Sea Trials, Shop Tests for Reciprocating Internal Combustion Engines and Gas-Fuelled Engines

Amended Rules and Guidance

Rules for the Survey and Construction of Steel Ships Parts B, D, GF, and N
Guidance for the Survey and Construction of Steel Ships Parts B, D, GF, and N
Guidance for High Speed Craft
Guidance for the Survey and Construction of Inland Waterway Ships
Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use

Reason for Amendment

Some requirements related to sea trials and those related to shop tests for reciprocating internal combustion engines are specified in Part B and D of the Guidance, while those related to gas-fuelled engines are specified in Annexes 3 and 4 of Part GF of the Guidance and Annexes 3 and 4 of Part N of the Guidance.

The aforementioned requirements were originally incorporated into the NK Guidance. Since then, however, a sufficient track record of their successful application has been established and it is now considered appropriate to move them to the NK Rules.

Accordingly, relevant requirements are moved from the NK Guidance to the NK Rules, and also amended as needed in consideration of the organization and formatting of the NK Rules.

Outline of Amendment

The main contents of this amendment are as follows:

(1) Deletes part of requirements related to sea trials from Part D of the Guidance and incorporates them into Part D of the Rules.
(2) Deletes part of requirements related to shop tests for reciprocating internal combustion engines from Part B of the Guidance and incorporates them into Part B of the Rules.
(3) Deletes Annexes 3 and 4 from Part GF of the Guidance and incorporates them into Part GF of the Rules as Annexes 1.1.3-2 and 1.1.3-3.
(4) Deletes Annexes 3 and 4 from Part N of Guidance and incorporates them into Part N of the Rules as Annexes 16.1.1-2 and 16.1.1-3.

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

Part BCLASS SURVEYS

Chapter 2 CLASSIFICATION SURVEYS

2.3 Sea Trials and Stability Experiments

Paragraph 2.3.1 has been amended as follows.

2.3.1 Sea Trials*

1 In the Classification Survey of all ships, sea trials specified in following **(1)** to **(13)** are to be carried out in full load condition, in the calmest possible sea and weather condition and in deep unrestricted water. However, where sea trials cannot be carried out in full load condition, sea trials may be carried out in an appropriate loaded condition. The noise measurements specified in **(11)** are to be carried out at either the full load condition or the ballast condition.

(1) Speed test

(a) For ships that are to perform the speed test in full load condition, the ship speed defined in **2.1.8, Part A** is to be confirmed. For ships that are unable to perform the speed test in full load condition, the ship speed at maximum continuous revolution of the main engine is to be confirmed. This speed is referred to as the "maximum speed of the ship" hereinafter.

(b) The ship speed at main engine outputs specified in **Table B2.2** (not including 110% and minimum revolutions) is also to be confirmed.

(2) Astern test~~.~~

(a) The test is to be carried out in accordance with ~~(a~~**i)** and ~~(b~~**ii)** below and the items regarding stopping ability specified in **An1.4.3, Annex 2.3.1-1** "Guidance for the Test of Ship Manoeuvrability" are to be measured.

~~(a~~i) While the ship is running ahead at maximum speed, an order for full astern is issued and the reversing operation from ahead run to full astern run is carried out as quickly as possible.

~~(b~~ii) For ships that are unable to perform the test at maximum speed, the ship is to run ahead at not less than the speed specified in **An1.1.1-9, Annex 2.3.1-1** "Guidance for the Test of Ship Manoeuvrability". While the ship is at this speed, an order for full astern is issued and the reversing operation from ahead run to full astern run is carried out as quickly as possible.

In applying this provision, the tests are to be carried out from all control positions where there are multiple control positions for the reversing operation to astern run.

(b) It is to be confirmed that the machinery is functioning normally while the ship is running astern. The main engine is to be kept at a rate of more than 70% of the maximum continuous revolutions. The ship is to be kept running astern for the periods specified in **i)** and **ii)** below corresponding to the type of engine and the performance is to be confirmed in accordance with **1.3.2, Part D**.

~~(a~~i) For ships with main engines other than steam turbines

Until the astern speed (rotational speed in rpm) stabilizes.

~~(b~~ii) For ships with steam turbines

A period of at least 15 *minutes*; the astern trial, however, is to be limited to 30 *minutes* or in accordance with manufacturer's recommendation to avoid overheating of the

turbine due to the effects of "windage" and friction.

(c) For low pressure (i.e. pressure less than 1 *MPa*) gas-fuelled dual fuel engines, the confirmation specified in **(b)(1)** is to be carried out for all operating modes (i.e. the applicable gas mode, diesel mode, etc.). This test is to be carried out at the maximum power available in gas mode (*See* **2.5.1-1(1) in Annex 1.1.3-3, Part GF** or **2.5.1-1(1) in Annex 16.1.1-3, Part N**).

(d) To high pressure gas-fuelled dual fuel engines, the requirements for low pressure gas-fuelled dual fuel engines specified in **(c)** apply mutatis mutandis.

(3) Steering test and the change-over test from the main to auxiliary steering gears. In the case of waterjet propulsion systems or azimuth thrusters, however, tests are to be as otherwise stipulated by the Society.

(a) In the steering test, the steering capabilities required by **15.2.2** and **15.2.3**, **Part D** are to be confirmed. Where it is impractical to perform the test with the ship at its deepest seagoing draught and running ahead at the speed corresponding to the number of maximum continuous revolutions of the main engine and maximum design pitch, ships may demonstrate compliance with this requirement by one of the following methods:

i) During sea trials, the ship is at even keel and the rudder fully submerged whilst running ahead at the speed corresponding to the number of maximum continuous revolutions of the main engine and maximum design pitch (in case of the auxiliary steering gear, one half of this speed or 7 *knots*, whichever is greater).

ii) Where full rudder immersion during sea trials cannot be achieved, an appropriate ahead speed is to be calculated using the submerged rudder blade area in the proposed sea trial loading condition. The calculated ahead speed is to result in a force and torque applied to the main steering gear which is at least as great as if it was being tested with the ship at its deepest seagoing draught and running ahead at the speed corresponding to the number of maximum continuous revolutions of the main engine and maximum design pitch (in case of the auxiliary steering gear, one half of this speed or 7 *knots*, whichever is greater).

iii) The rudder force and torque at the sea trial loading condition have been reliably predicted and extrapolated to the full load condition. The speed of the ship is to correspond to the number of maximum continuous revolutions of the main engine and maximum design pitch of the propeller (in case of the auxiliary steering gear, one half of this speed or 7 *knots*, whichever is greater).

(b) The Steering test and change-over test from main to auxiliary steering gears are to be carried out in accordance with the following **i)** through **x)** in addition to **(a)**. However, the tests required in **iii)**, **vi)**, **vii)**, **viii)**, **ix)** and **x)** may be dispensed with where such tests have been carried out either at dockside or in dry dock.

i) Running tests of the power units, including transfer between power units

ii) Isolation tests of one hydraulic actuating system including checking the time for regaining steering capability

iii) Tests of the hydraulic fluid recharging system

iv) Tests of the emergency power supply required by **15.2.6, Part D**

v) Operation tests of controls, including change-over between two control systems, change-over between the control system and the controller provided in the steering gear compartment, and change-over between automatic steering and manual steering

vi) Tests of the means of communication between the navigating bridge and the engine room, and between the engine room and the steering gear compartment

vii) Function tests of indicators for alarms, rudder angle indicator and power units required by **Chapter 15, Part D**

viii) Function tests of indicators for power failure and overcurrent alarms, operating condition of electric motor, and relief valves for preventing overpressure

ix) Function tests of the rudder stoppers

x) Where the steering gear is designed to avoid hydraulic locking, a demonstration of this feature

(4) Turning test~~:~~

The tests are to be carried out in accordance with **~~(a~~i)** and **~~(b~~ii)** below. The turning test of an individual ship may be dispensed with, provided that sufficient data is available from the turning test of a sister ship and subject to special approval by the Society.

~~(a~~i) A ship is steered to the left or right at the maximum rudder angle (normally 35 *degrees*, however, where a special rudder is provided, a different rudder angle considered appropriate by the Society) while running ahead at the maximum speed, and this rudder angle is to be kept until the ship makes a 360 *degree* circle. The turning ability specified in **An1.4.2, Annex 2.3.1-1** "Guidance for the Test of Ship Manoeuvrability" is to be measured and the ship's stability during the turn is to be confirmed.

~~(b~~ii) Notwithstanding the requirements in **(1)**, for ships that are unable to perform the test at maximum speed, the ship is to run ahead at not less than the speed specified in **An1.1.1-9, Annex 2.3.1-1** "Guidance for the Test of Ship Manoeuvrability". While the ship is at this speed, the ship is steered to the left or right at the maximum rudder angle (normally 35 *degrees*, however, where a special rudder is provided, a different rudder angle considered appropriate by the Society), and this rudder angle is kept until the ship makes a 360-*degree* circle.

(5) Confirmation of no abnormality for the operating condition of machinery and behaviour of the ship during the trials

The performance tests of machinery installations are to include the following **(a)** to **(j)** in order to verify that the machinery installations have sufficient normal functions and reliability and are free from detrimental vibration within the numbers of revolutions used. However, these tests may be dispensed with where such tests have been conducted while the ship was anchored or at dockside. The preparations specified in **2.6.1-2(1), Part D** are to be made before tests are carried out.

(a) For reciprocating internal combustion engines, the output test shown in **Table B2.2**, is to be used as the standard. For reciprocating internal combustion engines driving generators or auxiliary machinery (excluding auxiliary machinery for specific uses), operating tests may be carried out at the appropriate time after installation on board.

(b) For steam turbines and gas turbines used as main propulsion machinery, the output test is to be carried out at 3 or 4 levels of power output selected from normal continuous cruise power run and 4/4, 3/4, 2/4 and 1/4 of the maximum continuous output of the engine.

(c) Operating tests for starting devices

It is to be confirmed that the engines start continuously for the number required by **2.5.3-2** or **4.4.3-2, Part D**.

(d) Function tests of the alarms and safety devices

Function tests of the alarms and safety devices required by **2.4**, **3.3** and **4.3, Part D** are to be carried out.

(e) Fuel suitability

The suitability of residual and other special fuels for use in the engine is to be confirmed. However, this test may be dispensed with where the suitability has already been demonstrated at the shop trial.

(f) Governor tests

For reciprocating internal combustion engines driving main sources of electrical power

(including reciprocating internal combustion engines driving generators for both propulsion and main power supply), the characteristics for governors specified in **2.4.1-5(1), Part D** are to be confirmed.

(g) Low pressure (i.e. pressure less than 1 *MPa*) gas-fuelled engines are to comply with the requirements specified in **(a)** and **(g)**. For low pressure gas-fuelled dual fuel engines, the output tests and governor tests are to be carried out for all operating modes (i.e. the gas mode, diesel mode, etc.). This test is to be carried out at the maximum power available in gas mode (*See* **2.5.1-1(1) in Annex 1.1.3-2, Part GF** or **2.5.1-1(1) in Annex 16.1.1-2, Part N**). The 110% load test is not required for the gas mode.

(h) To high pressure gas-fuelled engines, the requirements for low pressure gas-fuelled engines specified in **(i)** apply mutatis mutandis.

(i) Function tests of the safety devices and alarms of boilers

(j) Function tests of the safety devices and alarms of exhaust gas economizers

(6) Performance test of windlasses

Each windlass is to be tested in accordance with the following **(a)** to **(c)** under working conditions after installation on board in order to demonstrate satisfactory operation and confirm that their construction and associated equipment are in good condition.

(a) Operation test

Each unit is to be independently tested for **i)** to **viii)** below:

i) Braking
ii) Clutch functioning
iii) Lowering and hoisting of the chain cable and the anchor
iv) Proper riding of the chain cable over the cable lifter
v) Proper transit of the chain cable through the hawse pipe and the chain pipe
vi) Effecting proper stowage of the chain cable and the anchor
vii) Proper seating of the anchors in the stored position
viii) Proper function of the chain cable stoppers if fitted

(b) Load test

Initially with 3 shots of chain cable (82.5 *m* or 45 *fathoms* in length) and the anchor submerged and hanging free, the test is to be carried out in accordance with the manner specified in **i)** to **iii)** below. For **i)** and **ii)**, it is to be measured and verified that the mean hoisting speed is not less than 0.15 *m/s*. Where it is difficult to have 3 shots of chain cable kept submerged due to the ship's locale, an alternative test approved by the Society may be employed.

i) Hoisting up 2 shots of chain cable on one side
ii) Hoisting up 2 shots of chain cable on the other side of **i)**
iii) Hoisting up one shot of chain cable together on both sides

(c) Cable lifter brake capacity test

The braking capacity is to be tested by intermittently paying out and holding the chain cable by means of the application of the brake at every 1/2 shot of chain cable.

(7) Performance test of automatic and remote control systems for main propulsion machinery, controllable pitch propellers, boilers and electric generating sets

The tests are to be carried out in accordance with the following **(a)** to **(e)**. However, where these tests have been carried out when the ship was anchored or at dockside, some of these tests may be dispensed with at the sea trial.

(a) The control systems for main propulsion machinery and controllable pitch propellers are to be subjected to the following **i)** to **iv)**.

i) The main propulsion machinery or the controllable pitch propellers are to be subjected to starting tests, ahead-astern tests and running tests in the whole range of output, by

means of the remote control devices in the main control station or the main control station on the bridge.

ii) In addition to output increase and decrease tests, the operation tests of the main propulsion machinery or the controllable pitch propellers using the bridge control devices are to be carried out. Where operation tests were carried out for the entire output range by the bridge control devices, consideration may be given to reduction of the test items with the exception of the starting test.

iii) Where there are two or more control stations for main propulsion machinery or controllable pitch propellers, the test on transfer of control is to be carried out while the ship is running ahead and when it is running astern. Where the remote devices for main propulsion machinery or controllable pitch propellers is in accordance with **18.3.2-2(3)(b), Part D**, the above-mentioned test may be carried out while the main propulsion machinery is stopped.

iv) After completion of the test on transfer of control specified in **iii)**, a demonstration that the main propulsion machinery or the controllable pitch propellers can be smoothly operated from the respective control stations is to be conducted.

(b) Boilers

Function tests of the control systems for boilers are to be carried out in accordance with the following **i)** to **iii)**.

i) It is to be confirmed that devices such as for feed water control and combustion can operate stably in response to load variations of the main boilers, and the main boilers can supply steam stably to main propulsion machinery, electric generating sets and auxiliary machinery essential for main propulsion of the ship without local manual operation.

ii) With respect to essential auxiliary boilers, it is to be confirmed that they can supply steam stably to auxiliary machinery essential for main propulsion of the ship without manual operation.

iii) Where an exhaust gas economizer is used as a source of steam for driving a generator and the boiler supplies extra steam automatically during power loss, operation tests of the automatic control devices for this system are to be carried out.

(c) Electric Generation Sets

Where generators supply electrical power to the loads necessary for propulsion of the ship, their motive power is relying upon the propulsion systems, tests of functioning of the systems of automatic or remote control of electric generating sets are to be carried out.

