RULES FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

Part D Machinery Installations

Rules for the Survey and Construction of Steel Ships
Part D 2011 AMENDMENT NO.1
Guidance for the Survey and Construction of Steel Ships
Part D 2011 AMENDMENT NO.2

Rule No.82 / Notice No.90 1st November 2011
Resolved by Technical Committee on 7th July 2011
Approved by Board of Directors on 27th September 2011

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RULES FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

RULES

Part D Machinery Installations

2011 AMENDMENT NO.1

Rule No.82 1st November 2011

Resolved by Technical Committee on 7th July 2011

Approved by Board of Directors on 27th September 2011

Rule No.82 1st November 2011
AMENDMENT TO THE RULES FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

"Rules for the survey and construction of steel ships" has been partly amended as follows:

Part D MACHINERY INSTALLATIONS

Amendment 1-1

Chapter 1 GENERAL

1.1 General

1.1.1 Scope

Sub-paragraph -2 has been amended as follows.

2 For machinery installations those which are fitted in either ships with a restricted area of service or ships categorized as "small ships", some of the requirements in this Part may be modified according to the requirements given in **Chapter 22** ~~provided the Society considers such modifications acceptable~~ or other suitable rules deemed appropriate by the Society.

EFFECTIVE DATE AND APPLICATION (Amendment 1-1)

1. The effective date of the amendments is 1 November 2011.
2. Notwithstanding the amendments to the Rule, the current requirements may apply to ships for which the date of contract for construction is before the effective date.

Amendment 1-2

Chapter 1 GENERAL

2.6 Tests

Paragraph 2.6.1 has been amended as follows.

2.6.1 Shop Tests

1 For components or accessories specified in **Table D2.5**, hydrostatic tests are to be carried out at the pressures shown in the Table.

2 For rotating assemblies of exhaust gas turboblowers, dynamic balancing tests are to be carried out after their assembly.

3 For the impellers and inducers of exhaust gas turboblowers, overspeed tests are to be carried out according to test procedures deemed appropriate by the Society.

4 For exhaust gas turboblowers, trial runs are to be carried out according to test procedures deemed appropriate by the Society.

~~**3**~~**5** For diesel engines, shop trials are to be carried out according to the test procedure deemed appropriate by the Society.

~~**4**~~**6** For diesel engines with novel design features or for those with no service records, in cases where it is deemed necessary by the Society, tests are to be carried out to verify their durability according to the procedure deemed appropriate by the Society.

Table D2.5 Hydrostatic Test Pressure

Part	Test Pressure[6](*MPa*)
Cylinder cover, cooling space[1]	0.7
Cylinder liner, over the whole length of cooling space[2]	0.7
Cylinder jacket, cooling space	0.4[3] or 1.5*P*, whichever is greater
Exhaust valve, cooling space	0.4 or 1.5*P*, whichever is greater
Piston crown[1],[4]	0.7
Fuel injection system: Pump body (pressure side[5]), Valve[5], Pipe	1.5*P* or *P* +30, whichever is smaller
Scavenging pump cylinder	0.4
Turboblower, cooling space	0.4 or 1.5*P*, whichever is greater
Exhaust pipe, cooling space	0.4 or 1.5*P*, whichever is greater
Heat exchanger	0.4 or 1.5*P*, whichever is greater
Engine driven pumps	0.4 or 1.5*P*, whichever is greater
Piping system	Apply the requirements in **12.6**

Notes:

(1) For forged steel cylinder covers with cooling spaces that have been machined up without a welding procedure and for piston crowns, if the accurate gauging of thickness after being machined up on both the inside and the outside, and confirmed of being free from surface defects by the Surveyor, the results may be accepted as a substitution for the above hydrostatic test.

(2) Where cylinder liners are machine finished on both the inside and the outside, accurately gauged for thickness, and confirmed free from surface defects by the Surveyor, the above test pressure of cylinder liners may be reduced to 0.4*MPa*.

(3) For diesel engines having no cylinder liner, the hydrostatic test pressure is to be 0.7*MPa*.

(4) The cooling space of piston crowns of crosshead type diesel engines are to be hydrostatically tested after assembled with piston rods.

(5) Where fuel oil injection pumps and fuel injection valves are made of forged steel, the hydrostatic test may be omitted.

(6) *P* is the maximum working pressure (*MPa*).

EFFECTIVE DATE AND APPLICATION (Amendment 1-2)

1. The effective date of the amendments is 1 November 2011.

2. Notwithstanding the amendments to the Rules, the current requirements may apply to the surveys for which the application is submitted to the Society before the effective date.

Amendment 1-3

Chapter 18 AUTOMATIC AND REMOTE CONTROL

18.2 System Design

Paragraph 18.2.7 has been amended as follows.

18.2.7 Computers and Computerized Systems

1 Computerized control systems, alarm systems and safety systems are divided into three categories as shown in **Table D18.1** based upon the impact a single failure has on human and vessel safety as well as the environment. These systems are to comply with the requirements in this Chapter and the following **2** through ~~**4**~~**5**. However, where this requirement is impracticable, the systems are to comply with requirements deemed appropriate by the Society.

Table D18.1 Computerized System Categories

Category	Effects in case of failure	System functionality
I	Those systems which will not lead to dangerous situations for human safety, safety of the vessel and threat to the environment.	- Systems related to informational or administrative tasks
II	Those systems which could eventually lead to dangerous situations for human safety, safety of the vessel and threat to the environment.	- Alarm systems - Control systems which are necessary to maintain the ship in normal operational and habitable conditions
III	Those systems which could immediately lead to dangerous situations for human safety, safety of the vessel and threat to the environment.	- Control systems for maintaining the vessel's propulsion and steering - Safety systems

2 Computers used for the control systems, alarm systems and safety systems for machinery and equipment, considered necessary by the Society, are to comply with the following:

(1) Reliability and maintainability
The reliability and maintainability of the computerized systems are not to be inferior to those of systems not relying upon computers.

(2) Requirements for Computers
(a) The composition of computers is to be so planned that the extent of any damage due to a failure in any part of a circuit or component is kept to a minimum as far as possible.
(b) Each component is to be protected against any fear of overvoltage (electronic noise) which may intrude from input or output terminals.
(c) Central processing units and important peripheral devices are to have self-monitoring functions.
(d) Important programs and data are to be ensured against loss in cases where an external electrical power supply may be temporarily interrupted.
(e) Computers are to be set up so they can be quickly re-started following planned procedures within a short period of time after electrical power has been restored after a power failure.
(f) Spare parts for all important elements which require special techniques for repair work, are to be kept in ample supply for easy replacement.
(g) Change-over to back-up means is to be able to be performed easily and soundly.

(3) Back-up means
   (a) In cases where one computer simultaneously performs fuel control (governor control, electronic injection control, etc.) and remote control of main propulsion machinery in diesel or turbine ships, or output control (rotational speed control, load control, etc.) and remote control of main propulsion machinery in electric propulsion ships, one of the following systems is to be provided in case of a computer failure. However, where this requirement is impracticable, the systems are to comply with requirements deemed appropriate by the Society.
      i) Stand-by computer
      ii) Governor controlled back-up systems operated at the main control station
   (b) Important safety systems utilizing computers are to be provided with back-up means which can be used in a short time in the event of failure of the computer in service.
   (c) In cases where visual display units (VDU) are adopted as indicators for the alarm systems stipulated in this Chapter, at least two VDUs are to be installed or other arrangements, deemed appropriate by the Society, are to be considered.

(4) Components of computerized systems
   The separation of computerized control systems and safety systems are to comply with the requirements in **18.2.4-1** and **18.2.6-1** respectively. However, in cases where these requirements are impracticable, those systems are to comply with requirements deemed appropriate by the Society.

3 The communication links for transferring data between separate terminals of those systems categorized as Categories II and III in **Table D18.1** are to comply with the following:

(1) In cases where the failure of a single component of the data communication link results in a loss of data communication, means are to be provided for the automatic restoration of the link.

(2) In cases where a data communication link covers two or more systems from among those control systems, alarms systems and safety systems specified in this Chapter, the link including cables is to be installed in duplicate; unless there are alternate means of performing the same functions without the use of the link.

(3) The data communication link is to be self-checking and visual and audible alarms are to be activated when failures in the link are detected.

(4) System self-checking capabilities are to be arranged to initiate a transition to the least hazardous state for the complete installation in cases where failures of data communication have occurred.

(5) The characteristics of the data communication links are to be able to ensure the prevention of overloading and that at all necessary information is transmitted in an appropriate amount of time.

4 The wireless data communication links for transferring data between separate terminals of those systems categorized as Category II in **Table D18.1** are to comply with the following **(1)** to **(3)** in addition to **3** above. However, in cases where systems categorized as Category III in **Table D18.1** are used, such systems are to comply with requirements deemed appropriate by the Society.

(1) In cases where functions that are required to operate continuously in order to provide essential services dependant on wireless data communication links are used, an alternative means of control which can be brought in action within an acceptable period of time is to be provided.

(2) Wireless data communications are to be employed recognized international wireless communication system protocols that incorporate the following:
   (a) Fault prevention, detection, diagnosis, and correction in order to ensure message integrity (i.e., the received message is neither corrupted nor altered when compared to the transmitted message).
   (b) Configuration and device authentication which only permit the connection of devices

included in the system design.

(c) Massage encryption which is capable of protecting the contents of confidential and/or criticality data.

(d) Security management which is capable of protecting the network and preventing unauthorized access.

(3) Wireless systems are to comply with the radio frequency and power level standards deemed appropriate by the Society.

~~4~~5 In cases where system specifications are modified, the following items are to be complied with:

(1) Systems categorized as Categories II and III in **Table D18.1** are to be protected against any program modifications by end users.

(2) For systems categorized as Category III in **Table D18.1**, any modifications of parameters by manufacturers are to be approved by the Society.

(3) Any modifications made after shipment are to be documented and traceable.

EFFECTIVE DATE AND APPLICATION (Amendment 1-3)

1. The effective date of the amendments is 1 January 2012.

2. Notwithstanding the amendments to the Rule, the current requirements may apply to systems installed on ships for which the date of contract for construction is before the effective date.

GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

GUIDANCE

Part D Machinery Installations

2011 AMENDMENT NO.2

Notice No.90 1st November 2011

Resolved by Technical Committee on 7th July 2011

Notice No.90 1st November 2011
AMENDMENT TO THE GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

"Guidance for the survey and construction of steel ships" has been partly amended as follows:

Part D MACHINERY INSTALLATIONS

Amendment 2-1

Annex D12.1.6-2 GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF PLASTIC PIPES

1.1 Scope

Sub-paragraph -2 has been amended as follows.

2 The guidance is not applicable to ~~flexible hoses, hoses and~~ mechanical joints and flexible couplings used in metallic piping systems.

1.2 Terminology

Sub-paragraph (1) has been amended as follows.

(1) "Plastic" means both thermoplastic and thermosetting plastic materials with or without reinforcement, such as *PVC* and fibre reinforced plastics - *FRP*. Plastic includes synthetic rubber and materials of similar thermo/mechanical properties.

1.5 Requirements for Pipe/Piping Systems Depending on Service and/or Locations

1.5.1 Fire Endurance

Sub-paragraph -1 has been amended as follows.

1 Pipes and their associated fittings whose integrity is essential to the safety of ships are required to meet the minimum fire endurance requirements of *Appendix* 1 or 2, as applicable, of *IMO Res*. *A*.753(18) (including any amendments due to *IMO Res*. *MSC*.313(88)).

1.6 Installation

1.6.1 Supports

Sub-paragraph -1 has been amended as follows.

1 Selection and spacing of pipe supports in shipboard systems are to be determined as a function of allowable stresses and maximum deflection criteria. Support spacing is not to be greater than that recommended the pipe manufacturer. The selection and spacing of pipe supports are to take into account pipe dimensions, length of the piping, mechanical and physical properties of pipe materials, mass of pipes and contained fluids, external pressures, operating temperatures, thermal expansion effects, loads due to external forces, thrust forces, water hammers, vibrations, and maximum accelerations to which such systems may be subjected. Combination of loads is to be considered.

Table 1 has been amended as follows.

Table 1 Fire Endurance Requirements Matrix

N	Piping Systems	Location										
		A	B	C	D	E	F	G	H	I	J	K
(Omitted)												
SAWATER[1]												
12	Bilge mains & branches	L1[7]	L1[7]	L1	×	×	—	○	○	○	—	L1
13	Fire mains & water sprays	L1	L1	L1	×	—	—	—	○	○	×	L1
14	Foam systems	L1W	L1W	L1W	—	—	—	—	—	○	L1W	L1W
15	Sprinkler systems	L1W	L1W	L3	×	—	—	—	○	○	L3	L3
16	Ballast	L3	L3	L3	L3	×	○[10]	○	○	○	L2W	L2W
17	Cooling water, essential services[12]	L3	L3	—	—	—	—	—	○	○	—	L2W
18	Tank cleaning services fixed machines	—	—	L3	—	—	○	—	○	○	—	L3[2]
19	Non-essential systems[13]	○	○	○	○	○	—	○	○	○	○	○
(Omitted)												
SANITARY/DRAINS/SCUPPERS												
23	Deck drains (internal)	L1W[4]	L1W[4]	—	L1W[4]	○	—	○	○	○	○	○
24	Sanitary drains (internal)	○	○	—	○	○	—	○	○	○	○	○
25	Scuppers and discharges (overboard)	○[1,8]	○[1,8]	○[1,8]	○[1,8]	○[1,8]	—	○	○	○	○[1,8]	○
(Omitted)												
MISCELLANEOUS												
28	Control air	L1[5]	L1[5]	L1[5]	L1[5]	L1[5]	—	○	○	○	L1[5]	L1[5]
29	Service air (non-essential)[13]	○	○	○	○	○	—	○	○	○	○	○
30	Brine	○	○	—	○	○	—	—	—	○	○	○
31	Auxiliary low pressure steam ($\leq 0.7MPa$)	L2W	L2W	○[9]	○[9]	○[9]	○	○	○	○	○[9]	○[9]

Notes:

(1) LOCATION

(Omitted)

(2) ABBREVIATIONS

L1 : ~~Fire endurance test (*IMO Res.A*753(18) *Appendix* 1) in dry conditions, 60 *min*~~ Pipes without leakage during pressure tests as a result of fire endurance tests (for more than one hour) and pressure tests (for more than 15 minutes) in dry conditions in accordance with *IMO Res. A*.753(18) *Appendix* 1 (including any amendments

due to *IMO Res. MSC*.313(88))

L1W : Pipes with negligible leakage, i.e. not exceeding 5% flow loss, during pressure tests as a result of fire endurance tests (for more than one hour) and pressure tests (for more than 15 minutes) in dry conditions in accordance with *IMO Res. A*.753(18) *Appendix* 1 (including any amendments due to *IMO Res. MSC*.313(88))

L2 : ~~Fire endurance test (*IMO Res.A*753(18) *Appendix* 1) in dry conditions, 30 *min*~~ Pipes without leakage during pressure tests as a result of fire endurance tests (for more than 30 minutes) and pressure tests (for more than 15 minutes) in dry conditions in accordance with *IMO Res. A*.753(18) *Appendix* 1 (including any amendments due to *IMO Res. MSC*.313(88))

L2W : Pipes with negligible leakage, i.e. not exceeding 5% flow loss, during pressure tests as a result of fire endurance tests (for more than 30 minutes) and pressure tests (for more than 15 minutes) in dry conditions in accordance with *IMO Res. A*.753(18) *Appendix* 1 (including any amendments due to *IMO Res. MSC*.313(88))

L3 : ~~Fire endurance test (*IMO Res.A*753(18) *Appendix* 2) in wet conditions, 30 *min*~~ Pipes without significant leakage, i.e. not exceeding 0.2 *l*/*min*., during pressure tests as a result of fire endurance tests (for more than 30 minutes) and pressure tests (for more than 15 minutes) in wet conditions in accordance with *IMO Res. A*.753(18) *Appendix* 1 (including any amendments due to *IMO Res. MSC*.313(88))

○ : No fire endurance test required

－ : Not applicable

× : Metallic materials having a melting point greater than 925℃

(3) FOOTNOTES

(Omitted)

4 : In the case of drains serving only the space concerned, "○" may replace "L1W".

(Omitted)

EFFECTIVE DATE AND APPLICATION (Amendment 2-1)

1. The effective date of the amendments is 1 November 2011.

Amendment 2-2

D1 GENERAL

D1.1.1 Scope

Sub-paragraph -3 has been added as follows.

3 The wording "other suitable rules" specified in **1.1.1-2 of the Rules** means the domestic law of the ship's flag state or other rules outside of domestic law which are deemed appropriate by the Flag Administration.

D5 POWER TRANSMISSION SYSTEMS

D5.3 Strength of Gears

Paragraph D5.3.1 has been added as follows.

D5.3.1 Application

In the case of bevel gear, the wording "deemed appropriate by the Society" in **5.3.1, Part D of the Rules** means as follows:

(1) The bending stress at the root sections of gear teeth and limiting tooth surface stress are to be according to AGMA standards or as deemed appropriate by the Society.

(2) Strength of the interior of gear teeth

The Vickers hardness (*HV*) of the interior of gear teeth is not to be less than the value calculated by the following formula:

If $\frac{z}{w} < 0.79$ then $\frac{z}{w}$ is to be taken as 0.79.

$$HV = 1.11 S_H p \left[\frac{z}{w} - \frac{\left(\frac{z}{w}\right)^2}{\sqrt{1+\left(\frac{z}{w}\right)^2}} \right]$$

HV : Vickers hardness

S_H : Safety factor for contact stress, is to comply with the requirements in **Annex D5.3.5 "GUIDANCE FOR CALCULATION OF STRENGTH OF GEARS" 1.6.3-9.**

p : Real hertzian stress (*MPa*)

$$p = AS_c$$

S_c: Contact stress (*MPa*), to be calculated according to *ANSI/AGMA 2003* standards.

A : If S_c is calculated according to *ANSI/AGMA 2003* standards, then the coefficients are to be determined, in consideration of analysis results, by the Society on a case by case basis. In addition, if S_c is calculated according to *ANSI/AGMA 2003-A86* standards, A is to taken as 1.7

w: Half the hertzian contact width (*mm*), to be calculated by the following formula:

$$w = \frac{p\rho_C}{56300}$$

$$\rho_C = \frac{\rho_1 \rho_2}{\rho_1 + \rho_2}$$

$$\rho_1 = 0.5 d_{vn1} \sin\alpha_n$$

$$\rho_2 = 0.5 d_{vn2} \sin\alpha_n$$

$$d_{vn1} = d_{m1} \frac{\sqrt{1+u^2}}{u} \frac{1}{\cos^2 \beta_{vb}}$$

d_{m1} : Mean pitch diameter of pinion （mm）

u : Gear ratio

$$\beta_{vb} = \arcsin(\sin\beta_m \cos\alpha_n)$$

β_m : Mean spiral angle

α_n : Normal pressure angle

$$d_{vn2} = u^2 d_{vn1}$$

z : Depth from teeth surface to evaluation point (mm)

EFFECTIVE DATE AND APPLICATION (Amendment 2-2)

1. The effective date of the amendments is 1 November 2011.

2. Notwithstanding the amendments to the Guidance, the current requirements may apply to ships for which the date of contract for construction is before the effective date.

Amendment 2-3

D1 GENERAL

D1.1 General

D1.1.4 Modification of Requirements

Sub-paragraph D1.1.4(1)(b)ii) has been amended as follows.

