Review of Shaft-related Requirements

Object of Amendment

Rules for the Survey and Construction of Steel Ships Part D
Rules/Guidance for the Survey and Construction of Inland Waterway Ships
Guidance for the Approval of Materials and Equipment for Marine Use

Reason for Amendment

IACS Unified Requirement (UR) M56 specifies requirements for strength calculations of marine gears, which have already been incorporated into the NK Rules. IACS recently adopted a revised version as UR M56(Rev.4, Corr.3) to clarify certain provisions.

In addition, NK reviewed its shaft-related requirements (such as the calculation of the required diameter of propeller shafts stipulated in Part D of the Rules for the Survey and Construction of Steel Ships), requirements regarding the terms used for the classification of main shafts in waterjet propulsion systems and other related requirements to ensure consistency with other rules and relevant URs.

Accordingly, relevant requirements are amended based on UR M56(Rev.4, Corr.3) and NK's internal review.

Outline of Amendment

The main contents of this amendment are as follows:

(1) Clarifies the calculation method for the strength of marine gears.
(2) Amends the terms regarding the classification of main shafts in waterjet propulsion systems.
(3) Clarifies the calculation method for the required shaft diameter between the forward stern tube sealing system and the intermediate shaft on the propeller shaft.
(4) Specifies the requirements related to the conditions of test products for approval tests of synthetic materials intended for use in aftmost stern tube bearings and aftermost shaft bracket bearings.

Effective Date and Application

Effective date of this amendment is 1 July 2026.

An asterisk (*) after the title of a requirement indicates that there is also relevant information in the corresponding Guidance.

ID:DD25-25

Amended-Original Requirements Comparison Table (Review of shaft-related requirements)

Amended	Original	Remarks
RULES FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS **Part D MACHINERY INSTALLATIONS** **Chapter 6 SHAFTINGS** **6.2 Materials, Construction and Strength** **6.2.4 Propeller Shafts and Stern Tube Shafts*** **3** The shaft diameter may be reduced by either a smooth taper or a blending radius nearly equal to the change in diameter to the diameter calculated by the formula given in **6.2.2-1** using the minimum specified tensile strength of the propeller shaft at the portions located forward of the fore end of the fwd stern tube seal. In cases where shafts are manufactured using stainless steel, shaft diameters calculated as $T_s = 400$ are to be used.	**RULES FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS** **Part D MACHINERY INSTALLATIONS** **Chapter 6 SHAFTINGS** **6.2 Materials, Construction and Strength** **6.2.4 Propeller Shafts and Stern Tube Shafts*** **3** The shaft diameter may be reduced by either a smooth taper or a blending radius nearly equal to the change in diameter to the diameter calculated by the formula given in **6.2.2-1** at the portions located forward of the fore end of the fwd stern tube seal. In cases where shafts are manufactured using stainless steel, shaft diameters calculated as $T_s = 400$ are to be used.	Clarify the value to be used for calculating the required diameter of the shaft between the forward of the fore end of the fwd stern tube seal and the intermediate shaft. (Refer to IACS UR M68.4)

Amended-Original Requirements Comparison Table (Review of shaft-related requirements)