(d) For the electric generating sets specified in **3.2.1-3, Part H** the following items are to be confirmed while the main propulsion machinery is operating in normal continuous cruise output. However, in cases where the main propulsion machinery is operating at an output other than normal continuous cruising output, the tests may be carried out while main propulsion machinery is operating at said output on the condition that all active peripheral equipment are operating at outputs that are the same as the normal continuous cruising output of the main propulsion machinery.

i) Where only one electric generating set is normally used, the standby generator, air circuit breakers, and important auxiliary machinery start up automatically when the main source of electrical power is stopped by tripping a circuit breaker

ii) Where two electric generating sets are normally used, preference tripping of unnecessary loads is performed and propulsion and steering of the ship are maintained, when the circuit breaker of one of the sets is tripped

(e) The "electric generating sets specified in **3.2.1-3, Part H**" mentioned in **(d)** above, refer to the application of **6.2.11-1** and **-3, Part H** for the ships specified in **6.1.1, Part H**.

(8) Accumulation test of boilers

The accumulation tests of boilers are to be carried out in accordance with the following **(a)** to **(c)**.

(a) The accumulation test is to be conducted as specified in **i)** and **ii)** below while the boiler is under the maximum firing condition. However, where data on the evaporation of the boiler submitted to the Society has been approved, the accumulation test specified in **i)** may be dispensed with.

i) When the safety valves of the boiler blow with all the stop valves closed, except for the valves for steam supply to machinery necessary to operate the boiler, the accumulation of pressure in the boiler drum is not to exceed 110% of the approved working pressure. However, the feed water necessary to maintain a safe water level may be supplied.

ii) For boilers with a superheater, where the accumulation test might overheat the superheater, the operation test of the means specified in **9.9.3-8, Part D** of the Rules may be carried out as an alternative after shutting off the main steam supply. In this case, the lift of each safety valve is to be checked beforehand.

(b) The accumulation test specified in **(a)** may be carried out at an appropriate time when the ship is anchored or at dockside.

(c) For boilers which are capable of refiring while using an exhaust gas economizer, in principle, the accumulation test is to be carried out in accordance with the methods specified in **(a)i)** and **ii)** under the maximum firing condition and at the maximum continuous output of the main engine.

(9) Measurement of torsional vibration for the shafting systems

The measurements of the torsional vibration for shafting systems are to be carried out in accordance with the following **(a)** to **(c)**.

(a) Measurements are to be carried out in accordance with the requirements of **8.1.3, Part D**. In cases where the confirmation of engine running conditions specified in **8.1.3-2, Part D** is performed at the estimated upper and lower borders by calculation, it is recommended that the fuel index around estimated borders also be confirmed with consideration given to possible differences between estimated borders and actual borders confirmed through measurements.

(b) For low pressure (i.e. pressure less than 1 *MPa*) gas-fuelled dual fuel engines, the measurements specified in **(a)** are to be carried out for both the diesel and gas mode. However, measurements in either diesel mode or in the gas mode (but not both modes) may be omitted where considered appropriate by the Society based upon relevant torsional vibration calculation sheets of diesel and gas mode.

(c) For high pressure gas-fuelled dual fuel engines, the requirements for low pressure gas-fuelled dual fuel engines specified in **(b)** apply mutatis mutandis.

(10) Measurement of the sound pressure levels of fixed fire detection and fire alarm systems

With respect to the measurement of the sound pressure levels of fixed fire detection and fire alarm systems, the sound levels specified in **29.2.5-1(9), Part R** are to be carried out by suitable instrument.

(11) Noise measurements. The measurements are to be in accordance with **Annex 2.3.1-2 "Procedures for on board Noise Measurements"**.

(12) Verification of Total Harmonic Distortion (THD) calculation report and harmonic filter operation guide

"Verification of Total Harmonic Distortion (THD) calculation report" refers to the measuring of the Total Harmonic Distortion (THD) value of the main busbar so as to confirm that said value does not exceed the acceptable limit given in the report.

(13) Other tests where deemed necessary by the Society

~~**2** In the steering test prescribed in **-1(3)**, the steering capabilities required by **15.2.2** and **15.2.3**, **Part D of the Rules** are to be confirmed. Where it is impractical to perform the test with the ship at its deepest seagoing draught and running ahead at the speed corresponding to the number of maximum continuous revolutions of the main engine and maximum design pitch, ships may demonstrate compliance with this requirement by one of the following methods:~~

~~(1) During sea trials, the ship is at even keel and the rudder fully submerged whilst running ahead at the speed corresponding to the number of maximum continuous revolutions of the main engine and maximum design pitch (in case of the auxiliary steering gear, one half of this speed or 7 *knots*, whichever is greater).~~

~~(2) Where full rudder immersion during sea trials cannot be achieved, an appropriate ahead speed is to be calculated using the submerged rudder blade area in the proposed sea trial loading condition. The calculated ahead speed is to result in a force and torque applied to the main steering gear which is at least as great as if it was being tested with the ship at its deepest seagoing draught and running ahead at the speed corresponding to the number of maximum continuous revolutions of the main engine and maximum design pitch (in case of the auxiliary steering gear, one half of this speed or 7 *knots*, whichever is greater).~~

~~(3) The rudder force and torque at the sea trial loading condition have been reliably predicted and extrapolated to the full load condition. The speed of the ship is to correspond to the number of maximum continuous revolutions of the main engine and maximum design pitch of the propeller (in case of the auxiliary steering gear, one half of this speed or 7 *knots*, whichever is greater).~~

~~**3**~~**2** The results of the tests specified in **-1** are to be submitted to the Society as Sea trial records.

~~**4**~~**3** 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 and the Society deems it appropriate.

Table B2.2 Sea Trials of Reciprocating Internal Combustion Engines

Test items		Use of engines		
		Main engines of ships in which reciprocating internal combustion engines are used as main propulsion machinery (excluding electric propulsion ships) (1)	Reciprocating internal combustion engines driving generators (including main engines of electric propulsion ships) (2)	Reciprocating internal combustion engines driving auxiliaries (excluding auxiliary machinery for specific use etc.)
Load test	110% power run	—	10 *minutes* at n_0 (n_0 is the rated engine speed.) (3)	—
	100% power (rated power) run	4 *hours* at engine speed in accordance with propeller curve (4) (5) (6)	1 *hour* at n_0 (3)	30 *minutes* at n_0
Overspeed run		30 *minutes* at 1.032n_0 or more (7) (8)	—	—
Minimum revolution test of main engine (9)		○(7)	—	—
Intermittent overload (10)		○		○

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, excluding propulsion engines for which intermittent overload is approved as well as propulsion engines also driving generators.

(2) The tests are to be performed based on the rated electrical powers of the driven generators.

(3) This may, if possible, be done during the electrical propulsion plant test, which is tested at 100% propulsion power (i.e., total electric motor capacity for propulsion) by distributing the power on as few generators as possible. The duration of this test is to be sufficient to reach the stable operating temperatures of all rotating machines or for at least 4 hours. When some of the generator set(s) cannot be tested due to insufficient time during the propulsion system test mentioned above, those required tests are to be carried out separately.

(4) In the case of controllable pitch propellers, the test is to be performed at rated engine speed n_0 at a propeller pitch leading to 100% power, or to the maximum achievable power if 100% power cannot be reached.

(5) In the case of propulsion engines also driving generators, tests are to be also carried out for 2 hours at 100% propeller branch power (unless already covered in the test at 100% power) and 1 hour with 100% power take off branch power at rated engine speed n_0 in addition to the test for 4 hours at 100% power.

(6) For ships in which the tests specified in **2.2.5-2(1), Rules for Automatic and Remote Control Systems** are performed for not less than 4 hours at 100% power, the 100% power test specified in this table may be omitted.

(7) Only for engines driving fixed pitch propellers.

(8) The test may be omitted if a 100% power test is performed at $1.032n_0$ or more. In cases where engine speed cannot reach the specified speed due to the planned propeller curve, etc., an overspeed test may be performed at maximum achievable continuous revolution (i.e., maximum engine speed within the range of torque limit, etc.).

(9) The test is to be carried out to identify the minimum working revolution of the main engine when the ship is steered to the maximum rudder angle.

(10) Only for engines for which intermittent overload is approved. The test is to be performed for the duration agreed upon with the manufacturer.

Part D MACHINERY INSTALLATIONS

Chapter 2 RECIPROCATING INTERNAL COMBUSTION ENGINES

2.1 General

Paragraph 2.1.1 has been amended as follows.

2.1.1 General*

(-1 to -5 are omitted)

6 Gas-fuelled engines to which **Chapter 16, Part N** applies are to be in accordance with ~~the requirements specified otherwise by the Society~~ **Annex 16.1.1-2** or **Annex 16.1.1-3** of **Part N** in addition to ~~those in~~ this chapter.

7 Gas-fuelled engines to which **Chapter 16, Part N** does not apply (**Part GF** applies instead) are to be in accordance with **Annex 1.1.3-2** or **Annex 1.1.3-3** of **Part GF** in addition to ~~those in~~ this chapter.

2.1.2 Terminology*

Sub-paragraph -4 has been amended as follows.

4 For low pressure gas-fuelled engines, the terminology is in accordance with ~~the requirements specified otherwise by the Society~~ **1.4 of Annex 1.1.3-3, Part GF**.

2.6 Tests

Paragraph 2.6.1 has been amended as follows.

2.6.1 Shop Tests*

1 (Omitted)

2 For reciprocating internal combustion engines, the purpose of the shop trials is to verify design premises such as engine power, safety against fire, adherence to approved limits such as maximum pressure, and functionality as well as to establish reference values or base lines for later reference in the operational phase. The programme is to be in accordance with the following: ~~are to be carried out according to the test procedure deemed appropriate by the Society.~~

(1) The following preparations are to be made before carrying out the engine tests:

(a) All relevant equipment for the safety of attending personnel such as oil mist detection arrangements, overspeed protective devices and any other shut down functions are to be made available and are to be operational.

(b) The overspeed protective device is to be set to a value which is not higher than the allowable overspeed value. This set point is to be verified by the surveyor.

(c) The engines are to be run as prescribed by the engine manufacturer.

(d) All fluids used for testing purposes (fuel oils, lubrication oils, cooling water, etc., including all fluids used temporarily or repeatedly for testing purposes only) are to be suitable for their intended purposes (i.e., they are to be clean, preheated if necessary and cause no harm to engine parts).

(2) For all stages of testing, the following **(a)** to **(c)** ambient conditions are to be recorded and the pertaining operation values (normally the following **(d)** to **(k)** items) for each load point 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. Calibration records for the instrumentation are to be presented to the attending surveyor. 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.

(a) Ambient air temperature

(b) Ambient air pressure

(c) Atmospheric humidity

(d) Power

(e) Speed

(f) Fuel index (or equivalent reading)

(g) Maximum combustion pressures (only when the cylinder heads installed are designed for such measurement)

(h) Exhaust gas temperature at the turbine inlet and from each cylinder

(i) Charge air temperature

(j) Charge air pressure

(k) Turbocharger speed

(3) All measurements conducted at the various load points are to be carried out under steady operating conditions. However, provision is to be made for time needed by the surveyor to carry out visual inspections for all load points. The readings for 100 % power (rated power at rated speed) are to be taken twice at an interval of at least 30 *minutes*.

(4) 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.

(5) The programme shown in **Table D2.7** is to be used for the shop trials of reciprocating internal combustion engines. In this case, refer to the *JIS* specified below or those considered equivalent thereto for more details on each respective testing procedure. However, additional tests may be requested by the Society depending on the engine application, service experience, or other relevant reasons. In addition, alternatives to the detailed tests may be agreed between the manufacturer and the Society when the overall scope of tests is found to be equivalent.

(a) In the case of reciprocating internal combustion engines used as main propulsion machinery (including those used as main propulsion machinery for electric propulsion ships);
JIS F 4304 "Shipbuilding - Internal combustion engines for propelling use-shop test code"

(b) In the case of reciprocating internal combustion engines driving other generators or essential auxiliary machinery;
JIS F 4306 "Shipbuilding - Water cooled four-cycle generator diesel engines"

(6) The following **(a)** to **(c)** are to be inspected. However, a part of or all of these inspections may be postponed until shipboard testing when agreed to by the Society.

(a) Jacketing of high-pressure fuel oil lines, including the system used for the detection of leakage

(b) Screening of pipe connections in piping containing flammable liquids

(c) Temperature of hot surface insulation
Random temperature readings are to be compared with corresponding readings obtained during the type test. This is to be done while running at the rated power of engine. If the insulation is modified subsequently to the type test, the Society may request temperature measurements as required by the type test.
In the case of reciprocating internal combustion engine with an application for approval of use dated before 1 July 2016 which is an engine type that does not have the results of temperature measurements required by the type test, temperature measurements are to be performed by a procedure deemed appropriate by the Society.

(7) Category *C* turbochargers installed on reciprocating internal combustion engines used as main propulsion machinery are to be checked for surge margins in accordance with the following. However, if successfully tested earlier on an identical configuration of the engine and turbocharger (including the same nozzle rings), submission of this test report may be accepted instead.

(a) For 4-stroke engines, the operations given in the following **i)** and **ii)** are to be performed without any indication of surging.
i) While at maximum continuous rating (maximum continuous power and speed), speed is to be reduced with the constant torque (fuel index) down to 90 % power.
ii) While at 50 % power and 80 % speed, speed is to be reduced to 72 % while keeping constant torque (fuel index).

(b) For 2-stroke engines, the surge margin is to be demonstrated by at least one of the following **i)** to **iii)**:
i) The engine working characteristics established at shop tests of the engine is to be plotted into the compressor chart of the turbocharger (established in a test rig). There is to be at least a 10 % surge margin in the full load range, i.e., working flow is to be 10 % above the theoretical mass flow at the surge limit where there are no pressure fluctuations.
ii) A sudden fuel cut-off to at least one cylinder at the following **1)** and **2)** loads is not to result in continuous surging and the turbocharger is to be stabilised at the new loads within 20 *seconds*. For applications with more than one turbocharger, the fuel supply to the cylinders closest upstream to each turbocharger is to be cut off.

1) The maximum power permitted for one cylinder misfiring.
2) The engine load corresponding to a charge air pressure of about 0.06 *MPa*, but without auxiliary blowers running.

iii) No continuous surging and the turbocharger is to be stabilised at the new load within 20 *seconds* when the power is abruptly reduced from 100 % to 50 % of the maximum continuous power.

(8) For electronically controlled engines, integration tests are to be made to verify that the response of the complete mechanical, hydraulic and electronic system is as predicted. The scope of these tests is to be determined based on a risk analysis by a method deemed appropriate by the Society and agreed with the Society, prior to the tests. The tests may be carried out using other alternative methods, subject to special consideration by the Society.

3 For low pressure gas-fuelled engines (specified in **4.2.2 of Annex 1.1.3-3, Part GF** or **5.2.2 of Annex 16.1.1-3, Part N**), the following requirements are to be complied with.

(1) The requirements specified in **-2(1)** to **(7)** apply subject to following **(2)** to **(5)** requirements.

(2) For dual fuel engines, the tests specified in **Table D2.7** are to be carried out for both diesel and gas mode. Tests for the gas mode are to be carried out based on the maximum power available in the gas mode (see **2.5.1-1(1) of Annex 1.1.3-3, Part GF** or **2.5.1-1(1) of Annex 16.1.1-3, Part N**). The 110 % load test is not required for the gas mode.

(3) In addition to the preparations specified in **-2(1)**, measures to verify that gas fuel piping for the engine is gas tight are to be carried out prior to the start-up of the engine.