For those machinery installations specified in **1.1.4**, **Part D of the Rules** (excluding those specified in other Parts of the Rules), some requirements of **Part D of the Rules** may be modified as follows:

(1) Prime movers (including power transmission systems and shafting systems; hereinafter the same) driving generators, auxiliary machinery essential for main propulsion and auxiliary machinery for manoeuvring and the safety:
   (a) Prime movers with an output less than 100 *kW*
      i) Submission of drawings may be omitted.
      ii) Materials which comply with the requirements of any national standard may be accepted for the principal components. In this case, materials (excluding valves and pipe fittings) are to be manufactured by a manufacturer approved by the Society.
      iii) Shop tests in the presence of the Surveyor may be substituted for manufacturer's tests. In this case, submission or presentation of test records may be required by the Surveyor.
   (b) Prime Movers with an output not less than 100 *kW* but less than 375 *kW*.
      i) Materials used for principal components may be dealt with under the requirements specified in **(a)ii)**.
      ii) Hydrostatic tests, ~~and~~ dynamic balancing tests, overspeed tests and trial runs of turboblowers at the manufacturer may be dealt with under the requirements specified in **(a)iii)**.

(2) Prime movers for auxiliary machinery for cargo handling:
   (a) Prime movers with an output less than 375 *kW* may be dealt with under the requirements of **(1)(a)**.
   (b) Prime movers with an output 375 *kW* or over may be dealt with under the requirements of **(1)(b)**.

((3) to (8) are omitted)

D2 DIESEL ENGINES

D2.6 Tests

Paragraph D2.6.1 has been amended as follows.

D2.6.1 Shop Tests

1 The programme for the overspeed tests required by **2.6.1-3**, **Part D of the Rules** is to be in accordance with the following:

(1) An overspeed test for the duration of 3 minutes, at 120% of the maximum speed at room temperature or at 110% of the maximum speed at working temperature, is to be carried out.

(2) For forged impellers and inducers subject to quality control through an approved non-destructive test method, overspeed tests may be dispensed with.

2 The programme for the shop trials required by **2.6.1-4**, **Part D of the Rules** is to be in accordance with the following:

(1) For exhaust gas turboblowers with novel design features or for the first unit of those with no service record, a 1-hour mechanical running test at maximum speed and maximum working temperature is to be carried out. exhaust gas turboblowers other than the first unit are to comply with the following requirements from (2) to (4):

(2) A 20-minute mechanical running test at maximum speed is to be carried out. However, the Society may reduce the duration of the test after taking test records, etc. into consideration.

(3) In cases where exhaust gas turboblowers are produced under an approved quality system and the type of exhaust gas turboblowers has sufficient test records, the test in (2) may be carried out on a sample basis.

(4) For manufacturers who have facilities at their works for testing exhaust gas turboblowers on the engines for which they are intended, the trial run may be replaced by a trial run on said engine for 20 minutes at 110% of the maximum continuous output of the engine.

3 The programme for shop trials in **2.6.1-~~3~~5**, **Part D of the Rules** is to be in accordance with the following:

(1) For all stages of testing, the pertaining operation values are to be measured and recorded by the engine manufacturer. All results are to be compiled in an acceptance protocol to be issued by the manufacturer. In addition, crankshaft deflection is to be checked and recorded in the results in cases where such a check is required by the manufacturer during the operating life of the engine.

(2) All measurements conducted at the various load points are to be carried out under steady operating conditions. The readings for 100% power (rated power at rated speed) are to be taken twice at an interval of at least 30 *minutes*.

(3) In cases where a no-load operation is conducted for adjusting engine conditions, the fuel delivery system, manoeuvring system and safety devices are to be properly adjusted by the manufacturer before the operation.

(4) The programme shown in **Table D2.6.1-1** is to be used as the standard for the shop trials of diesel engines. In this case, refer to the *JIS* specified below or those considered equivalent thereto for more details on each respective testing procedure:

(a) For the main engines of diesel ships or electrical propulsion ships;
JIS F 4304 “Shipbuilding - Internal combustion engines for propelling use-shop test code”

(b) For diesel engines driving generators or essential auxiliary machinery;
JIS F 4306 “Shipbuilding - Water cooled four-cycle generator diesel engines”

Table D2.6.1-1 Programme for Shop Trials of Diesel Engines

Test items	Use of engines		
	Main engines of diesel ships[1]	Main engines of electric propulsion ships[2]	Diesel engines driving generators or auxiliaries[2] (excluding auxiliary machinery for specific use)
110% power run[3]	45 *minutes* at engine speed in accordance with nominal propeller curve	45 *minutes* at n_o (n_o is the rated engine speed.)	same as for diesel ships
100% power run[4]	2 *hours* at n_o	same as for diesel ships	
Normal continuous cruise power run[5]	30 *minutes* at engine speed in accordance with nominal propeller curve	—	
75% power run[6]		30 *minutes* at n_o	
50% power run[6]			
25% power run[5]		—	
Starting manoeuvres	○	○	○
Reversing manoeuvres [7]	○	—	—
Governing characteristics	○	○	○
Performance of monitoring, alarm and safety devices	○	○	○
Open-up inspection	○	○	○

Notes:

(1) After testing has been completed, the fuel delivery system is to be blocked so as to limit the engines to run at not more than 100% power.

(2) After testing has been completed, the fuel delivery system is to be adjusted such that overload (110% power) can be given in service after installation on board, so that the governing characteristics including the activation of generator protective devices can be fulfilled at all times.

(3) The testing time may be shorten to 20 *minutes* for engines having cylinder bores of 400 *mm* or less and to 30 *minutes* for engines having cylinder bores exceeding 400 *mm* when deemed appropriate by the Society, in consideration of the conditions of quality assurance, etc. of the manufacturer. However, for the main diesel engines of diesel ships, submission of a test report for the same type engine proving their compatibility for over-loaded operation may be accepted as substitutions for the 110% power run.

(4) The testing time may be shortened to one hour when deemed appropriate by the Society, in consideration of the conditions of quality assurance, etc. of the manufacturer.

(5) The test item may be dispensed when deemed appropriate by the Society.

(6) The testing time may be shortened to 20 *minutes* for engines having cylinder bores of 400 *mm* or less when deemed appropriate by the Society.

(7) The test item applies only to direct reversible engines.

EFFECTIVE DATE AND APPLICATION (Amendment 2-3)

1. The effective date of the amendments is 1 November 2011.

2. Notwithstanding the amendments to the Guidance, the current requirements may apply to the surveys for which the application is submitted to the Society before the effective date.

Amendment 2-4

D14 PIPING SYSTEMS FOR TANKERS

D14.3 Piping Systems for Cargo Oil Pump Rooms, Cofferdams and Tanks adjacent to Cargo Oil Tanks

Paragraph D14.3.2 has been amended as follows.

D14.3.2 Ballast Tanks adjacent to Cargo Oil Tanks

1 Ballast piping systems of the forward ballast tanks, etc. (**14.3.2-1, Part D of the Rules**)

Ballast piping systems, etc. serving ballast tanks whose forward end is located afore of collision bulkheads and are adjacent to cargo oil tanks (hereinafter referred to as "forward ballast tanks") are to be in accordance with the following requirements in addition those in **14.3.2-2** to **14.3.2-4, Part D of the Rules**. However, ballast piping systems, in cases where they are as specified in the following **(2)** or **(3)** and serve ballast tanks which are not adjacent to cargo oil tanks, but whose forward end is located afore of collision bulkheads, are considered to be piping systems of forward ballast tanks and, therefore, are to be in accordance with the requirements for forward ballast tanks.

(1) Arrangements are to be made so that any ballast water in forward ballast tanks, except for those cases specified in the following **(2)** or **(3)**, can be ballasted/deballasted by pumps located in the forward part of the cargo tanks.

(2) In cases where ballast pipes of forward ballast tank are led to ballast pumps by passing through cargo oil tanks, except in cases where prohibited by **14.2.7, Part D of the Rules** or **D14.1.1**, the following requirements are to be complied with:
   (a) Flange joints with a nominal pressure less than 1 *MPa* are not to be used for pipe joints.
   (b) Stop valves are to be provided afore of collision bulkheads in addition to those bulkhead valves specified in **13.2.5-2, Part D of the Rules**.
   (c) Ballast pumps are to be provided in cargo oil pump rooms or other subdivisions that are without sources of ignition.
   (d) The requirements of **(a)** to **(e)** in the following **(3)** are to be complied with.

(3) In cases where ballast pipes of forward ballast tanks are led to other ballast piping systems serving ballast tanks which are adjacent to cargo oil tanks, the following requirements are to be complied with:
   (a) In applying the requirements specified in **Part H of the Rules**, forward ballast tanks are to be considered to be hazardous areas as specified in **4.3.2(2), Part H of the Rules**.
   (b) Vent pipe openings provided for forward ballast tanks are to be located on open decks at an appropriate distance of not less than 3 *m* away from any sources of ignition. In addition, the area around such vent pipe openings is defined as a hazardous area in accordance with **4.3.1(2)(i), Part H of the Rules** and **4.3.1(3)(a), Part H of the Rules**.
   (c) Means are to be provided, on open decks, to allow measurement of the concentration of flammable gases within forward ballast tanks. In this case, such means may be a combination of portable detecting instruments and sampling pipes. Such sampling pipes may be those sounding pipes specified in the following **(d)** in cases where deemed appropriate by the Society.
   (d) Sounding pipes provided for forward ballast tanks are to be led to open decks.
   (e) Access into forward ballast tanks is to be direct from open deck. However, indirect access from open decks into the forward ballast tanks through enclosed spaces may be acceptable provided that the following (i) or (ii) is satisfied.

(i) In cases where enclosed spaces are separated from the cargo oil tanks, access into forward ballast tanks are to be a gas tight bolted manhole located in such enclosed spaces. In this case, a warning sign is to be provided at the manhole stating that the forward ballast tank may only be opened after it has been proven to be gas free or the electrical equipment which is not electrically safe in the enclosed space is isolated.

(ii) In cases where enclosed spaces have common boundaries with the cargo tanks, such enclosed spaces are to satisfy the relevant requirements of hazardous areas and are, in addition, to be well ventilated.

(omitted)

EFFECTIVE DATE AND APPLICATION (Amendment 2-4)

1. The effective date of the amendments is 1 January 2012.

2. Notwithstanding the amendments to the Guidance, the current requirements may apply to ships for which the date of contract for construction* is before the effective date.