<table>
<tr><th>Amended</th><th>Original</th><th>Remarks</th></tr>
<tr>
<td>

Chapter 19 WATERJET PROPULSION SYSTEMS

19.4 Construction and Strength

19.4.1 Main Shaft

Table D19.1 Values of k according to Fitting Method

<table>
<tr><td colspan="2" rowspan="3">Shaft material</td><td colspan="5">Position</td></tr>
<tr><td colspan="4">Fitting parts of shafts with impellers and shaft couplings</td><td rowspan="3">Other parts</td></tr>
<tr><td colspan="4">Fitting method</td></tr>
<tr><td>Keyway</td><td>Spline</td><td>Flange Coupling</td><td>Force Fitting</td></tr>
<tr><td rowspan="3">Carbon steel or low alloy steel</td><td>Shafts other than the below ~~Shafts of Kind 2~~</td><td>105</td><td>108</td><td colspan="2">102</td><td>105</td></tr>
<tr><td>Shafts that have equivalent construction given in 6.2.7-1(1) ~~Shafts of Kind 1~~</td><td rowspan="2">The value in the Note below where $a_1 = 100$, or $a_2 = 80$</td><td rowspan="2">The value in the Note below where $a_1 = 102$, or $a_2 = 82$</td><td colspan="2" rowspan="2">The value in the Note below ~~W~~where $a_1 = 98$, or $a_2 = 78$</td><td rowspan="2">The value in the Note below where $a_1 = 100$, or $a_2 = 80$</td></tr>
<tr><td colspan="2">Austenitic stainless steel</td></tr>
<tr><td colspan="2">Martensite precipitation hardened type stainless steel</td><td>80</td><td>82</td><td colspan="2">78</td><td>80</td></tr>
</table>

Note:

$200 \le \sigma_y \le 400 : \ k = a_1 - 0.1(\sigma_y - 200)$

$\sigma_y > 400 : \ k = a_2$

where

σ_y : Yield point or 0.2 % of proof stress of main shaft material (N/mm^2)

</td>
<td>

Chapter 19 WATERJET PROPULSION SYSTEMS

19.4 Construction and Strength

19.4.1 Main Shaft

</td>
<td>Revise the terms regarding the classification of main shafts in waterjet propulsion systems in Table 19.1.</td>
</tr>
</table>

Amended	Original	Remarks
Annex 5.3.1 CALCULATION OF STRENGTH OF ENCLOSED GEARS **1.6 Surface Strength** **1.6.3 Permissible Contact Stress** **7** Hardness Ratio Factor, *Z_W* The hardness ratio factor, *Z_W*, accounts for the increase in surface durability of soft steel gears meshing with significantly harder gears with smooth surfaces in the following cases: (1) Surface-hardened pinion with through-hardened wheel $Z_W = 1.2\left(\frac{3}{R_{zH}}\right)^{0.15}$ (*HB*< 130) $= \left(1.2 - \frac{HB-130}{1700}\right)\cdot\left(\frac{3}{R_{zH}}\right)^{0.15}$ (130 ≤ *HB* ≤ 470) $= \left(\frac{3}{R_{zH}}\right)^{0.15}$ (*HB* >470) where *HB*: Brinell hardness of the tooth flanks of the softer gear of the pair *R_{ZH}*: equivalent roughness (*μm*) $R_{ZH} = \frac{R_{Z1}(10/\rho_{red})^{0.33}(R_{Z1}/R_{Z2})^{0.66}}{(v\cdot\nu_{40}/1500)^{0.33}}$ If *R_{ZH}* > 16 then *R_{ZH}* = 16 *μm* If *R_{ZH}* < 3, then *R_{ZH}* = 3 *μm* (2) Through-hardened pinion and wheel When the pinion is substantially harder than the wheel, the work hardening effect increases the load	**Annex 5.3.1 CALCULATION OF STRENGTH OF ENCLOSED GEARS** **1.6 Surface Strength** **1.6.3 Permissible Contact Stress** **7** Hardness Ratio Factor, *Z_W* The hardness ratio factor, *Z_W*, accounts for the increase in surface durability of soft steel gears meshing with significantly harder gears with smooth surfaces in the following cases: (1) Surface-hardened pinion with through-hardened wheel $Z_W = 1.2\left(\frac{3}{R_{zH}}\right)^{0.15}$ (*HB*< 130) $= \left(1.2 - \frac{HB-130}{1700}\right)\cdot\left(\frac{3}{R_{zH}}\right)^{0.15}$ (130 ≤ *HB* ≤ 470) $= \left(\frac{3}{R_{zH}}\right)^{0.15}$ (*HB* >470) where *HB*: Brinell hardness of the tooth flanks of the softer gear of the pair *R_{ZH}*: equivalent roughness (*μm*) $R_{ZH} = \frac{R_{Z1}(10/\rho_{red})^{0.33}(R_{Z1}/R_{Z2})^{0.66}}{(v\cdot\nu_{40}/1500)^{0.33}}$ (2) Through-hardened pinion and wheel When the pinion is substantially harder than the wheel, the work hardening effect increases the load	Specify the upper and lower limit values of the equivalent roughness (R_{ZH}). (Incorporation of IACS