(4) In addition to **-2(2)** and **(3)**, the following engine data are to be recorded.
(a) The item listed in **-2(2)(f)** is to be measured and recorded for both gas and diesel, as applicable
(b) Gas pressure and temperature

(5) The engines are to undergo integration tests to verify that the responses of the complete mechanical, hydraulic and electronic systems are as predicted for all intended operational modes. The scope of these tests is to be agreed to with the Society for selected cases based upon risk analysis by a procedure deemed appropriate by the Society and is to at least include the following incidents. The tests may be carried out using simulation or other alternative methods, subject to special consideration by the Society.
(a) Failure of ignition (spark ignition or pilot injection systems)
(b) Failure of a cylinder gas supply valve
(c) Failure of combustion (to be detected by e.g. misfiring, knocking, exhaust temperature deviation, etc.)
(d) Abnormal gas pressure
(e) Abnormal gas temperature

4 To shop trials of the high pressure gas-fuelled engines specified in **4.2.2 of Annex 1.1.3-2, Part GF** or **5.2.2 of Annex 16.1.1-2, Part N**, the requirements for the shop trials of low pressure gas-fuelled engines specified in **-3** apply mutatis mutandis.

~~**3 For reciprocating internal combustion engines with novel design features or for those with no service records, tests are to be carried out to verify their durability according to the procedure deemed appropriate by the Society.**~~

~~4~~5 (Omitted)

~~5~~6 (Omitted)

~~6~~7 (Omitted)

Table D2.7 has been added as follows.

Table D2.7 Programme for Shop Trials of Engines

Test items		Use of engines		
		Reciprocating internal combustion engines used as main propulsion machinery(1)	Reciprocating internal combustion engines driving generators (including those used as main propulsion machinery of electric propulsion ships) (2)	Reciprocating internal combustion engines driving auxiliaries (excluding auxiliary machinery for specific use etc.) (1)
Load test	110 % power run	15 *minutes* or until steady conditions have been reached, which is shorter, at 1.032 n_0 (n_0 is the rated engine speed) or more (3), (4)	15 *minutes* after having reached steady conditions at n_0	15 *minutes* after having reached steady conditions at n_0
	100 % power run	60 *minutes* at n_0	60 *minutes* at n_0	30 *minutes* at n_0
	90 % power run (or normal continuous cruise power) (5), (6)	30 *minutes* at engine speed in accordance with nominal propeller curve	—	—
	75% power (5), (6)		30 *minutes* at n_0	30 *minutes* in accordance with the nominal power consumption curve (7)
	50% power (5), (6)			
	25% power (5), (6)			
Idle run (5)		—	An adequate time at n_0	—
Reversing manoeuvres (8)		○	—	—
Intermittent overload (9)		○	—	○
Governor test		—	○	—
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, unless intermittent overload power is approved by the Society. In the case of propulsion engines also driving power take-off generators, the fuel delivery system is to be adjusted so that overload of generator (110 % power) can be given in service and the electrical protection of downstream system components is activated before the engine stalls.

(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) Submission of a test report for identical engine and turbocharger configuration proving their compatibility for over-loaded operation may be accepted as substitutions for the 110 % power run.

(4) In the case of propulsion engines also driving power take-off generators, the test is to be carried out at n_0 for 15 *minutes* after having reached a steady operating condition.

(5) The sequence is to be selected by the engine manufacturer.

(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) Only for variable speed engines.

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

(9) Only for engines for which intermittent overload is approved. The test is to be performed for the duration agreed upon with the manufacturer.

Part GF SHIPS USING LOW-FLASHPOINT FUELS

Chapter 1 GENERAL

1.1 General (*IGF Code* 2.1)

Paragraph 1.1.3 has been amended as follows.

1.1.3 Approval of Systems and Equipment, etc.*

1 For ships using natural gas as fuel, the systems and equipment following **(1)** to **(21)** that are provided to use the gas fuel are to be approved as specified separately by the Society.

((1)to (21) are omitted)

2 In addition to the requirements specified in **-1**, reciprocating engines designed to directly inject natural gas pre-compressed to a high pressure into cylinders and ignite with appropriate sources of ignition for due combustion at the termination of compression strokes (hereinafter referred to as "high pressure gas-fuelled engines"), and to gas fuel supply systems are to be in accordance with **Annex 1.1.3-2.**

3 In addition to the requirements specified in **-1**, trunk piston reciprocating engines supplied with low pressure natural gas as fuel (hereinafter referred to as "low pressure gas-fuelled engines"), and gas fuel supply systems are to be in accordance with **Annex 1.1.3-3.**

~~**2**~~**4** For ships that use low-flashpoint fuels other than natural gas, systems and equipment specified in **-1(1)** to **(2~~0~~1)** above provided for the purpose of using the low-flashpoint fuels are to be those deemed appropriate by the Society.

~~**3**~~**5** Boilers and internal combustion engines of piston type that are multi-fuel engines, and gas turbines are to be those deemed appropriate by the Society.

Annex 1.1.3-2 has been added as follows.

Annex 1.1.3-2 HIGH PRESSURE GAS-FUELLED ENGINES

Chapter 1 GENERAL

1.1 Scope

1 This annex applies to reciprocating engines designed to directly inject natural gas pre-compressed to a high pressure into cylinders and ignite with appropriate sources of ignition for due combustion (hereinafter referred to as "high pressure gas-fuelled engines"), and to gas fuel supply systems in accordance with the requirements in **1.1.3-2, Part GF of the Rules**.

2 High pressure gas-fuelled engines and gas fuel supply systems are to be in accordance with requirements related to reciprocating internal combustion engines and gas fuel supply system specified in **Part D** and **Part GF of the Rules**, in addition to the requirements of this annex.

3 High pressure gas-fuelled engines are to be in accordance with those requirements for low pressure gas-fuelled engines specified in **Annex 1.1.3-3** which the Society deems appropriate.

1.2 Equivalency

High pressure gas-fuelled engines which do not comply with the requirements of this annex may be accepted provided that they are deemed to be equivalent by the Society to those approved in accordance with this annex.

1.3 Submission of Plans and Documents

The plans and documents to be submitted are as follows.

(1) Plans and documents for approval
- (a) Drawings and data specified in **2.1.3-1(1), Part D of the Rules**
- (b) Drawings and data specified in **18.1.3(1)(a), (b) and (e), Part D of the Rules**
- (c) Gas fuel injection valves
- (d) High pressure oil pipes for actuating gas fuel injection valves and associated protective shielding
- (e) Gas fuel injection pipes and associated protective shielding
- (f) High pressure oil pipes for sealing gas fuel injection valves and associated protective shielding
- (g) Arrangements of gas detectors
- (h) Combustion monitoring devices
- (i) Gas fuel injection valve actuating devices
- (j) Governors
- (k) Engine control system diagrams (including monitor, safety and alarm devices) for gas fuel combustion operations
- (l) Gas leak protective devices at connections between engines and gas fuel supply piping
- (m) Gas fuel supply piping systems (including details of valves and pipe fittings) and protective devices for gas leaks from said systems
- (n) Other drawings and data as deemed necessary by the Society according to the type of high pressure gas-fuelled engine

(2) Plans and documents for reference

(a) Drawings and data specified in **2.1.3-1(2), Part D of the Rules**

(b) Instruction manuals (including procedures for onboard maintenance, inspection and overhaul)

(c) Other drawings and data deemed necessary by the Society

(3) Drawings and data for the purpose of inspecting and testing engines

Items specified in **2.1.3-1, Part D of the Rules**, which are intended for inspection and testing (indicated by "○" in **Table D2.1(1)** and **Table D2.1(2), Part D of the Rules**).

Chapter 2 CONSTRUCTION AND EQUIPMENT OF HIGH PRESSURE GAS-FUELLED ENGINES

2.1 General

1 High pressure gas-fuelled engines are to be dual fuel system types capable of operating on oil fuel and gas fuel, or gas-only system types.
2 High pressure gas-fuelled dual fuel engines are to be capable of supplying oil fuel to each cylinder in amounts sufficient for maintaining stable combustion of gas fuel under any conditions.
3 High pressure gas-fuelled engines are to be capable of maintaining stable operations even under any of the following **(1)** to **(3)** conditions:
(1) switching from one fuel to another (in the cases of dual fuel engines),
(2) rapid load fluctuations, and
(3) minimum load conditions during gas combustion.
4 Only oil fuel is, in principle, to be used when operation of high pressure gas-fuelled dual fuel engines is unstable.
5 High pressure gas-fuelled dual fuel engines are to be capable of quickly switching from gas combustion mode to oil fuel only combustion mode.

2.2 Construction and Strength

2.2.1 Gas Fuel Injection Valves

1 Gas fuel injection valves are to possess satisfactory operating characteristics and durability for the assumed service period.
2 Gas fuel injection valves are to be provided with sealing systems to effectively prevent gas fuel from leaking through spaces around valve spindles.
3 Gas fuel injection valves are to be provided with effective cooling systems.

2.2.2 Gas Fuel Injection Valve Actuating Systems

1 Gas fuel injection valve actuating systems are to be reliably functional and operational.
2 When operating gas fuel injection valves equipped with actuating oil piping systems and sealing oil piping systems, the high pressure sections of such systems fitted to engine bodies are to be protected from actuating oil splashing in accordance with the requirements in **2.5.4, Part D of the Rules**.
3 Appropriate means are to be provided in cases where gas fuel injection valve actuating oil is required to be kept clean.

2.2.3 Cylinder Covers

1 The shapes of combustion chambers and the arrangements of gas fuel injection valves and oil fuel (or pilot oil) injection valves are to be such that reliable ignition and combustion of gas fuel are ensured.
2 The portions of cylinder covers where gas fuel injection valves and oil fuel injection valves are fitted are to be so constructed as to prevent leakages of gas fuels and unburnt gases into cylinders.

2.3 Safety Systems

2.3.1 Combustion Monitoring Devices

1 When high pressure gas-fuelled engines are operated on gas fuel, the items specified in the following **(1)** to **(4)** are, in principle, to be monitored and gas fuel supplies to engines are to be

automatically cut off in cases where any abnormalities are detected:
(1) gas fuel injection valve function,
(2) pilot oil fuel injection valve function (in the case of dual fuel engines),
(3) exhaust gas valves function, and
(4) exhaust gas temperatures at cylinder outlets.

2 When high pressure gas-fuelled engines are operated on gas fuel, the following items are, in general, to be monitored:
(1) abnormalities in cylinder pressure, and
(2) blow-by through exhaust valves.

2.3.2 Protection Against Explosions

1 Relief valves approved in accordance with **2.4.3, Part D of the Rules** are to be provided for crankcases.

2 Scavenge spaces and exhaust systems are to be fitted with suitable pressure relief systems in accordance with **10.2.2** and **10.3.1-1, Part GF of the Rules** unless designed to withstand the worst case overpressure due to ignited gas leaks.

3 Relief valves for cylinders installed in accordance with the requirements of **2.4.2, Part D of the Rules** are to be provided, as far as practicable, with monitoring systems to verify valve closing.

4 Engines having spaces under pistons that directly lead to crankcases are also to be in accordance with **10.3.1-2, Part GF of the Rules**.

2.3.3 Governors

1 Governors for high pressure gas-fuelled engines are to be capable of being operated during gas fuel combustion mode. In the case of dual fuel engines, governors are additionally to be capable of being operated either during gas and oil fuel (or pilot oil) combustion mode, and/or oil fuel only combustion mode.

2 The governors in **-1** above are to be in accordance with the requirements in **2.4.1-1, Part D of the Rules** for each mode of operation.

3 High pressure gas-fuelled dual fuel engines are to be operated in any one of the modes specified in the following **(1)** to **(3)**:
(1) controllable gas fuel supply and fixed oil fuel (pilot oil) supply,
(2) controllable oil fuel (pilot oil) supply and fixed gas fuel supply, or
(3) controllable gas fuel and oil fuel supplies.

2.4 Accessory Equipment

2.4.1 Exhaust Gas Systems

Exhaust gas pipes of high pressure gas-fuelled engines are not to be connected to the exhaust gas pipes or the exhaust pipes of other engines or systems.

2.4.2 Starting Systems

Starting air branch pipes to cylinders are to be provided with effective flame arresters.

2.4.3 Gas Fuel Pipes

1 Gas fuel pipes (only those attached to engines) are to be provided with effective protective shielding against gas fuel bursting due to pipe failure.

2 Spaces between gas fuel pipes (only those attached to engines) and protective shielding are to be in accordance with the requirements in **9.6, Part GF of the Rules**: relevant requirements are to be applied mutatis mutandis.

3 Only approved type flexible tubes are to be used as protective shielding.

4 Gas fuel pipes are to be provided with systems for inerting and gas-freeing.

5 Expansion joints provided for gas fuel pipes (only those attached to engines) are to be approved as specified separately by the Society.

2.4.4 Cylinder Lubrication

Cylinder lubricating systems for high pressure gas-fuelled engines are, in general, to be capable of maintaining adequate alkali values and cylinder oil feeding rates for oil fuel only operation as well as the modes of operation specified in **2.3.3-3(1)** to **(3)**.

Chapter 3 CONTROL SYSTEMS AND SAFETY SYSTEMS

3.1 General

1 Control systems for operating high pressure gas-fuelled engines using gas fuel are to be in accordance with the requirements in **18.1** to **18.3** and **18.7, Part D of the Rules**: relevant requirements are to be applied mutatis mutandis.

2 Temperatures and pressures of gas fuel supplied to high pressure gas-fuelled engines are to be automatically controlled. In addition, visual and audible alarm devices which activate when temperatures and pressures exceed preset ranges are to be provided.

3.2 High Pressure Gas-fuelled Engines of Ships Subject to the Rules for Automatic and Remote Control Systems

High pressure gas-fuelled engines of ships subject to the application of the **Rules for Automatic and Remote Control Systems** are be in accordance with the requirements in **3.2**, **3.3** and **4.2** of the said rules. In addition, such engines are to be in accordance with the following **(1)** and **(2)** requirements:

(1) High pressure gas-fuelled engines are to be provided with safety systems which automatically cut off gas fuel supply when **(a)** or **(b)** given below occur. In addition, in the case of dual fuel engines, such systems are to automatically switch the mode of operation to oil fuel only or are to stop the engines. Automatic cut off of gas fuel supplies with the double block and bleed valves specified in **9.4.4, Part GF of the Rules**, however, may be accepted.
   (a) When the abnormalities specified in **2.3.1-1** are detected.
   (b) Other cases deemed necessary by the Society.

(2) High pressure gas-fuelled engines are to be provided with systems which automatically reduce speed or switches the mode of operation to oil fuel only, and which issue alarms in the event any of the abnormalities specified in the following **(a)** to **(d)** occurs:
   (a) abnormal gas fuel temperatures;
   (b) abnormal gas fuel supply pressures;
   (c) low pressures of hydraulic pneumatic sources, or loss of electric power supplies for gas fuel combustion control; or
   (d) others deemed necessary by the Society.

Chapter 4 TESTS

4.1 Approval of Use

For each type of high pressure gas-fuelled engine, approval of use is to be obtained by the engine designer (licensor) in accordance with requirements specified separately by the Society.

4.2 Shop Tests

4.2.1 Hydraulic Tests

Pressure parts and accessory equipment with pressure parts of high pressure gas-fuelled engines are to be subjected to hydraulic tests in accordance with the requirements of **2.6.1, Part D of the Rules** and **16.7.3, Part GF of the Rules**: relevant requirements are to be applied mutatis mutandis.