* "contract for construction" is defined in the latest version of IACS Procedural Requirement (PR) No.29.

IACS PR No.29 (Rev.0, July 2009)

1. The date of "contract for construction" of a vessel is the date on which the contract to build the vessel is signed between the prospective owner and the shipbuilder. This date and the construction numbers (i.e. hull numbers) of all the vessels included in the contract are to be declared to the classification society by the party applying for the assignment of class to a newbuilding.

2. The date of "contract for construction" of a series of vessels, including specified optional vessels for which the option is ultimately exercised, is the date on which the contract to build the series is signed between the prospective owner and the shipbuilder.

For the purpose of this Procedural Requirement, vessels built under a single contract for construction are considered a "series of vessels" if they are built to the same approved plans for classification purposes. However, vessels within a series may have design alterations from the original design provided:

(1) such alterations do not affect matters related to classification, or

(2) If the alterations are subject to classification requirements, these alterations are to comply with the classification requirements in effect on the date on which the alterations are contracted between the prospective owner and the shipbuilder or, in the absence of the alteration contract, comply with the classification requirements in effect on the date on which the alterations are submitted to the Society for approval.

The optional vessels will be considered part of the same series of vessels if the option is exercised not later than 1 year after the contract to build the series was signed.

3. If a contract for construction is later amended to include additional vessels or additional options, the date of "contract for construction" for such vessels is the date on which the amendment to the contract, is signed between the prospective owner and the shipbuilder. The amendment to the contract is to be considered as a "new contract" to which **1.** and **2.** above apply.

4. If a contract for construction is amended to change the ship type, the date of "contract for construction" of this modified vessel, or vessels, is the date on which revised contract or new contract is signed between the Owner, or Owners, and the shipbuilder.

Note:
This Procedural Requirement applies from 1 July 2009.

Amendment 2-5

D18 AUTOMATIC AND REMOTE CONTROL

D18.1 General

Paragraph D18.1.3 has been amended as follows.

D18.1.3 Drawings and Data

The drawings and data stipulated in **18.1.3(6), Part D of the Rules** refer to the following items that are standard for systems categorized as Categories II and III in **Table D18.1**. With respect to those automatic devices and equipment which have been already approved by the Society, only data on parts that differ from ship to ship need to be submitted.

(1) Hardware description
  (a) System block diagrams, showing the arrangement, input and output devices and interconnections
  (b) Connection diagrams including data communication, electrical power circuit diagrams
  (c) Back-up systems and back-up procedures
  (d) Protections against power failure and procedures for restarting the system after recovery of power

(2) Software description
  (a) Operating Systems and data communication software
  (b) Intended functions
  (c) Application software, control logic
  (d) Detailed descriptions of control and monitoring equipment, and safety systems

(3) Quality control of software
  (a) Quality standards
  (b) A quality plan for software lifecycle
  (c) Quality assurance procedures in production

(4) Documentation of software modification
  Work procedures for modifying program contents and data including upgrades

(5) Failure analysis for systems
  (a) Verification process and results (including counter measures) by failure analysis methods such as FTA, FMEA and FMECA
  (b) Evidence that the failure of a system of Category I will not impact human safety, safety of the vessel, or the environment

(6) Engineering analysis
  In accordance with requirements specified in **18.2.7-1, Part D of the Rules**, an engineering analysis deemed appropriate by the Society in cases where alternative designs or arrangements are used.

(~~6~~7) Test procedures for hardware
  Procedures according to the requirements of **18.7.1, Part D of the Rules**

(~~7~~8) Test procedures for software
  Procedures to verify that systems interact correctly to perform the intended functions and do not perform unintended functions (the test is carried out in each module, subsystem and whole system, if necessary)

(~~8~~9) Test procedures to verify the integration of systems at factory (including failure simulation)
  (a) Operation test procedures for the completed system combining actual hardware and

finalized software which were verified according to **(~~6~~7)** and **(~~7~~8)**

(b) Confirmation method for the adequacy of the results of failure analysis methods such as FTA, FMEA and FMECA

(~~9~~10)On-board test procedures

(a) Operation test procedures on board of the systems after installation of the software

(b) Verification test procedures related to the electromagnetic effects of at least the following in cases where wireless data communication systems are to be installed.

i) The electromagnetic effects of the wireless data communication system on other equipment.

ii) The effects of electromagnetic interference expected during normal operation on the wireless data communication system.

(~~10~~11)Detailed descriptions of system modifications and their verification test procedures (where the modification influences the functionality or safety of the systems)

(12) Description of the wireless data communication system

(a) Details of the manufacturer recommended installation and maintenance practices

(b) Network plans (including the arrangement of all system devices) as well as the identification of the type and location of all antennas

(c) Specifications of wireless communication system protocols and management functions (refer to **18.2.7-4.(2), Part D of the Rules**)

(d) Details of radio frequencies and power levels

(e) Evidence for approval of use from Society in accordance with **Chapter 1, Part 7 of "Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use."**

(~~11~~13)Spare parts and replacement procedures

D18.2 System Design

Paragraph D18.2.7 has been amended as follows.

D18.2.7 Computers and Computerized Systems

1 Examples of computerized systems relevant to **Table D18.1, Part D of the Rules** are shown in the **Table D18.2.7-1**. Where independent effective backup or other means of averting danger is provided, a Category III system may be downgraded to Category II.

2 The computers "considered necessary by the Society" specified in **18.2.7, Part D of the Rules** means those used for the following systems in general. In this case, programmable controllers such as sequencers are included.

(1) Control systems for the machinery and equipment specified in **18.1.1-1(1)** through **(5), Part D of the Rules**.

(2) Alarm systems specified in **18.2.5, Part D of the Rules**.

(3) The safety systems for the machinery and equipment specified in **18.1.1-1, Part D of the Rules**

(4) Control systems, alarm systems and safety systems relevant to **Table D18.1, Part D of the Rules**

3 The wording "requirements deemed appropriate by the Society" specified in **18.2.7-1, Part D of the Rules** means those cases where an alternative design or arrangement is used and the results of an engineering analysis conducted in accordance with relevant international or national standards acceptable to the Society are satisfactory and approved by the Society.

~~3~~4 "The extent of effect due to a failure of part of circuits or components is limited to a minimum" specified in **18.2.7-2(2)(a), Part D of the Rules** means, for example, that in a system always

controlled by two or more computers, the system can be made to cope with the failure of one computer without hindering performance.

~~4~~5 The requirements "deemed appropriate by the Society" specified in **18.2.7-2(3)(a), Part D of the Rules** mean that the results of a failure analysis such as FMEA on the system are satisfactory and approved by the Society.

~~5~~6 "Back-up means" specified in **18.2.7-2(3)(b), Part D of the Rules** refer to either of the following pieces of equipment or systems.

(1) Safety systems that do no rely on computers
(2) Stand-by computers

~~6~~7 "Other arrangements deemed appropriate by the Society" specified in **18.2.7-2(3)(c), Part D of the Rules** means, for example, the combination of a VDU and an alarm printer.

~~7~~8 "Requirements deemed appropriate by the Society" specified in **18.2.7(4) 18.2.7-2(4), Part D of the Rules** means the following.

(1) In cases where secondary control systems or stand-by computers are installed for those control systems specified in **-2(1)** above, the independence of such control systems may not be required for individual machinery or equipment. In such cases, local control equipment fitted to main propulsion machinery in accordance with the requirements given in **18.3.2-3(2), Part D of the Rules** may not be regarded as the secondary control systems.
(2) In cases where safety systems conform to the requirement given in **-~~5~~6**, the independence of individual machinery and equipment in systems, and their independence from other systems may not be required.
(3) In cases where secondary systems or stand-by computers are installed in both control systems and safety systems, the independence of individual machinery and equipment in their systems including alarm systems, and their independence from the other systems may not be required.

9 The wording "requirements deemed appropriate by the Society" specified in **18.2.7-4, Part D of the Rules** means that the results of the engineering analysis specified in **-3** are satisfactory and approved by the Society.

10 The wording "standards deemed appropriate by the Society" specified in **18.2.7-4(3), Part D of the Rules** means the requirements specified by the International Telecommunications Union (ITU) and the relevant flag state.

~~8~~11 "Parameters" specified in **18.2.7-~~4~~5(2), Part D of the Rules** means those settings specified in the relevant chapters of the equipment specified in **18.1.1-1, Part D of the Rules**.

Table D18.2.7-1 Examples of Computerized Systems

Category	Examples
I	- Maintenance support systems - Information and diagnostic systems
II	- Alarm and monitoring systems - Main propulsion remote control systems - Governor control systems - Control systems for auxiliary machinery - Bilge systems - Other systems considered necessary by the Society
III	- Control systems for propulsion with steering - Electronic fuel injection systems for main diesel engines - Burner control systems (for those main boilers and essential auxiliary boilers defined in **9.1.2(2), Part D of the Rules**) - Power supply control systems - Other systems considered necessary by the Society

EFFECTIVE DATE AND APPLICATION (Amendment 2-5)

1. The effective date of the amendments is 1 January 2012.

2. Notwithstanding the amendments to the Guidance, the current requirements may apply to systems installed on ships for which the date of contract for construction is before the effective date.

Amendment 2-6

Annex D1.1.3-1 GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF WATERJET PROPULSION SYSTEMS

1.2 Class Surveys

1.2.1 Classification Survey

Sub-paragraph −1(1) has been amended as follows.