Amended-Original Requirements Comparison Table (Review of shaft-related requirements)

Amended	Original	Remarks
capacity of the wheel flanks. Z_W applies to the wheel only, not to the pinion. $Z_W = 1$ ($HB_1/HB_2 < 1.2$) $= 1 + \left(0.00898\frac{HB_1}{HB_2} - 0.00829\right) \cdot (u-1)$ ($1.2 \leq HB_1/HB_2 \leq 1.7$) $= 1 + 0.00698 \cdot (u-1)$ ($HB_1/HB_2 > 1.7$) $HB_{1,2}$: Brinell hardness of the pinion and the wheel, respectively. If gear ratio u>20, then the value u=20 is to be used. In any case, if the calculated Z_W <1, then the value Z_W = 1 is to be used.	capacity of the wheel flanks. Z_W applies to the wheel only, not to the pinion. $Z_W = 1$ ($HB_1/HB_2 < 1.2$) $= 1 + \left(0.00898\frac{HB_1}{HB_2} - 0.00829\right) \cdot (u-1)$ ($1.2 \leq HB_1/HB_2 \leq 1.7$) $= 1 + 0.00698 \cdot (u-1)$ ($HB_1/HB_2 > 1.7$) $HB_{1,2}$: Brinell hardness of the pinion and the wheel respectively. If gear ratio u>20, then the value u=20 is to be used. In any case, if the calculated Z_W <1, then the value Z_W = 1 is to be used.	UR M56(Rev.4, Corr.3))
(3) In cases other than **(1)** and **(2)** above;	(3) In cases other than **(1)** and **(2)** above;	

Amended	Original	Remarks
RULES FOR THE SURVEY AND CONSTRUCTION OF INLAND WATERWAY SHIPS **Part 7 MACHINERY INSTALLATIONS** **Chapter 2 RECIPROCATING INTERNAL COMBUSTION ENGINES** **2.3 Crankshafts** **2.3.3 Shaft Couplings and Coupling Bolts*** **1** The diameter of coupling bolts at the joining face of the coupling between crankshafts or between a crankshaft and a thrust shaft is to be not less than the value obtained by the following formula. $$d_b = 0.75\sqrt{\frac{(0.95d_c)^3}{nD}\left(\frac{440}{T_b}\right)}$$ Where: d_b: Diameter of coupling bolts (*mm*) n: Number of bolts D: Diameter of pitch circle (*mm*) d_c: Required diameter of crankshaft calculated by the formula in **2.3.1-1** when the values of K_m, K_s and K_h are replaced with 1.0 (*mm*). T_b: Specified tensile strength of bolt material	**RULES FOR THE SURVEY AND CONSTRUCTION OF INLAND WATERWAY SHIPS** **Part 7 MACHINERY INSTALLATIONS** **Chapter 2 RECIPROCATING INTERNAL COMBUSTION ENGINES** **2.3 Crankshafts** **2.3.3 Shaft Couplings and Coupling Bolts*** **1** The diameter of coupling bolts at the joining face of the coupling between crankshafts, between a crankshaft and a thrust shaft, or between a crankshaft and a shaft mentioned in **2.2.4** is to be not less than the value obtained by the following formula. $$d_b = 0.75\sqrt{\frac{(0.95d_c)^3}{nD}\left(\frac{440}{T_b}\right)}$$ Where: d_b: Diameter of coupling bolts (*mm*) n: Number of bolts D: Diameter of pitch circle (*mm*) d_c: Required diameter of crankshaft calculated by the formula in **2.3.1-1** when the values of K_m, K_s and K_h are replaced with 1.0 (*mm*). T_b: Specified tensile strength of bolt material	Revise the description, as provision 2.2.4 does not exist in the Rules for the Survey and Construction of Inland Waterway Ships.