4.2.2 Shop Trials

High pressure gas-fuelled engines are to be tested as specified in **2.6.1-4, Part D of the Rules**. To implement surveys of tests, in lieu of traditional ordinary surveys where the Surveyor is in attendance, the Society may approve survey methods which it considers to be able to obtain information equivalent to that obtained through traditional ordinary surveys.

4.3 Tests after Installation On Board

Control systems of high pressure gas-fuelled engines and related equipment are to be tested depending upon their installation characters in accordance with the requirements of **18.7.3, Part D of the Rules** or the requirements of **2.2.4 of the Rules for Automatic and Remote Control Systems**: relevant requirements are to be applied mutatis mutandis.

4.4 Sea Trials

1 Performance of control systems of high pressure gas-fuelled engines and related equipment is to be verified during operations using gas fuel depending upon their installation characters in accordance with the requirements of **2.2.5 of the Rules for Automatic and Remote Control Systems**: relevant requirements are to be applied mutatis mutandis.

2 The seal trials specified in **2.3.1, Part B of the Rules** are to be carried out using gas fuel only. Some of the aforementioned tests, however, may be omitted in cases where deemed to be appropriate the Society.

Annex 1.1.3-3 has been added as follows.

Annex 1.1.3-3 LOW PRESSURE GAS-FUELLED ENGINES

Chapter 1 GENERAL

1.1 Scope

1 This annex applies to trunk piston reciprocating engines supplied with low pressure natural gas as fuel (hereinafter referred to as "low pressure gas-fuelled engines"), and gas fuel supply systems in accordance with the requirements of **1.1.3-3, Part GF of the Rules**.

2 Low pressure gas-fuelled engines and gas fuel supply systems are to be in accordance with requirements related to reciprocating internal combustion engines and gas supply systems specified in **Part D** and **Part GF of the Rules**, in addition to the requirements of this annex.

3 The following requirements specified in **Part GF of the Rules** as well as other requirements specified separately by the Society apply to low pressure gas-fuelled engines regardless of ship type, ship size and ship service area. However, **1.1.1-2, Part GF of the Rules** does not apply except where explicitly specified otherwise.

(1) **2.1-5(3)**
(2) **2.2.3-1**
(3) **2.2.4**
(4) **2.4.4-5(1)**
(5) **2.4.4-5(2)**
(6) **2.4.4-5(3)(a)** to **(c)**
(7) **2.4.4-5(4)(a)**
(8) **3.1-6**

1.2 Equivalency

Low pressure gas-fuelled engines which do not comply with the requirements of this annex may be accepted provided that they are deemed to be equivalent by the Society to those approved in accordance with this annex.

1.3 Submission of Plans and Documents

The plans and documents to be submitted are as follows.

(1) Plans and documents for approval
  (a) Drawings and data specified in **2.1.3-1(1), Part D of the Rules**
  (b) Drawings and data specified in **18.1.3(1)(a), (b) and (e), Part D of the Rules**
  (c) Gas fuel injection valves and associated actuating systems
  (d) Gas fuel injection pipes and associated protective shielding
  (e) Arrangements of gas detectors
  (f) Combustion monitoring devices
  (g) Governors
  (h) Engine control system diagrams (including monitor, safety and alarm systems) for gas fuel combustion operations
  (i) Gas leak protection systems at connections between engines and gas fuel supply piping

systems

(j) Gas fuel supply piping systems (including details of valves and pipe fittings) and protective devices for gas leaks from such systems

(k) Pilot oil fuel injection devices or ignition systems

(l) Schematic layout or other equivalent documents of gas system on the engine

(m) Gas piping system (including double-walled arrangement where applicable)

(n) Parts for gas admission system
The documentation to contain specifications for pressures, pipe dimensions and materials.

(o) Arrangement of explosion relief valves for crankcase (if required by **2.4.3, Part D of the Rules**), charge air manifold and exhaust gas manifold, as applicable

(p) Schematic layout or other equivalent documents of fuel oil system (main and pilot fuel systems) on the engine (only for dual fuel engines)

(q) Shielding of high pressure fuel pipes for pilot fuel system, assembly (only for dual fuel engines)

(r) Ignition system (only for gas only engines)

(s) Other drawings and data deemed necessary by the Society according to the type of low pressure gas-fuelled engine

(2) Plans and documents for reference

(a) Drawings and data specified in **2.1.3-1(2), Part D of the Rules**

(b) Other drawings and data deemed necessary by the Society

(3) Drawings and data for the purpose of inspecting and testing engines
Items specified in **2.1.3-1, Part D of the Rules**, which are intended for inspection and testing (indicated by "○" in **Table D2.1(1)** and **Table D2.1(2), Part D of the Rules**).

1.4 Terms

1 *Certified safe type* means electrical equipment that is certified in accordance with the recommendation published by the International Electrotechnical Commission (*IEC*), in particular publication *IEC* 60092-502:1999, or with recognized standards at least equivalent. The certification of electrical equipment is to correspond to the category and group for methane gas.

2 *Double block and bleed valves* means a set of two valves in series in a pipe and a third valve enabling the pressure release from the pipe between those two valves, specified in **2.2.1-9, Part GF of the Rules**. The arrangement may also consist of a two-way valve and a closing valve instead of three separate valves. The valves are to be in accordance with **9.4.4** to **9.4.6**.

3 *Dual fuel engine* means an engine that can burn natural gas as fuel simultaneously with liquid fuel, either as pilot oil or bigger amount of liquid fuel (gas mode), and also has the capability of running on liquid diesel fuel oil only (diesel mode).

4 *Engine room* is a machinery space or enclosure containing gas fuelled engine(s).

5 *Gas means* a fluid having a vapour pressure exceeding 0.28 *MPa* absolute at a temperature of 37.8℃.

6 *Gas admission valve* is a valve or injector on the engine, which controls gas supply to the cylinder(s) according to the cylinder(s) actual gas demand.

7 *Gas only engine* means an engine capable of operating on gas fuel only and not able to switch over to oil fuel operation.

8 *Gas piping* means piping containing gas or air / gas mixtures, including venting pipes.

9 *Gas Valve Unit* (*GVU*) is a set of manual shutoff valves, actuated shut-off and venting valves, gas pressure sensors and transmitters, gas temperature sensors and transmitters, gas pressure control valve and gas filter used to control the gas supply to each gas consumer. It also includes a connection for inert gas purging.

10 *Low pressure gas* means gas with a pressure up to 1 *MPa*.
11 *Lower Heating Value* (*LHV*) means the amount of heat produced from the complete combustion of a specific amount of fuel, excluding latent heat of vaporization of water.
12 *Methane Number* is a measure of resistance of a gas fuel to knock, which is assigned to a test fuel based upon operation in knock testing unit at the same standard knock intensity. (Pure methane is used as the knock resistant reference fuel, that is, methane number of pure methane is 100, and pure hydrogen is used as the knock sensitive reference fuel, methane number of pure hydrogen is 0.)
13 *Pilot fuel* means the fuel oil that is injected into the cylinder to ignite the main gas-air mixture on Gas-fuelled engines.
14 *Pre-mixed engine* means an engine where gas is supplied in a mixture with air before the turbocharger.
15 *Safety Concept* is a document describing the safety philosophy with regard to gas as fuel. It describes how risks associated with this type of fuel are controlled under reasonably foreseeable abnormal conditions as well as possible failure scenarios and their control measures. A detailed evaluation regarding the hazard potential of injury from a possible explosion is to be carried out and reflected in the safety concept of the engine.

Chapter 2 CONSTRUCTION AND EQUIPMENT OF LOW PRESSURE GAS-FUELLED ENGINES

2.1 General

1 Low pressure gas-fuelled engines are to be dual fuel system types capable of operating on oil fuel and gas fuel, or gas-only system types.

2 Low pressure gas-fuelled engines are to be capable of maintaining stable operation even under any of the following **(1)** to **(3)** conditions:

(1) switching from one fuel to another (in the cases of dual fuel engines),

(2) rapid load fluctuations, and

(3) minimum load conditions during gas combustion.

3 Gas fuel supply pressures for low pressure gas-fuelled engines are to always be kept higher than suction air pressures at the supply points of gas fuel to combustion chambers or the suction pipes before suction valves in order to prevent any back-flow of air into gas fuel lines.

4 The manufacturer is to declare the allowable gas composition limits for the engine and the minimum and (if applicable) maximum methane number.

5 Components containing or likely to contain gas are to be designed in accordance with the following **(1)** to **(5)**.

(1) Minimize the risk of fire and explosion so as to demonstrate an appropriate level of safety commensurate with that of an oil-fuelled engine

(2) Mitigate the consequences of a possible explosion to a level providing a tolerable degree of residual risk, due to the strength of the component(s) or the fitting of suitable pressure relief devices of an approved type

(3) Refer to **10.2** and **10.3, Part GF of the Rules**

(4) Discharge from pressure relief devices is to prevent the passage of flame to the machinery space and be arranged such that the discharge does not endanger personnel or damage other engine components or systems

(5) Relief devices are to be fitted with a flame arrester

2.2 Construction and Strength

2.2.1 Gas Fuel Valves and Actuating Systems

1 Gas fuel valves are to possess satisfactory operating characteristics and durability for the assumed service period.

2 Gas fuel valves are to be provided with sealing systems to effectively prevent gas fuel from leaking through spaces around valve spindles.

3 Actuating systems of gas fuel valves are to possess satisfactory operating characteristics and reliability.

2.2.2 Cylinder Covers

1 The shapes of combustion chambers and the arrangements of gas fuel valves are to be such that reliable ignition and combustion of gas fuel are ensured.

2 The portions of cylinder covers where gas fuel valves and oil fuel injection valves are fitted are to be so constructed as to prevent the leakages of gas fuels and unburnt gases into cylinders.

2.2.3 Crankcase

1 Crankcase explosion relief valves are to be installed in accordance with **2.4.3, Part D of the Rules**. Refer also to **10.3.1-2, Part GF of the Rules**.

2 For maintenance purposes, a connection, or other means, are to be provided for crankcase inerting and ventilating and gas concentration measuring.

2.2.4 Gas Ignition in Cylinder

For gas ignition in the cylinder, the requirements of **10.3, Part GF of the Rules** are to be applied.

2.3 Safety Systems

2.3.1 Protection Against Explosions

1 Suction manifolds and exhaust gas pipes are to be fitted with suitable pressure relief systems in accordance with the requirements of **10.2.2** and **10.3.1-1, Part GF of the Rules**.

2 Relief valves for cylinders installed in accordance with the requirements of **2.4.2, Part D of the Rules** are to be provided, as far as practicable, with monitoring systems to verify valve closing.

3 Gas fuel injection lines are to be provided with non-return valves or devices which have capabilities equivalent to those of the valves.

4 Flame arrestors are to be installed before cylinder heads in cases where gas is supplied in mixtures with air through common manifolds.

2.3.2 Governors

1 Governors for low pressure gas-fuelled engines are to be capable of being operated during gas fuel combustion mode. In the case of dual fuel engines, the governors are additionally to be capable of being operated either during gas and oil fuel (or pilot oil) combustion mode, and/or oil fuel only combustion mode.

2 The governors of **-1** above are to be in accordance with the requirements in **2.4.1-1, Part D of the Rules** in each mode of operation.

3 Low pressure gas-fuelled dual fuel engines are to be operated in any one of the modes specified in the following **(1)** to **(3)**:

(1) controllable gas fuel supply and fixed oil fuel (pilot oil) supply,

(2) controllable oil fuel (pilot oil) supply and fixed gas fuel supply, or

(3) controllable gas fuel and oil fuel supplies.

2.4 Accessory Equipment

2.4.1 Charge Air Systems

1 The charge air system on the low pressure gas-fuelled engine is to be designed in accordance with **2.1-5.**

2 In case of a single engine installation, the engine is to be capable of operating at sufficient load to maintain power to essential consumers after opening of the pressure relief devices caused by an explosion event. Sufficient power for propulsion capability is to be maintained.

3 Load reduction is to be considered on a case-by-case basis, depending upon engine configuration (single or multiple) and type of relief mechanism (self-closing valve or bursting disk).

2.4.2 Exhaust Gas Systems

1 The exhaust gas system on the low pressure gas-fuelled engine is to be designed in accordance with **2.1-5.**

2 In case of a single engine installation, the engine is to be capable of operating at sufficient load to maintain power to essential consumers after opening of the pressure relief devices caused by an explosion event. Sufficient power for propulsion capability is to be maintained.

3 Continuous relief of exhaust gas (through open rupture disc) into the engine room or other enclosed spaces is not acceptable.

2.4.3 Starting Systems

Starting air branch pipes to cylinders are to be provided with effective flame arresters.

2.4.4 Gas Fuel Pipes

1 Gas fuel pipes are to be provided with effective protective shielding against gas fuel bursting due to pipe failure, except where deemed appropriate by the Society.

2 Only approved type flexible tubes are to be used as protective shielding.

3 Gas fuel pipes are to be provided with systems for inerting and gas-freeing.

4 Expansion joints provided for gas fuel pipes (only those attached to engines) are to be approved as specified separately by the Society.

5 For piping attached to low pressure gas-fuelled engines, the following **(1)** to **(5)** also apply.

(1) The piping is to be designed in accordance with the criteria for gas piping (design pressure, wall thickness, materials, piping fabrication and joining details etc.) as given in **Chapter 7, Part GF of the Rules**.

(2) Arrangement of the gas piping system on the engine

Pipes and equipment containing fuel gas are defined as hazardous area zone 0 (refer to **12.5.1, Part GF of the Rules**). The space between the gas fuel piping and the wall of the outer pipe or duct is defined as hazardous area zone 1 (refer to **12.5.2(6), Part GF of the Rules**).

(3) Normal "double wall" arrangement

(a) The gas piping system on the low pressure gas-fuelled engine is to be arranged according to the principles and requirements of **9.6, Part GF of the Rules**.

(b) The design criteria for the double pipe or duct are given in the **9.8** and **7.4.1-4, Part GF of the Rules**.

(c) In case of a ventilated double wall, the ventilation inlet is to be located in accordance with the provisions of **13.8.3, Part GF of the Rules**.

(d) The pipe or duct is to be pressure tested in accordance with **12.6.1-2** to **-4, Part D of the Rules** to ensure gas tight integrity and to show that it can withstand the expected maximum pressure at gas pipe rupture.

(4) Alternative arrangement

(a) Single walled gas piping is only acceptable:

i) for engines installed in *ESD* protected machinery spaces, as defined in **5.4.1(2), Part GF of the Rules** and in compliance with other relevant parts of **Part GF of the Rules** (e.g. **5.6, Part GF of the Rules**);

ii) when complying with requirements specified separately by the Society.

(b) In case of gas leakage in an *ESD*-protected machinery space, which would result in the shutdown of the engine(s) in that space, a sufficient propulsion and manoeuvring capability including essential and safety systems is to be maintained. Therefore the safety concept of the engine is to clearly indicate application of the "double wall" or "alternative" arrangement. The minimum power to be maintained is to be assessed on a case-by-case basis in consideration of the operational characteristics of the ship.

(5) Gas admission valves

Gas admission valves are to be certified safe as follows:

(a) The inside of the valve contains gas and therefore it is to be certified for zone 0.

(b) When the valve is located within a pipe or duct in accordance with **(3)**, the outside of the valve is to be certified for zone 1.