1 Classification Surveys during Construction

(1) Plans and documents

Plans and documents to be submitted are generally as follows:

(a) Particulars
(b) Specifications
(c) Material specifications
(d) Details of welding procedures
(e) General arrangements and sectional assembly drawings (showing the materials and dimensions of various parts including water intake ducts)
(f) Shafting arrangements (showing arrangements, shapes and construction of main engines, gears, clutches, couplings, main shafts, main shaft bearings and thrust bearings, sealing devices and impellers)
(g) Details of water intake ducts
(h) Construction of impellers (showing detailed blade profiles, the maximum diameter of blades from the centre of main shafts, number of blades, and material specifications)
(i) Details of bearings (including thrust bearings), in the case of roller bearing, together with specifications of such bearings and the calculation sheets for the life times of roller bearings
(j) Details of sealing devices (including waterjet pump unit sealing devices)
(k) Details of deflectors
(l) Details of reversers
(m) Details of hydraulic actuators
(n) Piping diagrams (hydraulic systems, lubricating systems, cooling water systems and etc.)
(o) Arrangements of control systems and diagram of hydraulic and electrical systems (including safety devices, alarm devices and automatic steering)
(p) Arrangements and diagrams of an alternative source of power
(~~p~~q) Diagram of indication devices for deflector positions
(~~q~~r) Torsional vibration calculation sheets and calculation sheets for the bending natural frequency when bending vibration due to self-weight is expected
(~~r~~s) Strength calculation sheets for deflectors and reversers
(~~s~~t) Sea trail records
(~~t~~u) Others items considered to be necessary by the Society

Sub-paragraph -3 has been amended as follows.

3 Sea Trials

(1) In the Classification Survey of ships, the following tests are to be carried out during sea trials, in substitution for those tests specified in **2.3.1-1(3)**, **Part B of the Rules**. However, those tests required in **(c)**, **(d)**, **(e)**, **(f)** and **(g)** may be carried out either at dockside or in dry dock.
   (a) Tests on steering capabilities specified in **1.5.1**
   (b) Tests on operation of controls for steering and reversing systems, including tests on change-overs of control systems between navigation bridges and auxiliary steering stations, and change-overs between manual steering and automatic steering, if provided.
   (c) Tests on measures for maintaining power supplies and on the alternative source of power required by **1.6.2**
   (d) Tests on means of communication between navigation bridges and auxiliary steering stations, and between engine rooms and auxiliary steering stations
   (e) Tests on the functioning of relief valves for preventing over-pressure
   (f) Tests on the functioning of alarm and safety devices, and indication devices for deflector positions, reverser positions and impeller speed, and running indicators of electric motors for hydraulic power systems
   (g) Tests on the functioning of stoppers of reversers

(2) In the case of Classification Survey of ships not built under the Society's survey, the above tests may be dispensed with, provided that sufficient data on the previous tests are available and no alteration affecting the tests specified in **(1)** have been made after the previous tests.

1.2.2 Periodical Surveys

Sub-paragraph -1 has been amended as follows.

1 Annual Surveys

(1) General examinations
   The general conditions of propulsion systems are to be confirmed to be in good order.

(2) Performance tests
   The following tests are to be carried out:
   (a) Performance tests of steering and reversing systems
   (b) Tests on the functioning of control devices specified in **1.2.1-3(1)(b)**
   (c) Tests on the functioning of alarm and safety devices, and indication devices for deflector positions, reverser positions and impeller speed, and running indicators of electric motors for hydraulic power systems
   (d) Test for supply of the alternative source of power specified in **1.6.2-2.**

1.5 Steering and Reversing Systems

1.5.1 Capability of Steering and Reversing

Sub-paragraph -1 has been amended as follows.

1 Deflectors are, in principle, to be capable of ~~steering from 30 *degrees* on one side to 30 *degrees* on the other side with the ship at its load draught while~~ changing direction of the ship's directional control system from one side to the other at declared steering angle limits at an average rotational speed of not less than 2.3°/*s* with the ship running ahead at speeds specified in **2.1.8**, **Part A of the Rules** ~~and, under the same conditions, from 30 *degrees* on either side to 30 *degrees* on the other side in not more than 28 *seconds*~~. In addition, ships are to have sufficient steering capability according to their ship type. The wording "declared steering angle limits" refers to the operational limits of deflectors in terms of maximum steering angle according to manufacturer guidelines for safe operation.

1.6 Electric Installations

Paragraph 1.6.2 has been amended as follows.

1.6.2 Maintenance of Electric Supply

1 Main sources of electric power are to be so arranged that electric supplies to relevant equipment are maintained, or restored immediately in the case of a loss of any one of the generators in service, to ensure the functions of propulsion, steering and reversing of at least one of the propulsion systems, its associated control systems and its indication devices for deflector positions by the following arrangements:

(1) In cases where electrical power is normally supplied by one generator, adequate provisions are to be made for automatic starting and connecting to main switchboards of standby generators of sufficient capacity to maintain the functions of the above with automatic restarting of important auxiliaries including sequential operations in cases where there is a loss of electrical power of the generator in operation.

(2) If electrical power is normally supplied by more than one generator simultaneously in parallel operations, provisions are to be made to ensure that, in cases where there is a loss of electrical power of one of generating sets, the remaining ones are kept in operation to maintain the functions of the above. (See **2.3.6**, **Part H of the Rules**)

2 In cases where the propulsion power exceeds 2,500 *kW* per thruster unit, an alternative source of power is to be provided in accordance with the following:

(1) The alternative source of power is to be either:
   (a) An emergency source of electric power; or
   (b) An independent source of power located in the steering gear compartment and used only for this purpose.

(2) Any alternative source of power is to be capable of automatically supplying alternative power within 45 *seconds* to the deflector and its associated control system and its indication devices for deflector positions. In this case, the alternative source of power is to be capable of changing direction of the ship's directional control system from one side to the other at declared steering angle limits at an average rotational speed of not less than 0.5°/*s* with the ship running ahead at one half of the speeds specified in **2.1.8**, **Part A of the Rules** or 7 knots, whichever is greater.

Alternative sources of power are to have enough capacity for the continuous operation of such systems for at least 30 *minutes* in every ship of 10,000 *gross tonnage* or more, and for at least 10 *minutes* in every other ship.

(3) Automatic starting arrangements for generators or prime movers of pumps used as the independent source of power specified in **(1)(b)** are to comply with the requirements for starting devices and performance in **3.4.1, Part H**.

Paragraph 1.6.3 has been amended as follows.

1.6.3 Electrical Installations for Steering and Reversing Systems

In cases where hydraulic pumps for hydraulic power systems are driven by electric motors, electrical installations for steering and reversing systems are to comply with the following requirements in **(1)** through **(8)**:

(1) Each propulsion system is to be served separately by exclusive circuits fed directly from main switchboards. In cases where three or more propulsion systems are provided, these exclusive circuits may be composed of at least two systems. One of these circuits may be supplied through the emergency switchboard.

(2) Cables used in those exclusive circuits required in **(1)** are to be separated as far as practicable throughout their length.

(3) Audible and visual alarms are to be given on navigation bridges in the event of any power failure to electric motors for hydraulic pumps.

(4) Means for indicating that electric motors for hydraulic pumps are running are to be installed on navigation bridges and positions from which main engines are normally controlled.

(5) Short circuit protection and overload alarms are to be provided for such circuits and motors respectively. Overload alarms are to be both audible and visible and are to be situated in conspicuous positions in places from which main engines are normally controlled.

(6) Protection against excess current, including starting currents, if provided, is to be for not less than twice the full load current of those motors or circuits so protected, and to be arranged to permit the passage of any appropriate starting currents.

(7) In cases where a three-phase supply is used, alarms are to be provided that will indicate failure of any one of the supply phases. Such alarms are to be both audible and visible and are to be situated in conspicuous positions in places from which main engines are normally controlled.

(8) In cases where the propulsion power does not exceed 2,500 *kW* per thruster unit and emergency generators are provided, one hydraulic power system for the steering system (including associated control systems) is to be served by exclusive circuits fed directly from emergency switchboards. In this case, those exclusive circuits supplied through the emergency switchboards specified in **(1)** may be used as this circuit.

Annex D1.1.3-3 GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF AZIMUTH THRUSTERS

1.2 Class Surveys

1.2.1 Classification Surveys

Sub-paragraph -1(1) has been amended as follows.

1 Classification Survey during Construction

(1) Plans and documents

Plans and documents to be submitted are generally as follows:

(a) Particulars
(b) Specifications
(c) Material specifications
(d) Details of welding procedures for principal components
(e) General arrangements and sectional assembly drawings
(f) Shafting arrangements (details of propeller shafts, gears, clutches, gear shafts, shaft couplings, bearings and sealing devices and propellers, specifications and calculations and service life calculations of roller bearings, torsional vibration calculations and propeller pull-up length calculation sheets)
(g) Details of azimuth thruster casings
(h) Drawings of azimuth steering gears (details of actuating systems, gear assemblies, bearings and sealing devices for azimuth steering gears)
(i) Piping diagrams (hydraulic systems, lubricating systems, cooling water systems and etc.)
(j) Arrangements of control systems and diagram of hydraulic and electrical systems (including safety devices, alarm devices and automatic steering)
(k) Arrangements and diagrams of an alternative source of power
(~~k~~l) Diagrams of indication devices for azimuth angles
(~~l~~m) Strength calculations
(~~m~~n) Sea trial records
(~~n~~o) When a vibration measurement system specified in **1.2.2-5(1)** is being used, the following documents **i)** and **ii)**:
  i) Function description for vibration measurement system
  ii) Management manual including the following **1)** through **3)**
    1) List of the bearings for vibration measurement and measurement points.
    2) Guidance for the measurement (including the way for taking signals from the casing)
    3) Guidance for the analysis and the evaluation of the measurement result
(~~o~~p) When a Fe-density measurement system specified in **1.2.2-5(2)** is being used, the following documents **i)** and **ii)**:
  i) Function description for the Fe-density measurement system
  ii) Management manual including the following **1)** through **3)**
    1) Guidance for the lubricating oil sampling
    2) Guidance for the Fe-density measurement
    3) Guidance for the analysis and the evaluation of the measurement result
(~~p~~q) Other plans and documents considered necessary by the Society

Sub-paragraph -3 has been amended as follows.