Amended-Original Requirements Comparison Table (Review of shaft-related requirements)

Amended	Original	Remarks
(N/mm^2) When the specified tensile strength of the bolt material exceeds 1,000 N/mm^2, the value used for the formula is to be as considered appropriate by the Society. **Chapter 4 SHAFTINGS** **4.2 Materials, Construction and Strength** **4.2.4 Propeller Shafts and Stern Tube Shafts*** **3** The shaft diameter may be reduced by either a smooth taper or a blending radius nearly equal to the change in diameter to the diameter calculated by the formula given in **4.2.2-1** using the minimum specified tensile strength of the propeller shaft at the portion located forward of the fore end of the fwd stern tube seal. In cases where shafts are manufactured using stainless steel, shaft diameters calculated as $T_s = 400$ are to be used.	(N/mm^2) When the specified tensile strength of the bolt material exceeds 1,000 N/mm^2, the value used for the formula is to be as considered appropriate by the Society. **Chapter 4 SHAFTINGS** **4.2 Materials, Construction and Strength** **4.2.4 Propeller Shafts and Stern Tube Shafts*** **3** The shaft diameter may be reduced by either a smooth taper or a blending radius nearly equal to the change in diameter to the diameter calculated by the formula given in **4.2.2-1** at the portion located forward of the fore end of the fwd stern tube seal. In cases where shafts are manufactured using stainless steel, shaft diameters calculated as $T_s = 400$ are to be used.	Clarify the value to be used for calculating the required diameter of the shaft between the forward of the fore end of the fwd stern tube seal and the intermediate shaft. (IACS UR M68.4)

Amended	Original	Remarks
GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF INLAND WATERWAY SHIPS **Part 7 MACHINERY INSTALLATIONS** **Chapter 6 TORSIONAL VIBRATION OF SHAFTINGS** **6.2 Allowable Limit** **6.2.6 Detailed Evaluation for Strength** **2** In cases where the diameters of shafts are determined in accordance with **4.2.4-4**, allowable limit of torsional vibration stress τ_1 and τ_2 are to be calculated in accordance with the following: (1) When the number of revolutions is within the range of 80% to 105% of the number of maximum continuous revolutions, the torsional vibration allowable limit τ_1 is to be calculated by the following formulae: $\tau_1 = A - B\lambda^2 \quad (\lambda \leq 0.9)$ $\tau_1 = C \quad (0.9 < \lambda)$ τ_1 : Allowable limit of torsional vibration stresses for the range of $0.8 < \lambda \leq 1.05$ of the number of maximum continuous revolutions (N/mm^2) λ : Ratio of the number of revolutions to the number of maximum continuous revolutions	**GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF INLAND WATERWAY SHIPS** **Part 7 MACHINERY INSTALLATIONS** **Chapter 6 TORSIONAL VIBRATION OF SHAFTINGS** **6.2 Allowable Limit** **6.2.6 Detailed Evaluation for Strength** **2** In cases where the diameter of shafts are determined in accordance with **4.2.6-3**, allowable limit of torsional vibration stress τ_1 and τ_2 are to be calculated in accordance with the following: (1) When the number of revolutions is within the range of 80% to 105% of the number of maximum continuous revolutions, the torsional vibration allowable limit τ_1 is to be calculated by the following formulae: $\tau_1 = A - B\lambda^2 \quad (\lambda \leq 0.9)$ $\tau_1 = C \quad (0.9 < \lambda)$ τ_1 : Allowable limit of torsional vibration stresses for the range of $0.8 < \lambda \leq 1.05$ of the number of maximum continuous revolutions (N/mm^2) λ : Ratio of the number of revolutions to the number of maximum continuous revolutions	Correct the reference number.