(c) When the valve is arranged without enclosure in accordance with the "*ESD*-protected machinery space" (see **(4)**) concept, no certification is required for the outside of the valve, provided that the valve is de-energized upon gas detection in the space.

(d) However, if they are not rated for the zone they are intended for, it is to be documented that they are suitable for that zone. Documentation and analysis is to be based on *IEC*

60079-10-1:2015 or *IEC* 60092-502:1999.

2.4.5 Cylinder Lubrication

Cylinder lubricating systems for low pressure gas-fuelled dual fuel engines are, in general, to be capable of maintaining adequate alkali values and cylinder oil feeding rates for oil fuel only operation as well as the modes of operation specified in **2.3.2-3(1)** to **(3)**.

2.5 Design Requirements for Each Kind of Engines

2.5.1 Dual Fuel Engine

1 General

(1) The maximum continuous power that a dual fuel engine can develop in gas mode may be lower than the approved MCR of the engine (i.e. in oil fuel mode), depending in particular on the gas quality. This maximum power available in gas mode and the corresponding conditions are to be stated by the engine manufacturer and demonstrated during the type test.

(2) Low pressure gas-fuelled dual fuel engines are to be capable of supplying oil fuel to each cylinder in amounts sufficient for maintaining stable combustion of gas fuel under any conditions.

(3) Only oil fuel is, in principle, to be used when operation of low pressure gas-fuelled dual fuel engines are unstable.

2 Starting, changeover and stopping

(1) Dual fuel engines are to be arranged to use either oil fuel or gas fuel for the main fuel charge and with pilot oil fuel for ignition. The engines are to be arranged for rapid changeover from gas use to fuel oil use. In the case of changeover to either fuel supply, the engines are to be capable of continuous operation using the alternative fuel supply without interruption to the power supply.

(2) Changeover to gas fuel operation is to be only possible at a power level and under conditions where it can be done with acceptable reliability and safety as demonstrated through testing.

(3) Changeover from gas fuel operation mode to oil fuel operation mode is to be possible at all situations and power levels.

(4) The changeover process itself from and to gas operation is to be automatic but manual interruption is to be possible in all cases.

(5) In case of shut-off of the gas supply, the engines are to be capable of continuous operation by oil fuel only.

3 Gas supply to the combustion chamber is not to be possible without operation of the pilot oil injection. In addition, pilot injection is to be monitored for example by fuel oil pressure and combustion parameters.

2.5.2 Gas Only Engine

In case of failure of the spark ignition, the engine is to be shut down except when the following **(1)** to **(3)** are satisfied:

(1) the failure is limited to one cylinder;

(2) the gas supply to the failed cylinder is immediately shut off; and

(3) safe operation of the engine is substantiated by risk analysis and tests.

2.5.3 Pre-mixed Engine

Inlet manifolds, turbochargers, charge air coolers, etc. are to be regarded as parts of the fuel gas supply system, and failures of such components likely to result in gas leakages are to be considered in risk analysis by a method deemed appropriate by the Society.

Chapter 3 CONTROL, ALARM AND SAFETY SYSTEMS

3.1 General

1 Control systems for operating low pressure gas-fuelled engines using gas fuel are to be in accordance the requirements in **18.1** to **18.3** and **18.7, Part D of the Rules**: relevant requirements are to be applied mutatis mutandis.

2 Temperatures and pressures (or flow rates) of gas fuel supplied to low-pressure gas-fuelled engines are to be automatically controlled. In addition, visual and audible alarm devices which activate when temperatures and pressures exceed preset ranges are to be provided.

3 The engine control system is to be independent and separate from the safety system.

4 The gas supply valves are to be controlled by the engine control system or by the engine gas demand.

5 Combustion is to be monitored on an individual cylinder basis.

6 In the event that poor combustion is detected on an individual cylinder, gas operation may be allowed in the conditions specified in **10.3.1-6, Part GF of the Rules**.

7 Regardless of **-5**, if monitoring of combustion for each individual cylinder is not practicable due to engine size and design, common combustion monitoring may be accepted.

8 Unless risk analysis by a method deemed appropriate by the Society otherwise proves that risk is within the acceptable range otherwise, alarm and safety system functions for dual fuel or gas only engines are to be provided in accordance with **Table 3.1** (for dual fuel engines, **Table 3.1** applies only to the gas mode). However, even if risk analysis proves that risk is within the acceptable range, the alarm and safety system functions specified in **Part GF of the Rules** are still to be provided.

3.2 Low Pressure Gas-fuelled Engines of Ships Subject to the Rules for Automatic Remote Control Systems

Low pressure gas-fuelled engines of ships subject to the application of the **Rules for Automatic and Remote Control Systems** are to be in accordance with the requirements in **3.2, 3.3** and **4.2** of said rules. In addition, such engines are to be in accordance with the following **(1)** and **(2)** requirements:

(1) Low pressure gas-fuelled engines are to be provided with safety systems which automatically cut off the gas fuel supplies when any one of **(a)**, **(b)** or **(c)** given below occur. In addition, in the case of dual fuel engines, such systems are to automatically switch the mode of operation to oil fuel only or are to stop the engines. Automatic cut off of the gas fuel supplies with the double block and bleed valves specified in **9.4.4, Part GF of the Rules**, however, may be accepted.

(a) When operating on gas fuel, abnormalities are detected in the following:

i) gas fuel valve function

ii) pilot oil fuel injection valve (in the cases of dual fuel engines) or ignition system (in the cases of gas-only engines) function

iii) suction valve and exhaust valve function,

iv) exhaust gas temperatures at cylinder outlets

v) pressure in cylinder

vi) blow-by through suction valves or exhaust valves

(b) When gas leaks in the air space between the gas fuel piping and the wall of the outer pipe or duct specified in **9.6.1, Part GF of the Rules** are detected.

(c) Others deemed necessary by the Society.

(2) Low pressure engines are to be provided with systems which automatically reduce speed or

switches the mode of operation to oil fuel only, and which issues alarms in the event any of the abnormalities specified in the following **(a)** to **(d)** occurs:

(a) abnormal gas fuel temperatures;

(b) abnormal gas fuel supply pressures;

(c) low pressures of hydraulic and pneumatic sources, or loss of electric power supply for gas fuel combustion control; or

(d) others deemed necessary by the Society.

Table 3.1 Alarm and Safety System Functions for Dual Fuel and Gas Only Engines

Parameter	Alarm	Automatic activation of the double block and bleed valves	Automatic switching over to oil fuel mode[1)]	Engine shutdown
1. Abnormal pressures in the gas fuel supply line	X	X	X	X [5)]
2. Gas fuel supply systems - malfunction	X	X	X	X [5)]
3. Pilot fuel injection or spark ignition systems - malfunction	X	X [2)]	X	X [2)5)]
4. Exhaust gas temperature after each cylinder - high	X	X [2)]	X	X [2)5)]
5. Exhaust gas temperature after each cylinder - low[3)]	X	X [2)]	X	X [2)5)]
6. Cylinder pressure or ignition - failure, including misfiring, knocking and unstable combustion	X	X [2)4)]	X [4)]	X [2)4)5)]
7. Oil mist concentration in crankcase or bearing temperature[6)] - high	X	X	-	X
8. Pressure in the crankcase - high[4)]	X	X	X	-
9. Engine stops - any cause	X	X	-	-
10. Failure of the control-actuating medium of the block and bleed valves	X	X	X	-

Notes:

1) Dual fuel engine only, when running in gas mode

2) For gas only engines, the double block and bleed valves and the engine shutdown may not be activated in case of specific failures affecting only one cylinder, provided that the concerned cylinder can be individually shutoff and the safe operation of the engine in such conditions is demonstrated by the risk analysis.

3) Required only if necessary for the detection of misfiring. In addition, deviation from average is to be used for the operation setting of each function.

4) In the case where the failure can be corrected by an automatic mitigation action, only the alarm may be activated. If the failure persists after a given time, the safety actions are to be activated.

5) Gas only engine only

6) Where required by **2.4.5, Part D of the Rules**

Chapter 4 TESTS

4.1 Approval of Use

For each type of low pressure gas-fuelled engine, approval of use is to be obtained by the engine designer (licensor) in accordance with requirements specified separately by the Society.

4.2 Shop Tests

4.2.1 Hydraulic Tests

Pressure parts and accessory equipment with pressure parts of low pressure gas-fuelled engines are to be subjected to hydraulic tests in accordance with the requirements of **2.6.1, Part D of the Rules** and **16.7.3, Part GF of the Rules**: relevant requirements are to be applied mutatis mutandis.

4.2.2 Shop Trials

Low pressure gas-fuelled engines are to be tested as specified in **2.6.1-3, Part D of the Rules**. To implement surveys of tests, in lieu of traditional ordinary surveys where the Surveyor is in attendance, the Society may approve survey methods which it considers to be able to obtain information equivalent to that obtained through traditional ordinary surveys.

4.3 Tests after Installation On Board

Control systems of low pressure gas-fuelled engines and related equipment are to be tested depending upon their installation characters in accordance with the requirements of **18.7.3, Part D of the Rules** or the requirements of **2.2.4 of the Rules for Automatic and Remote Control Systems**: relevant requirements are to be applied mutatis mutandis.

4.4 Sea Trials

1 Performance of control systems of low pressure gas-fuelled engines and related equipment is to be verified during operations using the gas fuel depending upon their installation characters in accordance with the requirements of **2.2.5 of the Rules for Automatic and Remote Control Systems**: relevant requirements are to be applied mutatis mutandis.

2 The sea trials specified in **2.3.1, Part B of the Rules** are to be carried out using gas fuel only. Some of the aforementioned tests, however, may be omitted in cases where deemed appropriate by the Society.

Part N SHIPS CARRYING LIQUEFIED GASES IN BULK

Chapter 16 USE OF CARGO AS FUEL

16.1 General (IGC Code 16.1)

Paragraph 16.1.1 has been amended as follows.

16.1.1 General*

1 Except as provided for in **16.9**, methane (*LNG*) is the only cargo whose vapour or boil-off gas may be utilized in machinery spaces of category **A**, and, in these spaces, it may be utilized only in systems such as boilers, inert gas generators, internal combustion engines, gas combustion unit and gas turbines.

2 In addition to **-1** above, engines designed to directly inject methane gas fuel (boil-off gases and cargo vapour) precompressed to a high pressure into cylinders at a high pressure upon termination of the compression stroke and then ignite with an appropriate source of ignition for due combustion (hereinafter referred to as "high pressure gas-fuelled engines") as well as gas fuel supply systems are to be in accordance with **Annex 16.1.1-2**.

3 In addition to **-1** above, trunk-piston type engines supplied with low pressure natural gas as fuel (hereinafter referred to as "low pressure gas-fuelled engines") and gas fuel supply systems are to be in accordance with **Annex 16.1.1-3**.

Annex 16.1.1-2 has been added as follows.

Annex 16.1.1-2 HIGH PRESSURE GAS-FUELLED ENGINES

Chapter 1 GENERAL

1.1 Scope

1 The Guidance applies to engines so designed to directly inject methane gas fuel (boil-off gases and cargo vapour) precompressed to a high pressure into cylinders at a high pressure upon termination of the compression stroke and then ignite with an appropriate source of ignition for due combustion (hereinafter referred to as "high pressure gas-fuelled engines") as well as gas fuel supply systems in accordance with the requirements in **16.1.1, Part N of the Rules**.

2 High pressure gas-fuelled engines and gas fuel supply system are to comply with the relevant requirements of **Part D** and **Part N of the Rules**, in addition to the requirements of this Guidance and **Chapter 16, Part N of the Rules**.

3 High pressure gas-fuelled engines are to be in accordance with those requirements for low pressure gas-fuelled engines specified in **Annex 16.1.1-3** which the Society deems appropriate.

1.2 Equivalency

High pressure gas-fuelled engines which do not comply with the requirements of this Guidance may be accepted provided that they are deemed to be equivalent to those specified in this Guidance by the Society.

1.3 Drawings and Data

The drawings and data to be submitted are as follows.

(1) Drawings and data for approval
- (a) Drawings and data specified in **2.1.3-1(1), Part D of the Rules**
- (b) Drawings and data specified in **18.1.3(1)(a), (b) and (e), Part D of the Rules**
- (c) Gas fuel injection valves
- (d) High pressure oil pipe for actuating gas fuel injection valves with its shielding
- (e) Gas fuel injection pipe with its shielding
- (f) High pressure oil pipe for sealing gas fuel injection valves with its shielding
- (g) Arrangements of gas detectors
- (h) Combustion monitoring device
- (i) Gas fuel injection valve actuating device
- (j) Governor
- (k) Engine control system diagram (including monitor, safety and alarm devices) for gas fuel combustion operation
- (l) Gas leak protective device at connections between engines and gas fuel supply piping
- (m) Gas fuel make-up plant (including construction, equipment, and control systems)
- (n) Gas fuel supply piping system (including details of valves and pipe fittings) and protective device for gas leak from them
- (o) Automatic control and remote control systems for gas fuel supply system
- (p) Other drawings and data as deemed necessary by the Society according to the type of high

pressure Gas-fuelled engines

(2) Drawings and data for reference

(a) Drawings and data specified in **2.1.3-1(2), Part D of the Rules**

(b) Instruction manuals (including procedures for onboard maintenance, inspection and overhaul)

(c) Stress analysis of gas fuel supply piping system

(d) Other drawings and data as deemed necessary by the Society

(3) Drawings and data for reference

Items specified in **2.1.3-1, Part D of the Rules**, which are intended for inspection and testing (indicated by "○" in **Table D2.1(1)** and **Table D2.1(2), Part D of the Rules**).

Chapter 2 CONSTRUCTION AND EQUIPMENT OF HIGH PRESSURE GAS-FUELLED ENGINES

2.1 General

1 High pressure gas-fuelled engines are to be dual fuel system types capable of operating on oil fuel and gas fuel, or gas-only system types.
2 High pressure gas-fuelled dual fuel engines are to be capable of supplying oil fuel to each cylinder in amounts sufficient for maintaining stable combustion of gas fuel under any conditions.
3 High pressure gas-fuelled engines are to be capable of maintaining stable operations even under any of the following **(1)** to **(3)** conditions:
(1) switching from one fuel to another (in the cases of dual fuel engines),
(2) rapid load fluctuations, and
(3) minimum load conditions during gas combustion.
4 Only oil fuel is, in principle, to be used when operation of high pressure gas-fuelled dual fuel engines is unstable.
5 High pressure gas-fuelled dual fuel engines are to be capable of quickly switching from gas combustion mode to oil fuel only combustion mode.

2.2 Construction and Strength

2.2.1 Gas Fuel Injection Valves

1 Gas fuel injection valves are to have satisfactory operating characteristics and durability for the assumed service period.
2 Gas fuel injection valves are to be provided with a sealing system to effectively prevent gas fuel from leaking through spaces around valve spindles.
3 Gas fuel injection valves are to be provided with an effective cooling system.

2.2.2 Gas Fuel Injection Valve Actuating System

1 The gas fuel injection valve actuating system is to be reliably functional and operational.
2 When operating gas fuel injection valves equipped with an actuating oil piping system and a sealing oil piping system, the high pressure sections of these systems which are installed on the engine body are to be provided with protections against splash of actuating oil in accordance with the requirements in **2.5.4, Part D of the Rules.**
3 Appropriate means are to be provided if the gas fuel injection valve actuating oil is required to be kept clean.

