SEATING OF PROPULSION PLANTS AND AUXILIARY MACHINERY

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This latest edition incorporates all rule changes. The latest revisions are shown with a vertical line. The section title is framed if the section is revised completely. Changes after the publication of the rule are written in red colour.

Unless otherwise specified, these Rules apply to ships for which the date of contract for construction as defined in TL- PR 29 is on or after 1st of January 2022. New rules or amendments entering into force after the date of contract for construction are to be applied if required by those rules. See Rule Change Notices on TL website for details.

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# SEATING OF PROPULSION PLANTS AND AUXILIARY MACHINERY

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A. General

1. Scope

These Guidelines apply to the seating of propulsion plants and auxiliary machinery onto their structural foundation in sea-going and inland vessels and cover the mounting, fixing and securing of all associated plant components.

2. Documents for approval

2.1 Documents to be submitted

2.1.1 General

2.1.1.1 For the seating of a propulsion plant with the primary components of the driving chain, such as:

- main internal combustion engines, main turbines, diesel-electric drive (electric motor, generator and internal combustion engine or turbine)
- main gearboxes with secondary drives
- thrust blocks
- shaft bearings
- shaft generator plants and also for the seating of
- steering gears
- windlasses as well as for
- stern tubes fixed by cast resin

the following documents are to be submitted to TL electronically via EPAS or in paper form in triplicate for approval. EPAS submission is the preferred option.

2.1.1.2 Dimensioned assembly drawing including parts list with details concerning

- arrangement, number and size of chocks
- arrangement, number and dimensions of foundation bolts (through bolts and fitted bolts), nuts, extension sleeves, fitted sleeves, clamping sleeves, pins, washers, and disc springs
- materials for chocks, stoppers, foundation bolts, nuts, extension sleeves, fitted sleeves, clamping sleeves, pins, washers, and disc springs

2.1.3 Dimensioned section drawings in the vicinity of various foundation bolts.

2.1.4 Dimensioned individual part drawings of various foundation bolts.

2.1.5 Calculations for the requisite preloading forces and bolt elongations with details of the procedure for bolt tightening.

2.1.2 Seating on cast resin

For seating on cast resin the following procedure for submitting the documentation has to be applied:

- The name of manufacturer and the designation of the cast resin have to be submitted.
- The name of the application company of the cast resin has to be submitted.
- The documentation, which has been established by the shipyard for an actual mounting, has to be checked, confirmed and as far as necessary made up by the cast resin manufacturer or the application company.
- The documents created in this way have to be submitted to TL for approval exclusively by the cast resin manufacturer or an authorized representative.
It shall be avoided, that the shipyard as well as the cast resin manufacturer or the application company submit their documents separately to TL.

2.1.3 Resilient mounting

In the case of a resilient mounting the following documents are to be submitted additionally:

2.1.3.1 Description of the complete spring-mass system

2.1.3.2 Arrangement, number and securing measures for the resilient mounting components, vibration amplitude limiters, and, where appropriate, locking devices.

2.1.3.3 Specification data for the resilient mounting components:

- manufacturer
- designation, type, dimensions, shore hardness
- spring stiffness for the horizontal and vertical loading directions (static and dynamic)
- damping coefficients
- characteristic curves for the horizontal and vertical load direction with details concerning permissible continuous load
- data concerning the time settling behaviour at ambient conditions, compare the TL Rules, Chapter 4, Machinery, Section 1, C.

2.1.3.4 Specification data for the torsionally flexible coupling as well as for the essential flexible pipe connections.

2.1.3.5 Calculation of the natural frequencies of the total vibrational system for 6 degrees of freedom.

2.1.3.6 Calculation of the static displacements in the x, y, and z directions at the flexible system components, on the basis of all loadings effective at rated power, resulting from the engine’s dead weight, the engine’s rated torque, or shaft torque where there is a close-coupled gearbox, the ship’s angles of inclination (athwartship/for-and-aft), and, if applicable, propeller thrust.

2.1.3.7 Comparison of the calculated displacements with the permissible values for the flexible system components.

2.1.3.8 Calculation for the forced, damped vibrations. This calculation is only to be submitted when requested by TL. It is required if the natural frequency calculation predicts important resonances within the operating speed range.