Amended-Original Requirements Comparison Table (Review of shaft-related requirements)

Amended	Original	Remarks
A, B, C: Constants dependent on shaft materials, given in **Table 7.6.2.6-1.** (2) (Omitted)	A, B, C: Constants dependent on shaft materials, given in **Table 7.6.2.6-1.** (2) (Omitted)	

Amended-Original Requirements Comparison Table (Review of shaft-related requirements)

Amended	Original	Remarks
GUIDANCE FOR THE APPROVAL OF MATERIALS AND EQUIPMENT FOR MARINE USE **Part 6 MACHINERY** **Chapter 14 TYPE APPROVAL OF SYNTHETIC MATERIALS USED FOR AFTMOST STERN TUBE BEARINGS AND AFTMOST SHAFT BRACKET BEARINGS** **14.3 Approval Test**	**GUIDANCE FOR THE APPROVAL OF MATERIALS AND EQUIPMENT FOR MARINE USE** **Part 6 MACHINERY** **Chapter 14 TYPE APPROVAL OF SYNTHETIC MATERIALS USED FOR AFTMOST STERN TUBE BEARINGS AND AFTMOST SHAFT BRACKET BEARINGS** **14.3 Approval Test**	
14.3.4 Test Products **1** At least three representative diameter products of each kind of product are to be selected for approval testing, except for the wear test where one representative product may be selected. Each kind of product is to be as follows. (1) Same chemical composition range (2) Same reinforcement, only applicable to composite materials (3) Same production process	**(Newly added)** (Newly added)	IACS UR M85 Para.3.4
2 The test products used for approval testing are to be selected from the manufacturer's production line or stock by the Society's surveyor and are to be either of the following. (1) Finished certified components (2) Samples (semifinished components) taken from earlier stages of production of the components, when applicable	(Newly added)	IACS UR M85 Para.3.4

Amended-Original Requirements Comparison Table (Review of shaft-related requirements)

Amended	Original	Remarks
14.3.5 Test Laboratories **14.3.6 Test Reports** Manufacturers are to prepare test reports for the wear test specified in **14.3.2** and the material property test specified in **14.3.3** and submit them to the Society (branch office concerned). In cases where a Society's surveyor attends the test according to **14.3.5-2,** the test reports are to be submitted to the Society (branch office concerned) upon receiving confirmation from the attending surveyor. **14.4.1 Notification of Approval** The Society, when satisfied upon examination of the documents submitted in accordance with **14.2.2** and **14.3.6** and the attending surveyor's report, will issue a type approval certificate specifying the approval number, approval date, items of approval and approval conditions (including at least the product description and properties in accordance with the material property test, maximum nominal surface pressure and maximum operating temperature). In addition, the Society will stamp those documents submitted in accordance with **14.2.2** and **14.3.6** that it deems necessary with approval stamps and return them back to applicants.	**14.3.4 Test Laboratories** **14.3.5 Test Reports** Manufacturers are to prepare test reports for the wear test specified in **14.3.2** and the material property test specified in **14.3.3** and submit them to the Society (branch office concerned). In case where a Society's surveyor attends the test according to **14.3.4-2,** the test reports are to be submitted to the Society (branch office concerned) upon receiving confirmation from the attending surveyor. **14.4.1 Notification of Approval** The Society, when satisfied upon examination of the documents submitted in accordance with **14.2.2** and **14.3.5** and the attending surveyor's report, will issue a type approval certificate specifying the approval number, approval date, items of approval and approval conditions (including at least the product description and properties in accordance with the material property test, maximum nominal surface pressure and maximum operating temperature). In addition, the Society will stamp those documents submitted in accordance with **14.2.2** and **14.3.5** that it deems necessary with approval stamps and return them back to applicants.	
EFFECTIVE DATE AND APPLICATION **1.** The effective date of the amendments is 1 July 2026.		