2.2.3 Cylinder Covers

1 The shape of combustion chambers and the arrangements of gas fuel injection valves and oil fuel (or pilot oil) injection valves are to be such that reliable ignition and combustion of gas fuel are ensured.
2 The portion of the cylinder covers where gas fuel injection valves and oil fuel injection valves are fitted are to be so constructed as to prevent leakage of gas fuel and unburnt gases in the cylinders.

2.3 Safety Systems

2.3.1 Combustion Monitoring Device

1 When high pressure gas-fuelled engines are operated on gas fuel, the following items are, in principle, to be monitored and the gas fuel supply to the engines is to be automatically cut off in case

of any abnormal conditions concerning the following **(1)** through **(4)** are detected.
(1) Function of gas fuel injection valves
(2) Function of pilot oil fuel injection valves (in case of dual fuel engine)
(3) Function of exhaust gas valves
(4) Exhaust gas temperatures at each cylinder outlet

2 When high pressure Gas-fuelled engines are operated on gas fuel, the following items are to be monitored as standard.
(1) Abnormalities in each cylinder pressure
(2) Blow-by through exhaust valves

2.3.2 Protection against Explosions

1 Relief valves of an approved type are to be provided for the crankcase in accordance with **2.4.3, Part D of the Rules**.

2 Unless designed with the strength to withstand the worst case overpressure due to ignited gas leaks, scavenge spaces and exhaust system are to be fitted with suitable pressure relief systems in accordance with **16.7.1-4, Part D of the Rules**.

3 The relief valves for cylinders installed in accordance with the requirements of **2.4.2, Part D of the Rules**, are to be provided with a system to monitor certain closing of the valves as far as practicable.

4 Effective gas detecting systems to detect gas fuel leaks are to be fitted at the following locations **(1)** through **(4)**. If the sensors of these gas detecting systems are fitted to the high pressure gas-fuelled engine body, they are to be double as far as practicable.
(1) The lower space of each piston or the scavenging air manifolds of the crosshead-type high pressure gas-fuelled engines
(2) The crankcase of the trunk piston-type high pressure gas-fuelled engines. In this case, the sensors may be required at more than one location depending on the shape of crankcase.
(3) The void space between gas fuel injection lines and shielding systems specified in **2.4.3**, except the case of the same void space common to the void space of protective pipes for the gas fuel supply piping system or ducts specified in **3.2.3-2(1)** to **(3)**.
(4) Other locations considered necessary by the Society.

2.3.3 Governor

1 Governors for high pressure gas-fuelled engines are to be capable of being operated during gas fuel combustion mode. In the case of dual fuel engines, the governors are additionally to be capable of being operated either during gas and oil fuel (or pilot oil) combustion mode, and/or oil fuel only combustion mode.

2 The governors of **-1** above are to comply with the requirements in **2.4.1-1, Part D of the Rules** in each mode of operations.

3 High pressure gas-fuelled dual fuel engines are to be operated in any one of the modes specified in the following **(1)** to **(3)**:
(1) controllable gas fuel supply and fixed oil fuel (pilot oil) supply,
(2) controllable oil fuel (pilot oil) supply and fixed gas fuel supply, or
(3) controllable gas fuel and oil fuel supplies.

2.4 Accessory Equipment

2.4.1 Exhaust Gas Systems

The exhaust gas pipes of high pressure gas-fuelled engines are not to be connected to the exhaust gas pipes or the exhaust pipes of other engines or systems.

2.4.2 Starting Systems

Starting air branch pipes to each cylinder are to be provided with effective flame arresters.

2.4.3 Gas Fuel Injection Pipes

1 Gas fuel injection pipes (only those attached to engines) are to be provided with effective shielding against gas fuel spillage due to pipe failure.

2 Space between the gas fuel injection pipes and shielding is to be provided with means according to the requirements in **3.2.3-2(1)** to **(3)**.

3 When flexible tubes are used as shielding, they are to be of an approved type.

2.4.4 Cylinder Lubrication

Cylinder lubricating systems for high pressure gas-fuelled engines are to be capable of maintaining adequate alkali values and cylinder oil feeding rates according to the mode of operation on oil fuel only and also the modes of operation specified in **2.3.3-3(1)** to **(3)** as standard.

Chapter 3 GAS FUEL SUPPLY SYSTEMS

3.1 Gas Fuel Make-up Plants

3.1.1 General

1 Gas fuel make-up plants and oil fuel supply systems for high pressure gas-fuelled engines are to be capable of sustaining main engine operation so that at least normal navigation can be maintained even if one of the fuel systems for gas fuel or oil fuel fails.

2 High pressure gas compressors, pumps and heat exchangers forming gas fuel make-up plant are to comply with requirements specified separately by the Society.

3 Pressure vessels and piping systems composing a gas fuel make-up plant are to comply with the requirements of **Chapter 5, Part N of the Rules**.

4 High pressure gas-fuelled engines are to be provided with an appropriate system capable of reducing to allowable levels the pulsation of gas fuel supply pressures caused by high pressure gas compressors for gas fuel supply.

5 If the heating medium of gas fuel heat exchangers returns to spaces other than cargo spaces, it is to be so arranged that the heating medium is returned through degassing tanks located in cargo spaces. The degassing tanks are to be provided with a gas detecting system to issue alarms on detecting gas leaks. Vent outlets of the degassing tanks are to be provided with flame screens and the openings are to be located at safe positions.

3.2 Gas Fuel Supply Piping Systems

3.2.1 Materials

1 Materials of pipes, valves and pipe fittings of the gas fuel supply piping system are to comply with the relevant requirements in **Part K of the Rules**.

2 In addition to **-1** above, when design temperatures are lower than 0°C, the requirements in **Table N6.4, Part N of the Rules** are also to be complied with,

3 Notwithstanding the requirements in **-1** and **-2** above, the materials conforming to *JIS* standard or other standards as deemed appropriate by the Society may be used for pipes, valves and pipe fittings used in accessory piping systems or instrument piping systems with an outside diameter of not more than 25 *mm*.

4 Consideration is to be given to the cooling effects caused by bursting of the high pressure gas fuel in the event of a failure of the piping system, when the materials of gas fuel supply piping systems are selected.

3.2.2 Construction and Strength

1 Gas fuel supply piping systems are to be supported effectively by hull structures or engine frames considering the weight of the piping system, and deflections and vibrations of the hull.

2 Gas fuel supply piping systems are to be ensured to have sufficient construction strength by carrying out stress analysis considering the stresses produced by the weight of the piping system, internal pressure, heat contraction and hull deflections.

3 For all valves and expansion joints used in gas fuel supply lines, approval of use is to be obtained in accordance with requirements specified otherwise by the Society or with requirements for prototype tests specified otherwise by the Society.

4 Joints between the gas fuel supply lines are to be butt-welded joints with complete penetration, except where specially approved by the Society.

5 Pipe joints other than welded joints at the locations specially approved by the Society are to comply with the appropriate Standards recognized by the Society, or those whose structural strength

has been verified through tests and analysis as deemed appropriate by the Society.

6 For butt-welded joints specified in **-4** above, post-weld heat treatment is to be performed in accordance with **5.9.2, Part N of the Rules**.

3.2.3 Protection against Gas Fuel Leaks

1 Gas fuel supply piping systems are not to be led through the accommodation spaces, service spaces, and control stations.

2 If either of the following items **(1)** and **(2)** are relevant, the piping system may be led through or led into the spaces other than that specified in **-1** above.

(1) The system complying with **16.4.3(1), Part N of the Rules**, and in addition, with **(a)** to **(c)** given below:

(a) The pressure in the space between concentric pipes is monitored continuously, an alarm is to be issued and automatic double block and bleed valves specified in **16.4.5, Part N of the Rules** and the master gas valve specified in **16.4.6** are to be closed before the pressure drops to below the inner pipe pressure (however, the automatic double block and bleed valve connected to vent outlet is to be opened).

(b) Construction and strength of the outer pipes are to comply with the requirements in **5.4.4** and **5.11.4, Part N of the Rules**.

(c) It is to be so arranged that the inside of the gas fuel supply piping system between the master gas valve and the high pressure Gas-fuelled engine is to be automatically purged with inert gas, when the master gas valve is closed.

(2) The system complying with **16.4.3(2), Part N of the Rules**, and in addition with **(a)** through **(e)** given below:

(a) Materials, construction and strength of outer pipes of double wall pipes or ducts and mechanical ventilating systems are to be sufficiently durable against bursting and rapid expansion of high pressure gases following the inner pipe failure.

(b) The capacity of mechanical ventilating systems is to be determined considering the flow rate of gas fuel and construction and arrangement of protective pipes or ducts, as deemed appropriate by the Society.

(c) The air intakes of mechanical ventilating systems are to be provided with non-return devices effective for gas fuel leaks. However, if the air intakes are opened directly to exposed spaces and located at places free from risk of ignition of leaked gas fuel, these requirements may be dispensed with.

(d) The number of flange joints of outer pipes of double wall pipes or ducts is to be minimized.

(e) Measure specified in **(1)(c)** above.

Chapter 4 CONTROL SYSTEMS AND SAFETY SYSTEMS

4.1 General

1 Control systems for operating high pressure gas-fuelled engines using gas fuel are to comply with the requirements in **18.1** to **18.3** and **18.7, Part D of the Rules**.

2 High pressure gas compressors and pumps for supplying gas fuel in the gas fuel make-up plant are to be provided with the following safety systems:

(1) Remote stopping devices from readily accessible places and the position from which the main engine is normally controlled.

(2) Automatic stopping device actuated when the suction pressure of boil-off gas or cargo liquids drops to below the predetermined value according to the cargo tank construction system, before the tank pressure reaches the set pressure of negative pressure relief valves for cargo tanks.

(3) Emergency shut-down specified in **Table N18.1, Part N of the Rules**.

(4) Volumetric compressors are to be fitted with pressure relief valves discharging into the suction line of the compressor. The size of the pressure relief valves is to be determined in such away that, with the delivery valve kept close, the maximum pressure will not exceed the maximum working pressure by more than 10%.

3 The exit temperature and pressure of gas fuel at the gas fuel make-up plant are to be automatically controlled. Visual and audible alarm device are also to be provided such as to be activated when the temperature and pressure exceed the preset ranges.

4.2 High Pressure Gas-fuelled engines of Ships to which the Rules for Automatic and Remote Control Systems Apply

High pressure gas-fuelled engines of ships to which the requirements in **1.1.1 of the Rules for Automatic and Remote Control Systems** apply are to comply with the requirements in **3.2, 3.3** and **4.2** of the same **Rules**, in addition to the following requirements **(1)** and **(2)**:

(1) High pressure gas-fuelled engines are to be provided with safety system which automatically cut off gas fuel supply, and in addition, automatically transfer the mode of operation to oil fuel alone or stops the engines when abnormalities **(a)** to **(d)** given below occur. However, automatic cut off of gas fuel supply with the automatic double block and bleed valves specified in **16.4.5, Part N of the Rules** may be accepted.

- (a) When abnormalities specified in **2.3.1-1** or **-2** are detected.
- (b) When gas fuel leaks are detected by gas detecting devices specified in **3.2.3-2(2)** or **(3)(c)**.
- (c) When high pressure gas compressors or pumps for supplying gas fuel stopped for reasons specified in **4.3** (excluding however, the case in which arrangement is made for automatic starting of a stand-by compressor when the working compressor fails).
- (d) Other cases as deemed necessary by the Society.

(2) High pressure gas-fuelled engines are to be provided with a system which automatically reduces speed or transfers the mode of operation to oil fuel alone and issues an alarm in the event of the following **(a)** through **(g)**:

- (a) Abnormal gas fuel temperature
- (b) Abnormal gas fuel supply pressure
- (c) Abnormalities in high pressure gas compressors for gas fuel supply specified in **4.3(2)**.
- (d) Activation of alarms specified in **3.2.3-2(1)(a), (2)** or **(3)(b)**.
- (e) Low inert gas supply pressures for purging gas fuel pipe lines
- (f) Low pressures of hydraulic pneumatic sources loss of electric power supply for gas fuel combustion control

(g) Others as deemed necessary by the Society.

4.3 Gas Fuel Make-up Plant for Ships to which the Rules for Automatic and Remote Control Systems Apply

Gas fuel make-up plants of ships to which the requirements of **1.1.1 of the Rules for Automatic and Remote Control Systems** apply are to comply with the following requirements **(1)** and **(2)**:

(1) High pressure gas compressors for gas fuel supply are to be provided with safety devices specified in the following **(a)** through **(f)**:
   (a) Emergency shut-down devices specified separately by the Society
   (b) Device for reciprocating compressors to avoid continuous operation within the barred speed range
   (c) Automatic stopping device at overspeeds
   (d) Automatic stopping device at low lubricating oil pressure
   (e) Automatic stopping device at abnormal high discharge pressures
   (f) Automatic stopping device at abnormal low temperatures at boil-off gas heater outlets

(2) High pressure gas compressors for gas fuel supply are to be provided with alarm devices activated in the cases specified separately by the Society and in the event of the abnormal conditions specified in **-1** above.

Chapter 5 TESTS

5.1 Approval of Use

For each type of high pressure gas-fuelled engine, approval of use is to be obtained by the engine designer (licensor) in accordance with requirements specified separately by the Society.

5.2 Shop Test

5.2.1 Hydrostatic Tests

The parts and accessory equipments of high pressure gas-fuelled engines, which are exposed to pressures, are to be subjected to hydrostatic tests in accordance with the requirements of **2.6.1-1, Part D of the Rules**.

5.2.2 Shop Trials

High pressure gas-fuelled engines are to be tested as specified in **2.6.1-4, Part D of the Rules**. To implement surveys of tests, in lieu of traditional ordinary surveys where the Surveyor is in attendance, the Society may approve survey methods which it considers to be able to obtain information equivalent to that obtained through traditional ordinary surveys.

5.3 Tests after Installation On Board

The control systems of high pressure gas-fuelled engines and related equipments are to be subjected to tests in accordance with the requirements of **18.7.3, Part D of the Rules** or the requirements of **2.2.4 of the Rules for Automatic and Remote Control Systems** according to the kind of Installations Character.

5.4 Sea Trials

1 Performance of control systems of high pressure gas-fuelled engines and related equipment is to be verified during operations using gas fuel depending upon their installation characters in accordance with the requirements of **2.2.5 of the Rules for Automatic and Remote Control Systems**: relevant requirements are to be applied mutatis mutandis.

2 Sea trials specified in **2.3.1, Part B** are to be carried out for operations using the oil fuel only. In addition, however, either the testing items as considered to be necessary by the Society are to be carried out to verify the control performance of engine operations using the gas fuel.

Annex 16.1.1-3 has been added as follows.

Annex 16.1.1-3 LOW PRESSURE GAS-FUELLED ENGINES

Chapter 1 GENERAL

1.1 Scope

1 The Guidance applies to trunk-piston type engines supplied with low pressure natural gas as fuel (hereinafter referred to as "low pressure gas-fuelled engines") and gas fuel supply systems in accordance with the requirements of **16.1.1, Part N of the Rules**.

2 Low pressure gas-fuelled engines and gas fuel supply systems are to comply with relevant requirements of **Part D** and **Part N of the Rules**, in addition to the requirements of this Guidance and **Chapter 16, Part N of the Rules**.

3 The following requirements specified in **Part GF of the Rules** as well as other requirements specified separately by the Society apply to low pressure gas-fuelled engines regardless of ship type, ship size and ship service area except where explicitly specified otherwise.