For operation with misfiring, evidence for the acceptance of the loadings must be proved by calculation. The results from the calculation must be commented upon appropriately. Barred speed ranges are to be defined, and a comparison must be carried out of the amplitudes calculated with the values permissible for the flexible system components.

2.1.3.9 The main data and the results of the calculation for resilient mounting have to be summarized.

2.1.3.10 Trial measurements

Insofar as deemed necessary by TL, the proper design for the resilient mounting is to be verified by means of measurement in the course of the sea trial. The test program must be agreed with TL.

2.2 Documents to be presented to the TL Surveyor

On request the following documents have to be presented to the Surveyor:

- the documentation according to 2.1
- documents in analogous form as in 2.1 for mountings of auxiliary machinery not defined in 2.1.1.1
2.3 Deviations from the defined scope

Deviations from the scope defined in 2.1 and 2.2 will be defined, if necessary, case by case by TL.

B. Principles for the Workmanship of Seatings

1. General requirements

1.1 For the design and construction of ships’ structural foundations and their sub-structures TL Rules, Chapter 1, Hull apply.

1.2 Access to the assembly and inspection openings provided in the propulsion plant for maintenance activities must be maintained.

1.3 Each seating must only be carried out after completion of the process of alignment, where alignment is to be carried out taking into account thermal expansion under operational conditions and the dynamic behaviour of the plant components (coupling, gearbox, etc).

Care must be taken that the alignment of the individual plant components with respect to each other is not altered during the seating activities.

Before seating, all welding procedures in the seating area have to be finished.

1.4 In the course of the seating of the individual plant components the installation instructions of the manufacturers must be observed.

1.5 The seating must be carried out under the supervision of TL.

2. Mounting

2.1 Rigid mounting

A rigid mounting is a direct connection of the plant components to the ship’s structural foundations using rigid chocks.

The chocks must be of the same material throughout. Any deviations require the agreement of TL.

The use of shims is not permissible.

All innovative types of rigid mountings have to be approved by TL in advance. The kind of approval and the scope of examination will be defined by TL in individual cases.

2.1.1 Metal chocks

2.1.1.1 Metal chocks are preferably to be manufactured from steel, including cast steel; the use of grey iron is permissible.

To enable satisfactory adjusting of the chocks, the top plates of the foundations are to be machined in the vicinity of the chocks.

Multi-layer chocks are to be avoided.

Cut-outs in chocks should not amount to more than 20 % of the total surface area.

Chocks must be finished and trued up on both surfaces. The load-bearing area of the chock must amount to at least 75%.

Tack welds are not permissible on chocks.

2.1.1.2 Metal chocks with adjustable height have to be approved by TL for every application.

2.1.2 Cast resin chocks

2.1.2.1 The casting compounds provided for the manufacture of the cast resin chocks must be approved by TL for applications according to these Guidelines.

The chocks may only be poured by companies authorized by the cast resin manufacturer whilst maintaining the boundary conditions required by the process.
Authorization respectively evidence of training the personnel performing the cast resin process by the cast resin manufacturer has to be presented to the local TL Surveyor on request.

For approval of the submitted documentation see A.2.1.2

2.1.2.2 Two foundation bolts should as far as possible be located in each cast resin chock.

The height of a cast resin chock should in normal circumstances be between 20 and 50 mm. Lower or greater chock heights are possible dependent on the cast resin approval conditions. Under no circumstances may the height of the chock exceed the width or length of the chock.

Cast resin chocks may only be placed under load if the casting compound has achieved the requisite minimum hardness. This is to be verified by means of a hardness test.

2.1.2.3 Plant components mounted on cast resin are to be fitted with a reference plate that must contain the following details:

- name of the company carrying out the work
- designation of the casting compound
- tightening values of the foundation bolts
- date of pouring

The reference plate is to be manufactured in metal or plastic and permanently secured.

2.2 Resilient mounting

2.2.1 A resilient mounting is a connection of the plant components to the ship’s structural foundations using resilient mounting components.

Resilient mounts are to be type approved by TL.