3 Sea Trials

(1) In Classification Surveys of ships, the following tests are to be carried out during sea trials, as substitutes for those tests given in **2.3.1-1(3)**, **Part B of the Rules**. However, those tests required in **(c)**, **(d)**, **(e)** and **(f)** may be carried out either at dockside or in dry dock. Also, when it is difficult to carry out tests on the functioning of relief valves mentioned in **(e)** after installation on board, these tests may be carried out as shop tests.
   (a) Tests on steering capability specified in **1.5.1**
   (b) Tests on the operation of controls for steering, including tests on change-overs of control systems between navigation bridges and azimuth thruster compartments, and change-overs between manual steering and automatic steering, if provided.
   (c) Tests on measures for maintaining power supplies and on the alternative source of power required in **1.6.2**.
   (d) Tests on means of communication between navigation bridges and the azimuth thruster compartments, and between engine rooms and azimuth thruster compartments.
   (e) Tests on the functioning of relief valves for preventing over-pressure.
   (f) Tests on the functioning of alarm and safety devices as well as indication devices for azimuth angles, propeller speeds and direction of rotation and pitch positions, and running indicators of electric motors for azimuth steering gears

(2) In cases of Classification Surveys of ships not built under the Society's survey, the above tests may be dispensed with, provided that sufficient data on previous tests is available and no alterations affecting those tests specified in **(1)** have been made since such previous tests.

1.2.2 Periodical Surveys

Sub-paragraph -1 has been amended as follows.

1 Annual Surveys

The following tests **(1)** and **(2)** are to be carried out. When instruments specified in **-5(1)** and **(2)** are being used, the data and the result of the analysis are to be evaluated before the survey and are to be retained on board at all times.

(1) General examinations

The general conditions of thrusters are to be ascertained to confirm that they are properly functioning.

(2) Performance tests
   (a) Performance tests of azimuth steering gears are to be carried out.
   (b) Tests on the functioning of alarm and safety devices as well as indication devices for azimuth angles, propeller speeds and direction of rotation and pitch positions, and running indicators of electric motors for azimuth steering gears are to be carried out.
   (c) Tests on the functioning of those control devices specified in **1.2.1-3(1)(b)** are to be carried out.
   (d) Test for supply of the alternative source of power specified in **1.6.2-2.**
   (~~d~~e) Function tests on those arrangements specified in **1.10.1** are to be carried out. (Running tests on those discharging devices mentioned in **1.10.1-1** need not be carried out.)

1.5 Azimuth Steering Gears

1.5.1 Capability of Azimuth Steering Gears

Sub-paragraph -1 has been amended as follows.

1 The ~~capability of azimuthing~~ steering arrangement of thrusters ~~is to comply with the requirements for those main steering gears specified in **15.2.2(1), Part D**~~ are to be capable of changing direction of the ship's directional control system from one side to the other at declared steering angle limits at an average rotational speed of not less than 2.3°/*s* with the ship running ahead at speeds specified in **2.1.8**, **Part A of the Rules**. The wording "declared steering angle limits" refers to the operational limits in terms of maximum steering angle according to manufacturer guidelines for safe operation.

1.6 Electric Installations

Paragraph 1.6.2 has been amended as follows.

1.6.2 Maintenance of Electric Supplies

1 In cases where any generators in service are lost, main sources of electric power are to be so arranged that electric supplies to any relevant equipment are maintained or restored immediately in order to ensure the functions of propulsion and steering of at least one thruster, its associated control systems and indication devices for azimuth angles by the following arrangements:

(1) In cases where electrical power is normally supplied by one generator, adequate provisions are to be made for the automatic starting and the connecting to main switchboards of standby generators of sufficient capacities to maintain the functions of the above with automatic restarting of important auxiliaries, including sequential operations, in cases of loss of electrical power to generators in operation.

(2) If electrical power is normally supplied by more than one generator simultaneously in parallel operations, provisions are to be made to ensure that, in cases of loss of electrical power to one of such generating sets, the remaining ones are kept in operation to maintain the functions of those above. (See **2.3.6**, **Part H of the Rules**)

2 In cases where propulsion power exceeds 2,500 *kW* per thruster unit, an alternative source of power is to be provided in accordance with the following:

(1) The alternative source of power is to be either:
   (a) An emergency source of electric power; or
   (b) An independent source of power located in the steering gear compartment and used only for this purpose.

(2) Any alternative source of power is to be capable of automatically supplying alternative power within 45 *seconds* to the steering arrangement and its associated control system and its indication devices for azimuth angles. In this case, the alternative source of power is to be capable of changing direction of the ship's directional control system from one side to the other at declared steering angle limits at an average rotational speed of not less than 0.5°/*s* with the ship running ahead at one half of the speeds specified in **2.1.8**, **Part A of the Rules** or 7 knots, whichever is greater. Alternative sources of power are to have enough capacity for the continuous operation of such systems for at least 30 *minutes* in every ship of 10,000 *gross tonnage* or more, and for at least 10 *minutes* in every other ship.

(3) Automatic starting arrangements for generators or prime movers of pumps used as the independent source of power specified in **(1)(b)** are to comply with the requirements for starting devices and performance in **3.4.1, Part H**.

Paragraph 1.6.3 has been amended as follows.

1.6.3 Electrical Installations for Azimuth Steering Gears

Electrical installations for azimuth steering gears are to comply with the following requirements in **(1)** through **(5)**:

(1) Means for indicating that electric motors for steering are running are to be installed on navigation bridges and those positions from which main engines are normally controlled.

(2) Short circuit protections and overload alarms are to be provided for such circuits and motors respectively. Overload alarms are to be both audible and visible and are to be situated in conspicuous positions in those places from which main engines are normally controlled.

(3) Any protection against excess current, including starting currents, if provided, is to be for not less than twice the full load current of motors or circuits so protected, and is to be arranged to permit passage of appropriate starting currents.

(4) In cases where three-phase supplies are used, alarms are to be provided that will indicate the failure of any one of the supply phases. Such alarms are to be both audible and visible and are to be situated in conspicuous positions in those places from which main engines are normally controlled.

(5) In cases where the propulsion power does not exceed 2,500 *kW* per thruster unit and emergency generators are provided, one azimuth steering gear (including its associated control systems) is to be served by exclusive circuits fed directly from emergency switchboards. In such cases, those exclusive circuits supplied through emergency switchboards as specified in **1.6.1-1** may be used as such circuits.

EFFECTIVE DATE AND APPLICATION (Amendment 2-6)

1. The effective date of the amendments is 1 January 2012.

2. Notwithstanding the amendments to the Guidance, the current requirements may apply to propulsion and steering systems whose application for certification is dated before the effective date and which are installed in ships for which the date of contract for construction* before the effective date.

* "contract for construction" is defined in the latest version of IACS Procedural Requirement (PR) No.29.

IACS PR No.29 (Rev.0, July 2009)

1. The date of "contract for construction" of a vessel is the date on which the contract to build the vessel is signed between the prospective owner and the shipbuilder. This date and the construction numbers (i.e. hull numbers) of all the vessels included in the contract are to be declared to the classification society by the party applying for the assignment of class to a newbuilding.

2. The date of "contract for construction" of a series of vessels, including specified optional vessels for which the option is ultimately exercised, is the date on which the contract to build the series is signed between the prospective owner and the shipbuilder.

For the purpose of this Procedural Requirement, vessels built under a single contract for construction are considered a "series of vessels" if they are built to the same approved plans for classification purposes. However, vessels within a series may have design alterations from the original design provided:

(1) such alterations do not affect matters related to classification, or

(2) If the alterations are subject to classification requirements, these alterations are to comply with the classification requirements in effect on the date on which the alterations are contracted between the prospective owner and the shipbuilder or, in the absence of the alteration contract, comply with the classification requirements in effect on the date on which the alterations are submitted to the Society for approval.

The optional vessels will be considered part of the same series of vessels if the option is exercised not later than 1 year after the contract to build the series was signed.

3. If a contract for construction is later amended to include additional vessels or additional options, the date of "contract for construction" for such vessels is the date on which the amendment to the contract, is signed between the prospective owner and the shipbuilder. The amendment to the contract is to be considered as a "new contract" to which **1.** and **2.** above apply.

4. If a contract for construction is amended to change the ship type, the date of "contract for construction" of this modified vessel, or vessels, is the date on which revised contract or new contract is signed between the Owner, or Owners, and the shipbuilder.

Note:
This Procedural Requirement applies from 1 July 2009.

Amendment 2-7

Annex D2.3.1-2(2) GUIDANCE FOR CALCULATION OF CRANKSHAFT STRESS II

1.3 Calculation of Stresses

1.3.1 Alternating Bending Stress

Sub-paragraph -3 has been amended as follows.

3 Alternating Bending Stresses in Fillets and Outlets of Crankpin Oil Bores

(1) Calculation of alternating bending stresses in crankpin fillets is as follows:

$\sigma_{BH} = \pm(\alpha_B \cdot \sigma_{BFN})$

where

σ_{BH} : Alternating bending stress in crankpin fillet (N/mm^2)

α_B : Stress concentration factor for bending in crankpin fillet (see **1.4.2** and **1.4.4-4(2)(b)**)

(2) Calculation of alternating bending stresses in journal fillets (not applicable to semi-built crankshafts) is as the follow~~s~~ing formulae in **(a)** or **(b)**:

(a) $\sigma_{BG} = \pm(\beta_B \cdot \sigma_{BFN} + \beta_Q \cdot \sigma_{QFN})$

where

σ_{BG} : Alternating bending stress in journal fillet (N/mm^2)

β_B : Stress concentration factor for bending in journal fillet (see **1.4.3** and **1.4.4-4(2)(b)**)

β_Q : Stress concentration factor for compression due to radial force in journal fillet (see **1.4.3** and **1.4.4-4(3)(b)i)**)

(b) $\sigma_{BG} = \pm(\beta_{BQ} \cdot \sigma_{BFN})$

β_{BQ} : Stress concentration factor for bending and compression due to radial force in journal fillet (see **1.4.4-4(3)(b)ii)**)

(3) The calculation of the alternating bending stress in the outlet of crankpin oil bore (only applicable to radially drilled oil hole) is as follows:

$\sigma_{BO} = \pm(\gamma_B \cdot \sigma_{BON})$

where

σ_{BO} : Alternating bending stress in outlet of crankpin oil bore (N/mm^2)

γ_B : Stress concentration factor for bending in crankpin oil bore (see **1.4.4~~5~~**)

1.3.2 Alternating Torsional Stresses

Sub-paragraph -2 has been amended as follows.