(1) **2.1-5(3)**
(2) **2.2.3-1**
(3) **2.4.4-4(2)**
(4) **2.4.4-4(3)(b)**
(5) **4.1-7**

1.2 Equivalency

Low pressure gas-fuelled engines which do not comply with the requirements of this Guidance may be accepted provided that they are deemed to be equivalent to those specified in this Guidance by the Society.

1.3 Drawings and Data

The drawings and data to be submitted are as follows.

(1) Drawings and data for approval
  (a) Drawings and data specified in **2.1.3-1(1), Part D of the Rules**
  (b) Drawings and data specified in **18.1.3(1)(a), (b) and (e), Part D of the Rules**
  (c) Gas fuel injection valves and actuating systems
  (d) Gas fuel injection pipe and shielding arrangements
  (e) Arrangement of gas detectors
  (f) Combustion monitoring device
  (g) Governor
  (h) Engine control system diagram (including monitor, safety and alarm systems) for gas fuel combustion operation
  (i) Gas leak protection system at connections between engines and gas fuel supply piping systems
  (j) Gas fuel make-up plant (including construction, equipment, and control systems)
  (k) Gas fuel supply piping system (including details of valves and pipe fittings) and protective device for gas leaks from them

(l) Automatic control and remote control systems for gas fuel supply systems
(m) Pilot fuel injection devices or injection arrangements
(n) Schematic layout or other equivalent documents of gas system on the engine
(o) Gas piping system (including double-walled arrangement where applicable)
(p) Parts for gas admission system
The documentation to contain specifications for pressures, pipe dimensions and materials.
(q) Arrangement of explosion relief valves for crankcase (if required by **2.4.3, Part D of the Rules**), charge air manifold and exhaust gas manifold, as applicable
(r) Schematic layouts or other equivalent documents for fuel oil systems (main and pilot fuel systems) of the engine (in the case of dual fuel engines)
(s) Assembly drawings for the shielding of high pressure fuel pipes of pilot fuel system (in the case of gas only engines)
(t) Other drawings and data as deemed necessary by the Society according to the type of low pressure gas-fuelled engines

(2) Drawings and data for reference
(a) Drawings and data specified in **2.1.3-1(2), Part D of the Rules**
(b) Other drawings and data as deemed necessary by the Society

(3) Drawings and data for the purpose of inspecting and testing engines
Items specified in **2.1.3-1, Part D of the Rules**, which are intended for inspection and testing (indicated by "○" in **Table D2.1(1)** and **Table D2.1(2), Part D of the Rules**).

1.4 Terms

1 *Certified safe type* means electrical equipment that is certified in accordance with the recommendation published by the International Electrotechnical Commission (*IEC*), in particular publication *IEC* 60092-502:1999, or with recognized standards at least equivalent. The certification of electrical equipment is to correspond to the category and group for methane gas.

2 *Double block and bleed valve* means valves which have the functionality specified in **16.4.5, Part N of the Rules**.

3 *Dual fuel engine* means an engine that can burn natural gas as fuel simultaneously with liquid fuel, either as pilot oil or bigger amount of liquid fuel (gas mode), and also has the capability of running on liquid diesel fuel oil only (Diesel mode).

4 *Engine room* is a machinery space or enclosure containing gas fuelled engine(s).

5 *Gas* means a fluid having a vapour pressure exceeding 0.28 *MPa* absolute at a temperature of 37.8℃.

6 *Gas admission valve* is a valve or injector on the engine, which controls gas supply to the cylinder(s) according to the cylinder(s) actual gas demand.

7 *Gas only engine* means an engine that can be operated only with gas fuel and cannot be switched to oil-fuelled operation.

8 *Gas piping* means piping containing gas or air / gas mixtures, including venting pipes.

9 *Gas Valve Unit* (*GVU*) is a set of manual shutoff valves, actuated shut-off and venting valves, gas pressure sensors and transmitters, gas temperature sensors and transmitters, gas pressure control valve and gas filter used to control the gas supply to each gas consumer. It also includes a connection for inert gas purging.

10 *Low pressure gas* means gas with a pressure up to 1 *MPa*.

11 *Lower Heating Value* (*LHV*) means the amount of heat produced from the complete combustion of a specific amount of fuel, excluding latent heat of vaporization of water.

12 *Methane Number* is a measure of resistance of a gas fuel to knock, which is assigned to a test fuel based upon operation in knock testing unit at the same standard knock intensity. (Pure methane

is used as the knock resistant reference fuel, that is, methane number of pure methane is 100, and pure hydrogen is used as the knock sensitive reference fuel, methane number of pure hydrogen is 0.)

13 *Pilot fuel* means the fuel oil that is injected into the cylinder to ignite the main gas-air mixture on Gas-fuelled engines.

14 *Pre-mixed engine* means an engine where gas is supplied in a mixture with air before the turbocharger.

15 *Safety Concept* is a document describing the safety philosophy with regard to gas as fuel. It describes how risks associated with this type of fuel are controlled under reasonably foreseeable abnormal conditions as well as possible failure scenarios and their control measures. A detailed evaluation regarding the hazard potential of injury from a possible explosion is to be carried out and reflected in the safety concept of the engine.

Chapter 2 CONSTRUCTION AND EQUIPMENT OF LOW PRESSURE GAS-FUELLED ENGINES

2.1 General

1 Low pressure gas-fuelled engines are to be dual fuel system types capable of operating on oil fuel and gas fuel, or gas-only system types.

2 Low pressure gas-fuelled engines are to be capable of maintaining stable operation even under any of the following **(1)** to **(3)** conditions:

(1) switching from one fuel to another (in the case of dual fuel engine),

(2) rapid load transient, and

(3) minimum load condition during gas combustion

3 Gas fuel supply pressures for low pressure gas-fuelled engines are to always be kept higher than suction air pressures at the supply points of gas fuel to combustion chambers or the suction pipes before suction valves in order to prevent any back-flow of air into gas fuel lines.

4 The manufacturer is to declare the allowable gas composition limits for the engine and the minimum and (if applicable) maximum methane number.

5 Components containing or likely to contain gas are to be designed in accordance with the following **(1)** to **(5)**.

(1) Minimize the risk of fire and explosion so as to demonstrate an appropriate level of safety commensurate with that of an oil-fuelled engine

(2) Mitigate the consequences of a possible explosion to a level providing a tolerable degree of residual risk, due to the strength of the component(s) or the fitting of suitable pressure relief devices of an approved type

(3) Refer to **10.2** and **10.3, Part GF of the Rules**

(4) Discharge from pressure relief devices is to prevent the passage of flame to the machinery space and be arranged such that the discharge does not endanger personnel or damage other engine components or systems

(5) Relief devices are to be fitted with a flame arrester

2.2 Construction and Strength

2.2.1 Gas Fuel Valves and Actuating Systems

1 Gas fuel valves are to have satisfactory operating characteristics and durability for the assumed service period.

2 Gas fuel valves are to be provided with a sealing system to effectively prevent gas fuel from leaking through spaces around valve spindles.

3 The actuating systems of gas fuel valves are to have satisfactory operating characteristics and reliability.

2.2.2 Cylinder Covers

1 The shape of combustion chambers and the arrangements of gas fuel valves are to be such that reliable ignition and combustion of gas fuel are ensured.

2 The portions of cylinder covers where gas fuel valves and oil fuel injection valves are fitted are to be so constructed as to prevent the leakage of gas fuel and unburnt gases in the cylinders.

2.2.3 Crankcase

1 Crankcase explosion relief valves are to be installed in accordance with **2.4.3, Part D of the Rules**. Refer also to **10.3.1-2, Part GF of the Rules**.

2 For maintenance purposes, a connection, or other means, are to be provided for crankcase inerting and ventilating and gas concentration measuring.

2.2.4 Gas Ignition in Cylinder

For gas ignition in the cylinder, the requirements of **16.7, Part N of the Rules** are to be applied.

2.3 Safety Systems

2.3.1 Protection against Explosions

1 Suction manifolds and exhaust gas pipes are to be fitted with suitable pressure relief systems in accordance with **16.7.1-4, Part N of the Rules**.

2 Each gas fuel injection line is to be provided with a non-return valve or devices which have capabilities equivalent to those of the valves.

3 When gas is supplied in a mixture with air through a common manifold, flame arrestors are to be installed before each cylinder head.

4 Effective gas detecting systems to detect gas fuel leaks are to be fitted at the following locations **(1)** and **(2)**.

(1) Crankcases. In this case, the sensors may be required at more than one location depending on the shape of the crankcase; and

(2) Other locations considered necessary by the Society.

2.3.2 Governors

1 In addition to operations using gas fuel, governors of low pressure gas-fuelled engines are to be functional in either the simultaneous combustion mode of gas and oil fuel (or pilot oil) or the combustion mode of oil fuel.

2 The governors of **-1** above are to comply with the requirements in **2.4.1-1, Part D of the Rules** in each mode of operations.

3 Low pressure gas-fuelled dual fuel engines are to be operated in any one of the modes specified in the following **(1)** to **(3)**:

(1) controllable gas fuel supply and fixed oil fuel (pilot oil) supply,

(2) controllable oil fuel (pilot oil) supply and fixed gas fuel supply, or

(3) controllable gas fuel and oil fuel supplies.

2.4 Accessory Equipment

2.4.1 Charge Air Systems

1 The charge air system on the low pressure gas-fuelled engine is to be designed in accordance with **2.1-5**.

2 In case of a single engine installation, the engine is to be capable of operating at sufficient load to maintain power to essential consumers after opening of the pressure relief devices caused by an explosion event. Sufficient power for propulsion capability is to be maintained.

3 Load reduction is to be considered on a case-by-case basis, depending upon engine configuration (single or multiple) and type of relief mechanism (self-closing valve or bursting disk).

2.4.2 Exhaust Gas Systems

1 The exhaust gas system on the low pressure gas-fuelled engine is to be designed in accordance with **2.1-5**.

2 In case of a single engine installation, the engine is to be capable of operating at sufficient load to maintain power to essential consumers after opening of the pressure relief devices caused by an explosion event. Sufficient power for propulsion capability is to be maintained.

3 Continuous relief of exhaust gas (through open rupture disc) into the engine room or other enclosed spaces is not acceptable.

2.4.3 Starting Systems

Starting air branch pipes to each cylinder are to be provided with effective flame arresters.

2.4.4 Gas Fuel Injection Pipes

1 Except where specifically approved by the Society, gas fuel injection pipes is to be provided with effective shielding against gas fuel bursting due to failures of pipes.

2 Spaces between the gas fuel injection pipes and the shielding is to be provided with means according to the requirements in **3.2.2-2**.

3 When flexible tubes are used as the shielding, they are to be of an approved type.

4 For piping attached to low pressure gas-fuelled engines, the following **(1)** to **(5)** also apply.

(1) Requirements of **5.1** to **5.9** and **Chapter 16, Part GF of the Rules** are applied.

(2) Arrangement of the gas piping system on the engine

Pipes and equipment containing fuel gas are defined as hazardous area zone 0 (refer to **12.5.1, Part GF of the Rules**). The space between the gas fuel piping and the wall of the outer pipe or duct is defined as hazardous area zone 1 (refer to **12.5.2(6), Part GF of the Rules**).

(3) Normal "double wall" arrangement

(a) The gas piping system on the low pressure gas-fuelled engine are applied the requirements of **16.4.3, Part N of the Rules**.

(b) The design criteria for the double pipe or duct are given in the **9.8** and **7.4.1-4, Part GF of the Rules**.

(c) In case of a ventilated double wall, the ventilation inlet is applied the provisions of **16.4.3(2), Part N of the Rules**.

(d) The pipe or duct is to be pressure tested in accordance with **12.6.1-2** to **-4, Part D of the Rules** to ensure gas tight integrity and to show that it can withstand the expected maximum pressure at gas pipe rupture.

(4) Alternative arrangement

Single walled gas piping is only acceptable in cases where the requirements of **Part N of the Rules** permit (e.g. **16.4.4-1, Part N of the Rules**).

(5) Gas admission valves

Gas admission valves are to be certified safe as follows:

(a) The inside of the valve contains gas and therefore it is to be certified for zone 0.

(b) When the valve is located within a pipe or duct in accordance with **(3)**, the outside of the valve is to be certified for zone 1.

(c) However, if they are not rated for the zone they are intended for, it is to be documented that they are suitable for that zone. Documentation and analysis is to be based on *IEC* 60079-10-1:2015 or *IEC* 60092-502:1999.

2.4.5 Cylinder Lubrication

Cylinder lubricating systems for low pressure gas-fuelled engines are to be capable of maintaining adequate alkali values and cylinder oil feeding rates according to the mode of operation on oil fuel only and also the modes of operation specified in **2.3.2-3(1)** to **(3)** as standard.

2.5 Design Requirements for Each Kind of Engines

2.5.1 Dual Fuel Engine

1 General

(1) The maximum continuous power that a dual fuel engine can develop in gas mode may be

lower than the approved MCR of the engine (i.e. in oil fuel mode), depending in particular on the gas quality. This maximum power available in gas mode and the corresponding conditions are to be stated by the engine manufacturer and demonstrated during the type test.

(2) Low pressure gas-fuelled dual fuel engines are to be capable of supplying oil fuel to each cylinder in amounts sufficient for maintaining stable combustion of gas fuel under any conditions.

(3) Only oil fuel is, in principle, to be used when operation of low pressure gas-fuelled dual fuel engines are unstable.

2 Starting, changeover and stopping

(1) Dual fuel engines are to be arranged to use either oil fuel or gas fuel for the main fuel charge and with pilot oil fuel for ignition. The engines are to be arranged for rapid changeover from gas use to fuel oil use. In the case of changeover to either fuel supply, the engines are to be capable of continuous operation using the alternative fuel supply without interruption to the power supply.

(2) Changeover to gas fuel operation is to be only possible at a power level and under conditions where it can be done with acceptable reliability and safety as demonstrated through testing.

(3) Changeover from gas fuel operation mode to oil fuel operation mode is to be possible at all situations and power levels.

(4) The changeover process itself from and to gas operation is to be automatic but manual interruption is to be possible in all cases.

(5) In case of shut-off of the gas supply, the engines are to be capable of continuous operation by oil fuel only.

3 Gas supply to the combustion chamber is not to be possible without operation of the pilot oil injection. In addition, pilot injection is to be monitored for example by fuel oil pressure and combustion parameters.

2.5.2 Gas only engine

In case of failure of the spark ignition, the engine is to be shut down except when the following **(1)** to **(3)** are satisfied:

(1) the failure is limited to one cylinder;

(2) the gas supply to the failed cylinder is immediately shut off; and

(3) safe operation of the engine is substantiated by risk analysis and tests.

2.5.3 Pre-mixed Engine

Inlet manifolds, turbochargers, charge air coolers, etc. are to be regarded as parts of fuel gas supply systems, and failures of such components likely to result in gas leakages are to be considered in risk analysis by a method deemed appropriate by the Society.

Chapter 3 GAS FUEL SUPPLY SYSTEMS

3.1 Gas Fuel make-up Plants

3.1.1 General

1 Gas fuel make-up plants and oil fuel supply systems for low pressure gas-fuelled engines are to be capable of sustaining main engine operation so that at least normal navigation can be maintained even if one of the fuel systems for gas fuel or oil fuel fails.