2.2.2 See also the TL Rules, Chapter 4, Machinery, Section 1, D.4.

2.2.3 The resilient mounting of high speed and medium speed diesel engines is primarily used in order to reduce the transmission of vibrations and structure-borne sound into the ship’s hull. The desired insulation effect can, however, only be achieved if the natural frequencies of the resilient mounting are sufficiently separated from the excitation frequencies. For plants operating at constant speed a safety margin of at least 10 % between the rated speed and the resonance speed must be maintained.

2.2.4 In the design of a resilient mounting account must be taken of the ageing and natural wear of the mounting components. The settling rates over defined time intervals must be checked and recorded in accordance with the manufacturer’s details. When the maximum permissible amount of settling is reached the resilient mounting must be renewed.

2.2.5 Pipe connections to resiliently mounted plant components require flexible connectors, which must be held as short as possible, type approved by TL and, insofar as prescribed by TL, must be designed to be flame-resistant. Flexible hoses are preferably to be installed in the length-wise direction of the plant with a small amount of slack.

2.2.6 Mounting components

The properties (quality, elasticity and loading direction) of the resilient mounting components must be matched to vibrational conditions and component weights.

The mounting components are to be arranged so that an uniform loading is ensured.

Mounting components must be protected effectively and permanently against the effects of oil and fuel.

To limit the vibrational amplitudes a sufficient number of buffer stops are to be installed.

3. Fixing to the foundation

3.1 Instructions for installation

In order to ensure the fixing of the propulsion plant
under all operating conditions, the individual plant components must be effectively and permanently secured to the foundations in accordance with the manufacturers instructions for installation.

3.2 Choice of fixing

The fixing can, according to choice, be carried out by means of:

- fitted bolts or fitted sleeves located at the drive end in conjunction with side stoppers, see Annex A, Fig. A.4

- front stoppers located at the drive end with bolted connection to the engine in conjunction with side stoppers, see Annex A, Fig. A.7

- front stoppers in conjunction with fitted bolts (in the case of gear boxes with an integrated thrust bearing), see Annex A, Figs. A.8 and A.9

- fitted pins and clamping sleeves (only permissible for smaller plants)

- special configurations (in accordance with the instructions of the component manufacturers), see Annex A, Figs. A.5 and A.6

3.3 Chocks

Chocks for front and side stoppers are to be made from metallic materials. There must be metal-to-metal contact on both sides and they must be secured against displacement.

For propulsion plants the stopper chocks are to be manufactured to a wedge or double wedge design. Positioning of the wedge-shaped chocks without clearance must be executed with the plant at its operating thermal condition. The subsequent fixing is preferably to be ensured by welding up the wedges over the entire wedge length, see Annex A, Figs. A.10, A.11 and A.12.

3.4 Stoppers

For the seating of high speed and medium speed engines with more than 6 cylinders in one line and a cylinder diameter ≥ 250 mm, a further pair of side stoppers is to be provided near the midpoint of the engine length, in the vicinity of a bearing stool, in addition to the side stopper pair at the opposite end to the coupling.

The transmission of the propeller thrust to the ship’s structure can be achieved via front stoppers or fitted bolts.

According to the special conditions of a mounting on cast resin chocks, the conditions of 4.2.2.2 are to be observed.

Front stoppers are to be structurally designed so that they can withstand the maximum ahead and astern occurring propeller thrust, without taking into account the foundation bolt preloading.

Examples of stopper arrangements for engines and steering gears can be found in Annex A

4. Securing to the foundation

4.1 General

Only bolted joints are permissible for securing the propulsion plants to the ship’s structural foundations, see Annex A, Figs. A.13 - A.17.

4.1.1 Foundation bolts (through bolts and fitted bolts) are, if at all possible, to be designed as headed bolts, and are to be installed so that a check of the bolt preloading can be executed at any time.

The requisite preloading of the foundation bolts is to be specified in co-ordination with the engine manufacturer or the manufacturer of the individual plant component.

4.1.2 When using necked-down bolts (bolts with a reduced shank diameter) the shank diameter has to be less than the thread root diameter but on the other hand may not be less than 80 % of the thread root diameter. Otherwise subsequent heat treatment
and/or material testing of the finished bolts must be carried out.