2 Alternating Torsional Stresses in Fillets and Outlets of Crankpin Oil Bores

(1) Calculation of alternating torsional stresses in crankpin fillets is as follows:

$\tau_H = \pm(\alpha_T \cdot \tau_N)$

where

τ_H : Alternating torsional stress in crankpin fillet (N/mm^2)

α_T : Stress concentration factor for torsion in crankpin fillet (see **1.4.2** and **1.4.4-4(1)(c)**)

τ_N : Nominal alternating torsional stress related to crankpin diameter (N/mm^2)

(2) Calculation of alternating torsional stresses in journal fillets (not applicable to semi-built crankshafts) is as follows:

$\tau_G = \pm(\beta_T \cdot \tau_N)$

where

τ_G : Alternating torsional stress in journal fillet (N/mm^2)

β_T : Stress concentration factor for torsion in journal fillet (see **1.4.3** and **1.4.4-4(1)(c)**)

τ_N : Nominal alternating torsional stress related to journal diameter (N/mm^2)

(3) Calculation of alternating stresses in outlets of crankpin oil bores due to torsion (only applicable to radially drilled oil holes) is as follows:

$\sigma_{TO} = \pm(\gamma_T \cdot \tau_N)$

where

σ_{TO} : Alternating stress in outlet of crankpin oil bore due to torsion (N/mm^2)

γ_T : Stress concentration factor for torsion in outlet of crankpin oil bore (see **1.4.4**)

τ_N : Nominal alternating torsional stress related to crankpin diameter (N/mm^2)

1.4 Stress Concentration Factors

1.4.1 Explanation of Terms and Symbols

Sub-paragraph -2 has been amended as follows.

2 The symbols used in this **1.4** mean as follows (see **Fig.5**):

D : Crankpin diameter (mm)

D_{BH} : Diameter of axial bore in crankpin (mm)

D_O : Diameter of oil bore in crankpin (mm)

R_H : Fillet radius of crankpin (mm)

T_H : Recess of crankpin fillet (mm)

D_G : Journal diameter (mm)

D_{BG} : Diameter of axial bore in journal (mm)

R_G : Fillet radius of journal (mm)

T_G : Recess of journal fillet (*mm*)

E : Pin eccentricity (*mm*)

S : Pin overlap (*mm*)

$$S = \frac{D + D_G}{2} - E$$

W : Web thickness (*mm*)

In the case of 2-stroke semi-built crankshafts with $T_H > R_H$, the web thickness is to be considered as equal to:

$W_{red} = W - (T_H - R_H)$ (see **Fig.3**)

B : Web width (*mm*)

In the case of 2-stroke semi-built crankshafts, the web width is to be taken in way of crankpin fillet radius center according to **Fig.3**.

$r = R_H / D$ (in crankpin fillets), R_G / D (in journal fillets) $(0.03 \le r \le 0.13)$

$s = S/D$ $(s \le 0.5)$

$w = W/D$ $(0.2 \le w \le 0.8)$

$b = B/D$ $(1.1 \le b \le 2.2)$

$d_O = D_O / D$ $(0 \le d_O \le 0.2)$

$d_G = D_{BG} / D$ $(0 \le d_G \le 0.8)$

$d_H = D_{BH} / D$ $(0 \le d_H \le 0.8)$

$t_H = T_H / D$

$t_G = T_G / D$

Where the geometry of crankshaft is outside the above ranges, stress concentration factors in crankpin fillets and journal fillets are to be calculated by utilizing the Finite Element Method (FEM) given in **1.4.4**.

Paragraph 1.4.4 has been renumbered to 1.4.5, and Paragraph 1.4.4 has been added as follows.

1.4.4 Stress Concentration Factors by utilizing FEM

1 Finite Element Model

(1) The model is to consist of one complete crank, from the main bearing centreline to the opposite side main bearing centreline.

(2) Element type used in the vicinity of the fillets is to be as follows:

(a) 10-node tetrahedral elements

(b) 8-node hexahedral elements

(c) 20-node hexahedral elements

(3) Mesh properties in fillet radii applied to ±90 degrees in a circumferential direction from the crank plane are as follows:

(a) Maximum element size a through the entire fillet as well as in the circumferential direction is to be $a=R_H/4$ in crankpin fillets and $a=R_G/4$ in journal fillets. When using 20-node hexahedral elements, the element size in the circumferential direction may be extended up to 5a. In the case of multi-radii fillet, the local fillet radius is to be applied.

(b) Element size in fillet depth direction is to be of a to first layer thickness, 2a to second layer thickness and 3a to third layer thickness. (see **Fig. 6**)

(4) A minimum of 6 elements are to be set across the web thickness.

(5) The rest of the crank is to be suitable for numeric stability of the solver.
(6) Counterweights have to be modelled only when influencing the global stiffness of the crank significantly.
(7) Modelling of oil drillings is not necessary as long as the influence on global stiffness is negligible and the proximity to the fillet is more than $2R_H$ or $2R_G$ (see **Fig. 7**)
(8) Drillings and holes for weight reduction have to be modelled.
(9) Sub-modelling may be used as far as the software requirements are fulfilled.

Fig. 6 Element size in fillet depth direction

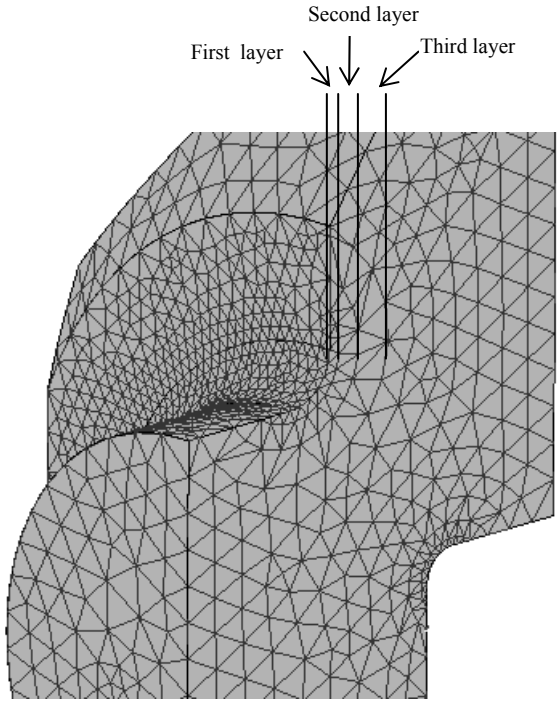
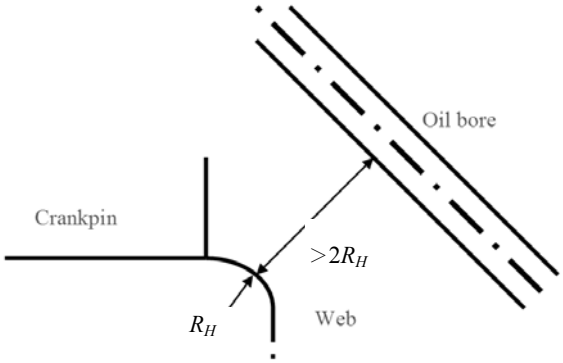


Fig. 7 Oil bore proximity to fillet



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2 Material properties

Material properties applied to steels as follows.
Young's Modulus $E= 2.05 \cdot 10^5$ MPa
Poisson's ratio $\nu=0.3$

3 Element mesh quality criteria

If the actual element mesh does not fulfil any of the following criteria at the area examined for SCF evaluation, then a second calculation with a refined mesh is to be performed.

(1) The quality of the mesh is to be assured by checking the stress component normal to the surface of the fillet radius. Ideally, this stress is to be zero. With principal stresses $\sigma 1$, $\sigma 2$ and $\sigma 3$, the following criterion is required:

$$\min(|\sigma_1|,|\sigma_2|,|\sigma_3|) < 0.03 \cdot \max(|\sigma_1|,|\sigma_2|,|\sigma_3|)$$

(2) Unaveraged nodal stress results calculated from each element connected to a node is to differ less than by 5 % from the 100 % averaged nodal stress results at this node at the examined location.

4 Load cases

The following load cases have to be calculated.

(1) Torsion

(a) Calculation is to be performed under the boundary and load conditions given in **Fig. 8** where the torque is applied to the central node located at the crankshaft axis. This node acts as the master node with 6 degrees of freedom and is connected rigidly to all nodes of the end face.

(b) For all nodes in both the journal and crankpin fillet, principal stresses are extracted and the equivalent torsional stress is calculated:

$$\tau_{equiv} = \max\left(\frac{|\sigma_1 - \sigma_2|}{2}, \frac{|\sigma_2 - \sigma_3|}{2}, \frac{|\sigma_1 - \sigma_3|}{2}\right)$$

(c) The maximum value taken for the subsequent calculation of the stress concentration factors for torsion in crankpin and journal fillet.

