed the maximum

continuous power for which the engine type concerned has been reviewed/ approved.

- b) Where the rotational speed of the shafting is different from the design value, thereby increasing the stresses in excess of the maximum allowable limits, the power developed in the trials is to be suitably modified so as to confine the stresses within the design limits.

### **3.1.3 Determination of the power and rotational speed**

- a) The rotational speed of the shafting is to be recorded in the course of the river trials, preferably by means of a continuous counter.
- b) In general, the power is to be determined by means of torsionometric readings, to be effected with procedures and instruments deemed suitable by BKI.

As an alternative, for reciprocating internal combustion engines and gas turbines, the power may be determined by measuring the fuel consumption and on the basis of the other operating characteristics, in comparison with the results of bench tests of the prototype engine.

Other methods of determining the power may be considered by BKI on a case-by-case basis.

## **3.2 Navigation and maneuvering tests**

### **3.2.2 Speed Trials**

- a) Where required, the speed of the vessel is to be determined using procedures deemed suitable by BKI.
- b) The vessel speed is to be determined as the average of the speeds taken in not less than two pairs of runs in opposite directions.

### **3.2.2 Astern Trials**

- a) The ability of the machinery to reverse the direction of thrust of the propeller in sufficient time, and so to bring the vessel to rest within reasonable distance from maximum ahead service speed, shall be demonstrated and recorded.
- b) The stopping times, vessel headings and distances recorded on trials, together with the results of trials to determine the ability of vessels having multiple propellers to navigate and manoeuvre with one or more propellers in operative shall be available on board for the use of the Master or designated personnel.
- c) Where the vessel is provided with supplementary means for maneuvering or stopping, the effectiveness of such means shall be demonstrated and recorded as referred to in paragraphs a) and b).

## **3.3 Test of diesel engines**

### **3.3.1 General**

- a) The scope of the trials of diesel engines may be expanded in consideration of the special operating conditions, such as towing, etc.
- b) Where the machinery installation is designed for residual or other special fuels, the ability of engines to burn such fuels is to be demonstrated.

### **3.3.2 Main propulsion engines driving fixed propellers**

River trials of main propulsion engines driving fixed propellers are to include the following tests:

- a) operation at rated engine speed  $n_0$  for at least 2 hours
- b) operation at engine speed corresponding to normal continuous cruise power for at least 1 hours
- c) operation at engine speed  $n = 1,032 \cdot n_0$  for 30 minutes
- d) operation at minimum load speed
- e) starting and reversing maneuvers
- f) operation in reverse direction of propeller rotation at a minimum engine speed of  $n = 0,7 \cdot n_0$  for 10 minutes
- g) tests of the monitoring, alarm and safety systems
- h) for engines fitted with independently driven blowers, emergency operation of the engine with the blowers inoperative

**Notes**

- *The test in c) is to be performed only where permitted by the engine adjustment.*
- *The test in f) may be performed during the dock or rivers trials.*

**3.3.3 Main propulsion engines driving controllable pitch propellers or reversing gears**

- a) The scope of the river trials for main propulsion engines driving controllable pitch propellers or reversing gears is to comply with the relevant provisions of 3.3.1.
- b) Engines driving controllable pitch propellers are to be tested at various propeller pitches.

**3.3.4 Engines driving generators for propulsion**

River trials of engines driving generators for propulsion are to include the following tests:

- a) operation at 100 % power (rated power) for at least 2 hours
- b) operation at normal continuous cruise power for at least 1 hours
- c) operation at 110 % power for 30 minutes
- d) operation in reverse direction of propeller rotation at a minimum engine speed 70 % of the nominal propeller speed for 10 minutes
- e) starting maneuvers
- f) tests of the monitoring, alarm and safety systems

**Notes**

- *The test in d) may be performed during the dock or river trials.*
- *The above tests a) to f) are to be performed at rated speed (with a constant governor setting). The powers refer to the rated electrical powers of the driven generators.*

**3.3.5 Engines driving auxiliaries**

- a) Engines driving generators or important auxiliaries are to be subjected to an operational test for at

least 2 hours. During the test, the set concerned is required to operate at its rated power for at least 1 hours.

- b) It is to be demonstrated that the engine is capable of supplying 100 % of its rated power and, in the case of shipboard generating sets, account is to be taken of the times needed to actuate the generator's overload protection system.

### 3.4 Tests of gears

#### 3.4.1 Tests during river trials

During the river trials, the performance of reverse and/or reduction gearing is to be verified, both when running ahead and astern.