4.1.3 Tack welds are not permissible on foundation bolts and nuts.

4.1.4 The mating surfaces for bolt heads, nuts and extension sleeves on the bed plates and top plates must be machined plane parallel.

4.1.5 In order to hold amounts of settling as small as possible, the number of parting lines in the bolted joints is to be limited to a minimum.

If washers are necessary, they must be provided to a machined and rigid design. Collared washers are to be located as required, see Annex A, Fig. A.17.

4.1.6 For the layout of the foundation bolts a sufficient high utilisation of the bolt material has to be considered. It is recommended to provide in the range of the minimum bolt cross section an utilisation of at least 70% of the material’s yield strength.

4.2 Foundation bolts

4.2.1 Mounting on metal chocks

4.2.1.1 Bolted joints are to be dimensioned so that, according to calculation, a bolt elongation of at least 0.25 mm is achieved under the requisite preloading, see calculation example in C.6.

4.2.1.2 Fitted bolts are to be specified for fixing and securing the plant components. With appropriate dimensioning, fitted bolts can be taken into account for the transmission of propeller thrust.

4.2.1.3 The nuts for the foundation bolts must be secured with locking nuts. Self-locking nuts are permissible. Securing of the nut can be dispensed with if the bolted joint is based on a bolt prestress, calculated on the thread root cross-sectional area, of at least 250 N/mm².

4.2.2 Mounting on cast resin chocks

4.2.2.1 Foundation bolts are preferably to be designed as necked-down bolts. The requisite preloading for the foundation bolts is to be established by the companies involved in the seating, taking account of the surface pressure approved by TL for the cast resin that is to be used. Here care must be taken that the bolt preloading defined by the permissible surface pressure for the cast resin is greater than the load acting on the bolted joint under maximum operational loading conditions.

4.2.2.2 Fitted bolts must be provided on principle for fixing and securing the plant components; they must not be taken into account in the transmission of propeller thrust.

For directly coupled 2-stroke combustion engines, fitted bolts can be accepted for the transmission of propeller thrust under the following conditions:

- agreement of the engine manufacturer or licensee is provided
- agreement of the cast resin producer is provided
- fitting bolts have been structurally designed so, that they can withstand the maximum occurring ahead and astern propeller thrust without taking into account the preloading of the foundation bolts
- on request by TL a commented calculation of the loads in the fitted bolts is provided

4.2.2.3 Bolted joints are to be dimensioned so, that under the requisite preloading, a calculated minimum bolt elongation is achieved as a function of the cast resin surface pressure that is present, see calculation example in C.6.

4.2.2.4 The nuts of the foundation bolts are to be secured with locking nuts. Self-locking nuts are permissible. Securing of the nut can be dispensed with if the bolted joint is based on a bolt pre-stress, calculated on the thread root cross-sectional area, of at least 150 N/mm² for high speed and medium speed engines, or 100 N/mm² for low speed engines respectively, see calculation example in C.8.
4.3 Materials

4.3.1 Quality standards

The quality standards for the foundation bolts and nuts must correspond to the TL Rules, Chapter 2, Material, Section 14, C. and have to be tested.

4.3.2 Certificates

For new seatings, evidence of quality standards is to be provided in form of TL Material Certificates according to TL Rules, Chapter 2, Material, Section 1, F., which have to be issued by a TL Surveyor.

Standardized, in bulk production manufactured bolts and nuts with threads up to M 39, which are made from alloyed or unalloyed steel of the strength category according to ISO 898 (EN 20898-1 and -2), and which are subject to a continuous quality control, may be accepted with Manufacturer's Inspection Certificates according to TL Rules, Chapter 2, Material, Section 1, F., with details concerning the chemical and mechanical characteristics of the material.

For auxiliary machinery and in case of repairs Manufacturer's Inspection Certificates according to TL Rules, Chapter 2, Material, Section 1, F. with details concerning the mechanical and chemical characteristics of the material may be accepted with agreement of the TL Surveyor.

5. Surveys after the sea trials

Directly following the sea trials the seating of propulsion plants has to be checked visually and the tightening torque/hydraulic pressure of the main engine foundation bolts has to be measured and recorded.