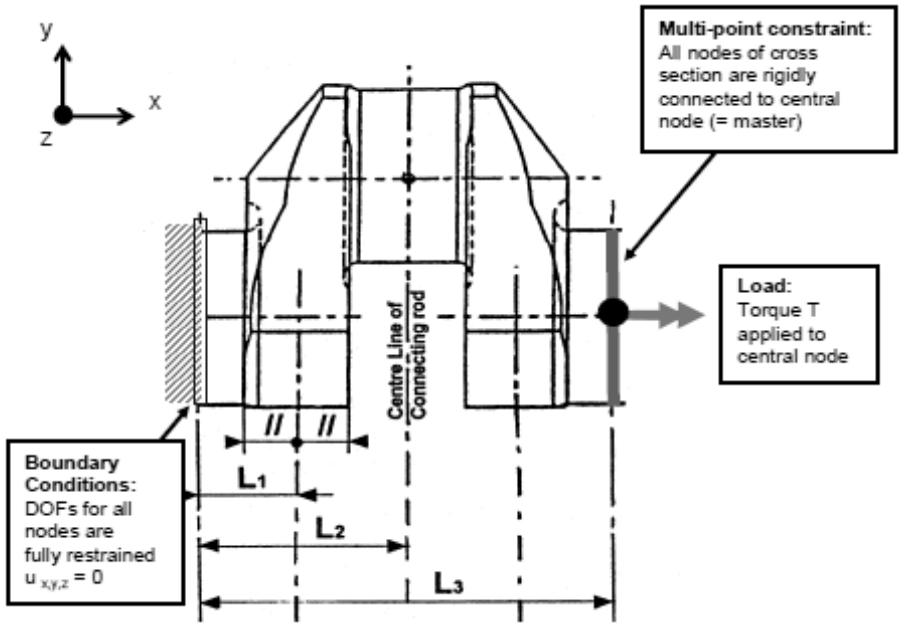
$$\alpha_T = \frac{\tau_{equiv,a}}{\tau_N}$$

$$\beta_T = \frac{\tau_{equiv,\beta}}{\tau_N}$$

where τ_N is nominal torsional stress for the crankpin and journal respectively and is calculated as follows (for W_P see **1.3.2**):

$$\tau_N = \frac{T}{W_P}$$

Fig.8 Boundary and load conditions for the torsion load case



(2) Pure bending (4 point bending)

(a) Calculation is to be performed under the boundary and load conditions given in **Fig.9** where the bending moment is applied to the central node located at the crankshaft axis.

(b) For all nodes in both the journal and crankpin fillet, von Mises equivalent stresses σ_{equiv} are extracted. The maximum value is used to calculate the stress concentration factors for bending in crankpin and journal fillet according to:

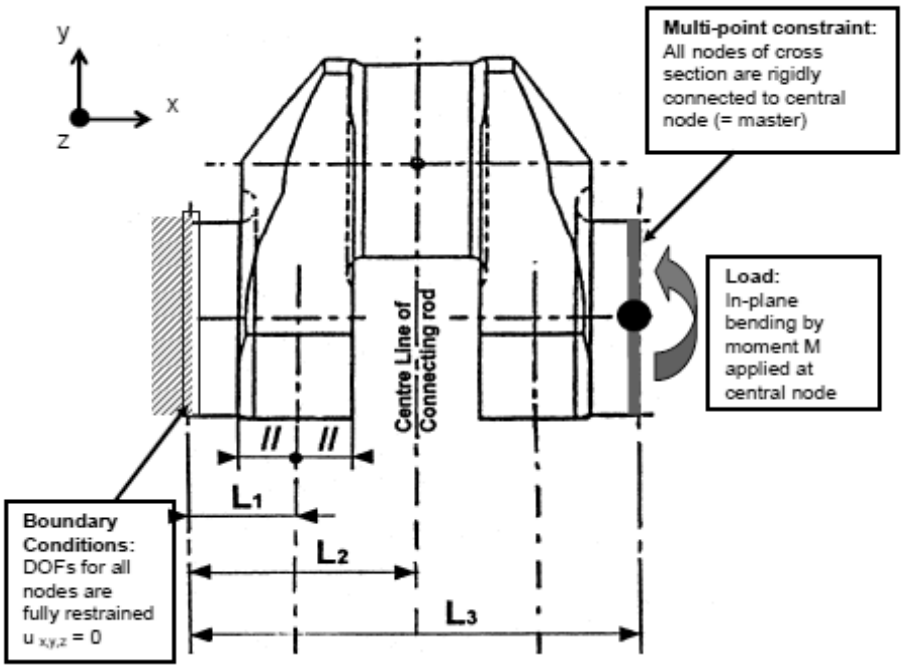
$$\alpha_B = \frac{\sigma_{equiv,a}}{\sigma_N}$$

$$\beta_B = \frac{\sigma_{equiv,\beta}}{\sigma_N}$$

where σ_N is nominal mending stress for the crankpin and journal respectively and is calculated as follows (for W_{eqw} see **1.3.1-2(2)**):

$$\sigma_N = \frac{M}{W_{eqw}}$$

Fig.9 Boundary and load conditions for the pure bending load case



(3) Bending with shear force (3-point bending)

(a) Calculation is to be performed under the boundary and load conditions given in **Fig.10** where the force is applied to the central node located at the pin centre-line of the connecting rod.

Fig.10 Boundary and load conditions for the 3-point bending load case of an inline engine.

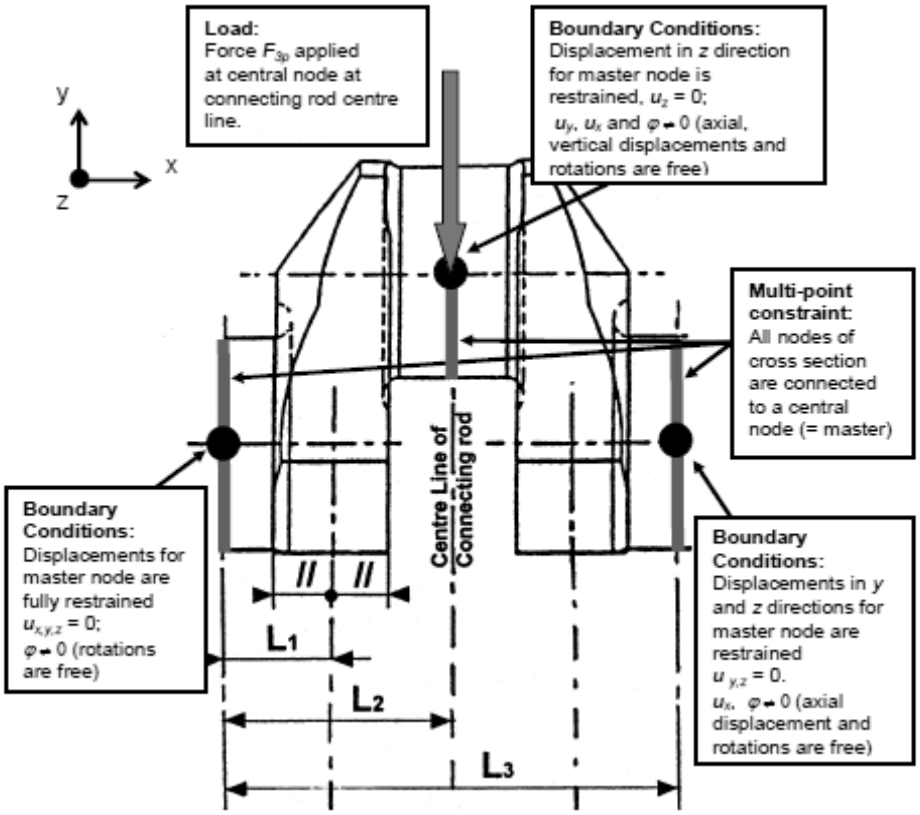
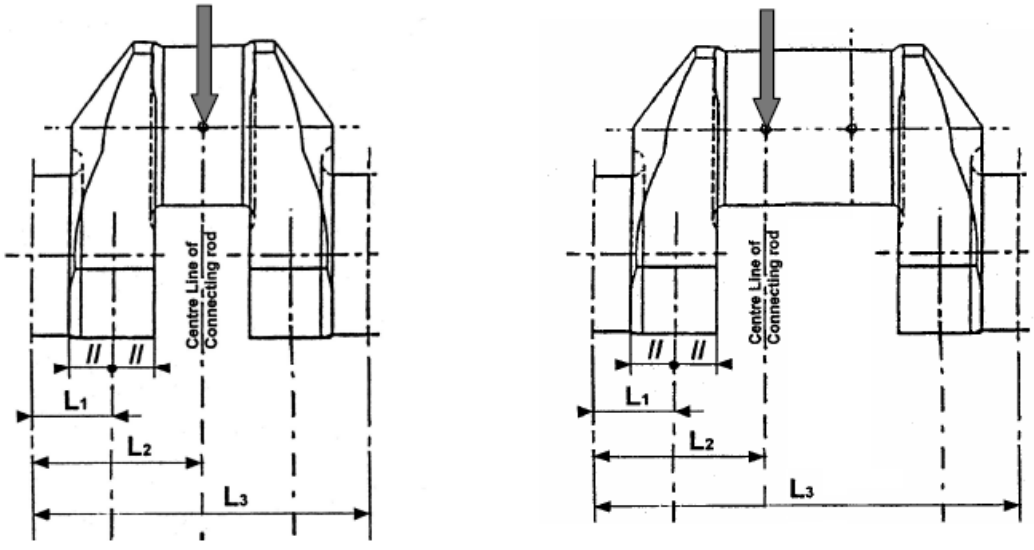


Fig.11 Load applications for In-line and V-type engines



(b) The maximum equivalent von Mises stress σ_{3P} in the journal fillet is evaluated. The stress concentration factors in the journal fillet can be determined as shown **i)** or **ii).**

i) Stress concentration factor for compression due to radial force in journal fillet β_Q is calculated in accordance with the following:

$$\sigma_{3P} = \sigma_{N3P} \cdot \beta_B + \sigma_{Q3P} \cdot \beta_Q$$

where

σ_{3P} : as found by the Finite Element Calculation

σ_{N3P}: Nominal bending stress in the web centre due to force F_{3P} applied to the centre-line of the actual connecting rod (see Figure 11)

β_B : as determined in **1.4.4-4(2)(b)**

$\sigma_{Q3P} = Q_{3P} / (B \cdot W)$

Q_{3P} : the radial (shear) force in the web due to the force F_{3P} applied to the centre-line of the actual connecting rod (see Figures 1 and 2)

ii) The stress concentration factor for bending and compression due to radial force in journal fillet β_{BQ} is calculated in accordance with the following:

$$\beta_{BQ} = \frac{\sigma_{3P}}{\sigma_{N3P}}$$

for the relevant parameters see **i)**.

EFFECTIVE DATE AND APPLICATION (Amendment 2-7)

1. The effective date of the amendments is 1 January 2012.

2. Notwithstanding the amendments to the Guidance, the current requirements may apply to crankshafts whose application for design approval before the effective date.