In addition, the following checks are to be carried out:

- check of the bearing and oil temperature
- detection of possible gear hammering, where required
- test of the monitoring, alarm and safety systems

#### 3.4.2 Check of the tooth contact

- a) Prior to the start of river trials, the teeth of the gears belonging to the main propulsion plant are to be coloured with suitable dye to enable the contact pattern to be established. During the river trials, the gears are to be checked at all forward and reverse speeds to establish their operational efficiency and smooth running as well as the bearing temperatures and the pureness of the lubricating oil. At latest on conclusion of the river trials, the gearing is to be examined via the inspection openings and the contact pattern checked. If possible the contact pattern has to be checked after conclusion of every load step. Assessment of the contact pattern is to be based on the guide values for the proportional area of contact in the axial and radial directions of the teeth given in Table 1.24 and shall take account of the running time and loading of gears during the river trial.
- b) In the case of multistage gear trains and planetary gears manufactured to a proven high degree of accuracy, checking of the contact pattern after river trials may, with the consent of BKI, be reduced in scope.

**Table 1.24 Percentage area of contact**

Material Shaping of teeth	Working depth (without tip relief)	Width of tooth (without end relief)
heat-treated, hobbed, formed by generating method	33 % average values	70 %
surface-hardened, ground, shaved	40 % average values	80 %

### 3.5 Tests of main propulsion shafting and propellers

#### 3.5.1 Shafting vibrations

Torsional, bending and axial vibration measurements are to be carried out where required by B.5. The type of the measuring equipment and the location of the measurement points are to be specified.

### **3.5.2 Bearings**

The temperature of the bearings is to be checked under the machinery power conditions specified in 3.1.2

### **3.5.3 Stern tube sealing gland**

The stern tube oil system is to be checked for possible oil leakage at the stern tube seal.

### **3.5.4 Propellers**

- a) For controllable pitch propellers, the functioning of the system controlling the pitch from full ahead to full astern position is to be demonstrated. It is also to be checked that this system does not induce any overload of the engine.
- b) The proper functioning of the devices for emergency operations is to be tested during the river trials.

## **3.6 Tests of piping systems**

### **3.6.1 Functional tests**

During the river trials, piping systems serving propulsion and auxiliary machinery, including the associated monitoring and control devices, are to be subjected to functional tests at the nominal power of the machinery. Operating parameters (pressure, temperature, consumption) are to comply with the values recommended by the equipment manufacturer.

### **3.6.2 Performance tests**

BKI reserves the right to require performance tests, such as flow rate measurements, should doubts arise from the functional tests.

## **3.7 Tests of steering gear**

### **3.7.1 General**

- a) The steering gear is to be tested during the river trials under the conditions stated in 3.1 in order to demonstrate, to the Surveyor's satisfaction, that the applicable requirements of E. are fulfilled.
- b) For controllable pitch propellers, the propeller pitch is to be set at the maximum design pitch approved for the maximum continuous ahead rotational speed.
- c) If the vessel cannot be tested at the deepest draught, alternative trial conditions will be given special consideration by BKI. In such case, the vessel speed corresponding to the maximum continuous number of revolutions of the propulsion machinery may apply.

### **3.7.2 Tests to be performed**

Tests of the steering gear are to include at least:

- a) functional test of the main and auxiliary steering gear with demonstration of the performances required by E.4.2 and E.4.3
- b) test of the steering gear power units, including transfer between steering gear power units
- c) test of the isolation of one power actuating system, checking the time for regaining steering capability
- d) test of the hydraulic fluid refilling system



- e) test of the alternative power supply required by E.4.4
- f) test of the steering gear controls, including transfer of controls and local control
- g) test of the means of communication between the navigation bridge, the engine room and the steering gear compartment
- h) test of the alarms and indicators
- i) Where the steering gear design is required to take into account the risk of hydraulic locking, a test is to be performed to demonstrate the efficiency of the devices intended to detect this.

**Notes**

- *Tests d) to i) may be carried out either during the mooring trials or during the river trials.*
- *For vessels of less than 500 tons gross tonnage, BKI may accept departures from the above list, in particular to take into account the actual design features of their steering gear.*
- *Azimuth thrusters are to be subjected to the above tests, as far as applicable.*

**3.8 Tests of windlasses**

**3.8.1** The working test of the windlass is to be carried out in the presence of a Surveyor.

**3.8.2** The anchor equipment is to be tested during river trials. As a minimum requirement, this test is required to demonstrate that the conditions specified in B.7.4 can be fulfilled.

**4 Inspection of machinery after river trials****4.1 General**

- a) For all types of propulsion machinery, those parts which have not operated satisfactorily in the course of the river trials, or which have caused doubts to be expressed as to their proper operation, are to be disassembled or opened for inspection.

Machinery or parts which are opened up or disassembled for other reasons are to be similarly inspected.

- b) Should the inspection reveal defects or damage of some importance, BKI may require other similar machinery or parts to be opened up for inspection.
- c) An exhaustive inspection report is to be submitted to BKI for information.

**4.2 Diesel engines**

- a) In general, for all diesel engines, the following items are to be verified:
  - the deflection of the crankshafts, by measuring the variation in the distance between adjacent webs in the course of one complete revolution of the engine
  - the cleanliness of the lubricating oil filters.
- b) In the case of propulsion engines for which power tests have not been carried out in the workshop, some parts, agreed upon by the interested parties, are to be disassembled for inspection after the river trials.

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