C. Basic Calculations

The following basic calculations are mainly valid for cast resin chocks, but they may basically be transferred also to other types of mountings, as e.g. metal chocks.

1. Definitions, symbols and units

\[ A_e = \text{Effective total mating surface of cast resin chocks [mm}^2\text{]} \]

\[ A_m = \text{Required minimum mating surface of cast resin chocks [mm}^2\text{]} \]

\[ A_p = \text{Effective piston area of hydraulic tension device [mm}^2\text{]} \]

\[ D_m = \text{Minimum shank diameter of foundation bolt [mm]} \]

\[ D_o = \text{Outer diameter of thread of foundation [mm]} \]

\[ D_r = \text{Thread root diameter of foundation bolt [mm]} \]

\[ D_s = \text{Shank diameter of foundation bolt [mm]} \]

\[ D_{s1} \ldots D_{si} = \text{Individual shank diameters of foundation bolt corresponding to } L_1 \ldots L_i \text{ [mm]} \]

\[ F_o = \text{Axial bolt force exerted on each bolt under operational loading conditions [N]} \]

\[ F_p = \text{Preloading force exerted on each bolt by tightening [N]} \]

\[ k = \text{Hydraulic coefficient for setting and resilience behaviour [-]} \]

\[ \Delta L = \text{Theoretical elongation of foundation bolt [mm]} \]

\[ \Delta L_m = \text{Required minimum theoretical elongation of foundation bolt [mm]} \]

\[ L_1 \ldots L_i = \text{Individual part shank lengths of foundation bolt corresponding to } D_{s1} \ldots D_{si} \text{ [mm]} \]

\[ n = \text{Number of foundation bolts [-]} \]

\[ p_a = \text{TL approved surface pressure [N/mm}^2\text{]} \]
2. Calculation of the required minimum mating surface of cast resin chocks

\[
A_m = \frac{W}{p_w} \quad [N/mm^2]
\]

Boundary conditions:
- \( p_w \leq 0.7 \) [N/mm²]
- \( 0.7 < p_w \leq 0.9 \) [N/mm²] with special authorization by TL
- \( A_m \leq A_e \) [mm²]

3. Calculation of preloading force exerted on one foundation bolt by tightening

\[
F_p = \frac{(p_t - p_w) A_e}{n} \quad [N]
\]

Boundary conditions:
- \( p_t \leq p_a \) [N/mm²]
- \( F_p > F_o \) [N]

4. Calculation of tightening torque of foundation bolt if using a torque wrench

\[
T = \frac{F_p \cdot D_o}{5000} \quad [Nm]
\]

Boundary conditions:
- The calculation is valid for steel foundation bolts with usual standard thread and oil-lubricated thread courses and nut mating surfaces without slide additives, such as Molybdendisulfid (MoS₂), being used.
- If such additives are used, the preloading forces actually applied have to be proved to TL by measurements.

5. Calculation of hydraulic pressure if using hydraulic tension device

\[
p_h = 10 \frac{F_p}{A_p \cdot k} \quad [bar]
\]

Boundary conditions:
- \( k = 0.85 \)
- If hydraulic coefficients k are to be used which deviate from the given one the preloading forces actually applied have to be proved to TL by measurements.

6. Calculation of bolt elongation on basis of preloading force

\[
\Delta L = F_p \left( \frac{L_1}{D_1^2} + \frac{L_2}{D_2^2} + \ldots + \frac{L_i}{D_i^2} \right) 618 \cdot 10^{-8} \quad [mm]
\]

Boundary conditions:
- \( \Delta L \geq \Delta L_m \)

Cast resin chocks.
- \( \Delta L_m = 0.0343 p_t \) [mm] for \( p_t \geq 3.5 \) [N/mm²]
- \( \Delta L_m = 0.12 \) [mm] for \( p_t < 3.5 \) [N/mm²]

Metal chocks.
ΔLₘᵢ = 0.25 [mm]

7. Calculation of equivalent and/or tensile stress related to the minimum shank diameter of foundation bolt on basis of preloading force

7.1 Tightening of bolts by torque wrench

7.1.1 Bolt with non-reduced shank diameter (Dₘ = Dₛ)

\[ \sigma_e = 1.5 \frac{F_p}{D_r^2} \quad [N/mm^2] \]

Boundary conditions:
\[ \sigma_e \leq 0.9 R_{eh} [N/mm^2] \]

7.1.2 Necked-down bolt with reduced shank (0.8 Dₛ ≤ Dₘ < 1.0 Dₛ)

\[ \sigma_e = 1.72 \frac{F_p}{D_m^2} \sqrt{0.6 + \frac{D_f}{D_m^2} (P + 0.2 D_f)} \quad [N/mm^2] \]

Boundary condition:
\[ \sigma_e \leq 0.9 R_{eh} [N/mm^2] \]

7.2 Tightening of bolts by hydraulic tension device

\[ \sigma_t = 1.274 \frac{F_p}{D_m^2} \quad [N/mm^2] \]

Boundary condition:
\[ \sigma_t \leq 0.8 R_{eh} [N/mm] \] for \[ k = 0.85 \]

8. Calculation of tensile stress related to thread root diameter of foundation bolt on basis of preloading force

\[ \sigma_t = 1.274 \frac{F_p}{D_r^2} \quad [N/mm^2] \]

8.1 Criterion for locking of nuts

Locking of nuts is required under following proviso
\[ \sigma_t < 150 [N/mm^2] \]

For low-speed engines is valid:
\[ \sigma_t < 100 [N/mm^2] \]
Bolt Material: ........................................

Yield Strength: .......................... N/mm²

Figure A.2 - Foundation Bolt
Bolt material: ........................................

Yield Strength:   ................................ N/mm²

Figure A.3 - Fitted Foundation Bold
Figure A.4 - Illustration of method of locating engine on seating using fitted bolts and side stoppers.
Figure A.5 - Illustration of method of locating engine on seating using side stoppers and fitted bolts located at one engine side.
Figure A.6: Illustration of method of locating engine on seating using side stoppers and fitted bolts located at one side and in the middle of the engine.
Figure A.7 Illustration of method of locating engine on seating using front and side stoppers

- Front stopper with bolted connection
- Drive end
- C.L. Thrust bearing
- C.L. No. 1 Cyl.
- C.L. No. 2 Cyl.
- C.L. No. 3 Cyl.
- C.L. No. 4 Cyl.
- C.L. No. 5 Cyl.
- C.L. No. 6 Cyl.
- Side stopper
- Through bolts
- Adjusting screw
- Top plate
- Chocks
Figure A.8 - Illustration of method of locating propulsion plant with main engine and separate gear box.

- 8-cyl. Main engine with 2 pairs of side stopper
- Cyl. 1, Cyl. 2, Cyl. 3, S.Cyl. 4, Cyl. 5, Cyl. 6, Cyl. 7, Cyl. 8
- Elastic coupling
- Main gear box with integrated thrust bearing
- Propeller
- Fitted bolts
- Side stoppers
- Front stoppers
Figure A.9 Illustration of method of locating propulsion plant with main engine and close-coupled gear box.
Figure A.10 Illustration of a side stopper when mounting on metal chocks.
Figure A.11 - Illustration of a side stopper when mounting on cast resin chocks
Bed plate
(engine, gear etc.)

Metal chock

Machined plate parallel

Front stopper

Figure A.12 - Illustration of a front stopper with bolted connection and metal chock
Figure A.13  Principal arrangement for the fixing of a rudder drive with double acting cylinders

= Stopper to be provided
Figure A.14 Principal arrangement for the fixing of a rudder drive with single acting cylinders

Stopper to be provided
Figure A.15 - Principal arrangement for the fixing of a rudder drive with rotating piston

Stopper to be provided
Figure A.16 Illustration of a front stopper with bolted connection and metal chock
Figure A.17 - Illustration of a fitted bolt connection when mounting on metal chocks
Figure A.18 Illustration of a necked-down bolt connection with fitted sleeve when mounting on cast resin chocks
Figure A.19 Illustration of a necked-down bolt connection when mounting on cast resin chocks
Figure A.20 Illustration of a necked-down bolt connection with fitted sleeve when mounting on cast resin chocks