2 Low pressure gas compressors and heat exchangers forming gas fuel make-up plants are to comply with requirements specified separately by the Society.

3 Pressure vessels and piping systems composing a gas fuel make-up plant are to comply with the requirements of **Chapter 5, Part N of the Rules**.

4 If the heating medium of gas fuel heat exchangers returns to spaces other than cargo spaces, it is to be so arranged that the heating medium is returned through degassing tanks located in cargo spaces. The degassing tanks are to be provided with a gas detecting system to issue alarms on detecting gas leaks. Vent outlets of the degassing tanks are to be provided with flame screens and the openings are to be located at safe positions.

3.2 Gas Fuel Supply Piping Systems

3.2.1 General

Gas fuel supply piping systems are to comply with the relevant requirements of **16.4.1-2, Part N of the Rules**.

3.2.2 Protection against Gas Fuel Leaks

1 Gas fuel supply piping systems are not to be led through the accommodation spaces, service spaces and control stations.

2 The arrangements are to comply with the requirements in **16.4.3(1)** or **(2), Part N of the Rules** when gas fuel supply piping systems are led through or led into the spaces other than those specified in **-1** above.

Chapter 4 CONTROL, ALARM AND SAFETY SYSTEMS

4.1 General

1 Control systems for operating low pressure gas-fuelled engines using gas fuel are to comply with the requirements in **18.1 to 18.3** and **18.7, Part D of the Rules**.

2 Gas fuel supply compressors in the gas fuel make-up plant are to be provided with the following safety systems :

(1) Remote stopping devices from readily accessible places and the position from which station of the main engine is normally controlled.

(2) Automatic stopping devices actuated when the suction pressure of boil-off gases drops to below the predetermined value according to the cargo tank construction system, before the tank pressure reaches the set pressure of negative pressure relief valves for cargo tanks.

(3) Emergency shut-down specified in **Table N18.1, Part N of the Rules**.

(4) Volumetric compressors are to be fitted with pressure relief valves discharging into the suction line of the compressor. The size of the pressure relief valves is to be determined in such away that, with the delivery valve kept close, the maximum pressure will not exceed the maximum working pressure by more than 10%.

3 The exit temperature and pressure or flow rate of the gas fuel at the gas fuel make-up plant are to be automatically controlled. Visual and audible alarm device are also to be provided such as to be activated when the temperature and pressure exceed the preset ranges.

4 The engine control system is to be independent and separate from the safety system.

5 The gas supply valves are to be controlled by the engine control system or by the engine gas demand.

6 Combustion is to be monitored on an individual cylinder basis.

7 In the event that poor combustion is detected on an individual cylinder, gas operation may be allowed in the conditions specified in **10.3.1-6, Part GF of the Rules**.

8 Regardless of **-6**, if monitoring of combustion for each individual cylinder is not practicable due to engine size and design, common combustion monitoring may be accepted.

9 Unless risk analysis by a method deemed appropriate by the Society proves that risk is within the acceptable range, alarm and safety system functions of dual fuel or gas only engines are to be provided in accordance with **Table 4.1**. (for dual fuel engines, **Table 4.1** applies only to gas mode) However, even if risk analysis proves that risk is within the acceptable range, the alarm and safety system functions specified in **Part N of the Rules** are still to be provided.

Table 4.1 Alarm and Safety System Functions for Dual Fuel Engines

Parameter	Alarm	Automatic activation of the double block and bleed valves	Automatic switching over to oil fuel mode	Engine shutdown
1. Abnormal pressures in the gas fuel supply line	X	X	X	-
2. Gas fuel supply systems - malfunction	X	X	X	-
3. Pilot fuel injection or spark ignition systems - malfunction	X	X	X	-
4. Exhaust gas temperature after each cylinder - high	X	X	X	-
5. Exhaust gas temperature after each cylinder - low[1)]	X	X	X	-
6. Cylinder pressure or ignition - failure, including misfiring, knocking and unstable combustion	X	X [2)]	X [2)]	-
7. Oil mist concentration in crankcase or bearing temperature[3)] - high	X	X	-	X
8. Pressure in the crankcase - high[2)]	X	X	X	-
9 Engine stops - any cause	X	X	-	-
10. Failure of the control-actuating medium of the block and bleed valves	X	X	X	-

Notes:

1) Required only if necessary for the detection of misfiring. In addition, deviation from average is to be used for the operation setting of each function.

2) In the case where the failure can be corrected by an automatic mitigation action, only the alarm may be activated. If the failure persists after a given time, the safety actions are to be activated.

3) Where required by **2.4.5, Part D of the Rules**

4.2 Low Pressure Gas-fuelled engines of Ships to which the Rules for Automatic Remote Control Systems Apply

Low pressure gas-fuelled engines of ships to which the requirement **1.1.1, of Rules for Automatic and Remote Control Systems** apply are to comply with the requirements of **3.2, 3.3** and **4.2** of the same **Rules**, in addition to the following requirements **(1)** and **(2)**.

(1) Low pressure gas-fuelled engines are to be provided with safety systems which automatically cut off the gas fuel supply, and in addition, automatically transfer the mode of operation to oil fuel alone or stop the engines when abnormalities **(a)** to **(c)** given below occur. However, automatic cut off of the gas fuel supply with the automatic double block and bleed valves specified in **16.4.5, Part N of the Rules** may be accepted.

(a) When operating on gas fuel, abnormalities are detected in the following:

i) gas fuel valve function

ii) pilot oil fuel injection valve function

iii) suction valve and exhaust valve function

iv) exhaust gas temperatures at cylinder outlets

v) pressure in cylinder

vi) blow-by through suction valves or exhaust valves

(b) When gas leaks to double wall pipes or void spaces of ducts specified in **3.2.2-2** are

detected.

(c) Others as deemed necessary by the Society.

(2) Low pressure gas-fuelled engines are to be provided with a system which automatically reduces speed or transfers the mode of operation to oil fuel alone and issues an alarm in the event of the following **(a)** through **(f)**:

(a) Abnormal gas fuel temperature.

(b) Abnormal gas fuel supply pressure.

(c) Activation of an alarm issued before the pressure of the space between concentric pipes specified in **3.2.2-2** drops to below the atmospheric pressure.

(d) Low inert gas supply pressure for purging gas fuel pipe lines.

(e) Low pressures of hydraulic and pneumatic sources or loss of electric power supply for gas fuel combustion control.

(f) Others as deemed necessary by the Society.

4.3 Gas Fuel Supply Compressors for Ships to which the Rules for Automatic and Remote Control Systems Apply

Gas fuel supply compressors of ships to which the requirements of **1.1.1 of the Rules for Automatic and Remote Control Systems** apply are to be provided with safety systems and alarm systems specified in the following **(1)** through **(8)**:

(1) Monitoring systems and protective devices specified separately by the Society.

(2) Emergency shut-down devices specified separately by the Society.

(3) Automatic stopping device at overspeeds.

(4) Automatic stopping device at low lubricating oil pressures.

(5) Automatic stopping device at abnormal high discharge pressures.

(6) Automatic stopping device at abnormal low temperatures at boil-off gas heater outlets.

(7) Devices to avoid continuous operations in the barred speed ranges.

(8) Safety systems and alarm systems specified in **3.9 of the Rules for Automatic and Remote Control Systems** when gas compressors are driven by steam turbines.

Chapter 5 TESTS

5.1 Approval of Use

For each type of low pressure gas-fuelled engine, approval of use is to be obtained by the engine designer (licensor) in accordance with requirements specified separately by the Society.

5.2 Shop Test

5.2.1 Hydrostatic Tests

The parts and accessory equipments of low pressure gas-fuelled engines, which are exposed to pressures, are to be subjected to hydrostatic tests in accordance with the requirements of **2.6.1, Part D of the Rules**.

5.2.2 Shop Trials

Low pressure gas-fuelled engines are to be tested as specified in **2.6.1-3, Part D of the Rules**. To implement surveys of tests, in lieu of traditional ordinary surveys where the Surveyor is in attendance, the Society may approve survey methods which it considers to be able to obtain information equivalent to that obtained through traditional ordinary surveys.

5.3 Tests after Installation On Board

The control systems of low pressure gas-fuelled engines and related equipment are to be subjected to tests in accordance with the requirements of **18.7.3, Part D of the Rules** or the requirements of **2.2.4 of the Rules for Automatic and Remote Control Systems** according to the kind of Installations Character.

5.4 Sea Trials

1 Performance of control systems of high pressure gas-fuelled engines and related equipment is to be verified during operations using gas fuel depending upon their installation characters in accordance with the requirements of **2.2.5 of the Rules for Automatic and Remote Control Systems**: relevant requirements are to be applied mutatis mutandis.

2 Sea trials specified in **2.3.1, Part B** are to be carried out for operations using the oil fuel only. (In case of dual fuel engine) In addition, however, either the testing items as considered to be necessary by the Society are to be carried out to verify the control performance of engine operations using the gas fuel.

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

Part B CLASS SURVEYS

B1 GENERAL

B1.4 Preparation for Survey and Other Items

B1.4.2 Preparation for Surveys

Sub-paragraph -16 has been amended as follows.

16 The ~~following~~ preparations are to be made before carrying out the engine tests specified in **2.3.1-1(5), Part B of the Rules** ~~and~~ in accordance with **2.6.1-2(1), Part D of the Rules**~~:~~.

~~(1) All relevant equipment for the safety of attending personnel such as oil mist detection arrangements, overspeed protective devices and any other shut down functions are to be made available and are to be operational.~~

~~(2) The overspeed protective device is to be set to a value which is not higher than the allowable overspeed value. This set point is to be verified by the surveyor.~~

~~(3) The engines are to be run as prescribed by the engine manufacturer.~~

~~(4) All fluids used for testing purposes (fuel oils, lubrication oils, cooling water, etc., including all fluids used temporarily or repeatedly for testing purposes only) are to be suitable for their intended purposes (i.e., they are to be clean, preheated if necessary and cause no harm to engine parts).~~

B2 CLASSIFICATION SURVEYS

B2.3 Sea Trials and Stability Experiments

Paragraph B2.3.1 has been amended as follows.

B2.3.1 Sea Trials

1 The Speed test required by **2.3.1-1(1), Part B of the Rules** is to be carried out in accordance with (1) and (2) below.

(1) For ships that are to perform the speed test in full load condition, the ship speed defined in **2.1.8, Part A of the Rules** is to be confirmed. For ships that are unable to perform the speed test in full load condition, the ship speed at maximum continuous revolution of the main engine is to be confirmed. This speed is referred to as the "maximum speed of the ship" hereinafter.

(2) The ship speed at main engine outputs specified in **Table B2.3.1-5** (not including 110% and minimum revolutions) is also to be confirmed.

2 The Astern test required by **2.3.1-1(2), Part B of the Rules** is to be carried out in accordance with the following (1) to (3).

(1) It is to be confirmed that the machinery is functioning normally while the ship is running astern. The main engine is to be kept at a rate of more than 70% of the maximum continuous revolutions. The ship is to be kept running astern for the periods specified in (a) and (b) below corresponding to the type of engine and the performance is to be confirmed in accordance with **1.3.2, Part D of the Rules**.

(a) For ships with main engines other than steam turbines

Until the astern speed (rotational speed in rpm) stabilizes.

(b) For ships with steam turbines

A period of at least 15 *minutes*; the astern trial, however, is to be limited to 30 *minutes* or in accordance with manufacturer's recommendation to avoid overheating of the turbine due to the effects of "windage" and friction.

(2) For low pressure (i.e. pressure less than 1 *MPa*) gas-fuelled dual fuel engines, the confirmation specified in (1)(a) is to be carried out for all operating modes (i.e. the applicable gas mode, diesel mode, etc.). This test is to be carried out at the maximum power available in gas mode (*See* **2.5.1-1(1) in Annex 4, Part GF** or **2.5.1-1.(1) in Annex 4, Part N**).

(3) To high pressure gas-fuelled dual fuel engines, the requirements for low pressure gas-fuelled dual fuel engines specified in (2) apply mutatis mutandis.

3 The Steering test and change-over test from main to auxiliary steering gears required by **2.3.1-1(3), Part B of the Rules** are to be carried out in accordance with the following (1) through (10) in addition to **2.3.1-2, Part B of the Rules**. However, the tests required in (3), (6), (7), (8), (9) and (10) may be dispensed with where such tests have been carried out either at dockside or in dry dock.

(1) Running tests of the power units, including transfer between power units

(2) Isolation tests of one hydraulic actuating system including checking the time for regaining steering capability

(3) Tests of the hydraulic fluid recharging system

(4) Tests of the emergency power supply required by **15.2.6, Part D of the Rules**

(5) Operation tests of controls, including change-over between two control systems, change-over between the control system and the controller provided in the steering gear compartment, and change-over between automatic steering and manual steering

(6) Tests of the means of communication between the navigating bridge and the engine room, and between the engine room and the steering gear compartment

(7) Function tests of indicators for alarms, rudder angle indicator and power units required by **Chapter 15, Part D of the Rules**

(8) Function tests of indicators for power failure and overcurrent alarms, operating condition of electric motor, and relief valves for preventing overpressure

(9) Function tests of the rudder stoppers

(10) Where the steering gear is designed to avoid hydraulic locking, a demonstration of this feature

4 The performance tests of machinery installations required by **2.3.1-1(5), Part B of the Rules** are to include the following **(1)** to **(10)** in order to verify that the machinery installations have sufficient normal functions and reliability and are free from detrimental vibration within the numbers of revolutions used. However, these tests may be dispensed with where such tests have been conducted while the ship was anchored or at dockside. The details of these tests may be found in *JIS F* 0801 "Test Code of Propelling Machinery at Sea Trials" or other documents considered equivalent thereto. The preparations specified in **B1.4.2-16** are to be made before tests are carried out.

(1) For reciprocating internal combustion engines, the output test shown in **Table B2.3.1-5**, is to be used as the standard. For reciprocating internal combustion engines driving generators or auxiliary machinery (excluding auxiliary machinery for specific uses), operating tests may be carried out at the appropriate time after installation on board.

(2) For steam turbines and gas turbines used as main propulsion machinery, the output test is to be carried out at 3 or 4 levels of power output selected from normal continuous cruise power run and 4/4, 3/4, 2/4 and 1/4 of the maximum continuous output of the engine.

(3) Operating tests for starting devices

It is to be confirmed that the engines start continuously for the number required by **2.5.3-2** or **4.4.3-2, Part D of the Rules**.

(4) Function tests of the alarms and safety devices

Function tests of the alarms and safety devices required by **2.4**, **3.3** and **4.3, Part D of the Rules** are to be carried out.

(5) Fuel suitability

The suitability of residual and other special fuels for use in the engine is to be confirmed. However, this test may be dispensed with where the suitability has already been demonstrated at the shop trial.

(6) Governor tests

For reciprocating internal combustion engines driving main sources of electrical power (including reciprocating internal combustion engines driving generators for both propulsion and main power supply), the characteristics for governors specified in **2.4.1-5(1), Part D of the Rules** are to be confirmed.

(7) Function tests of the safety devices and alarms of boilers

(8) Function tests of the safety devices and alarms of exhaust gas economizers

(9) Low pressure (i.e. pressure less than 1 *MPa*) gas-fuelled engines are to comply with the requirements specified in **(1)** and **(6)**. For low pressure gas-fuelled dual-fuel engines, the output tests and governor tests are to be carried out for all operating modes (i.e. the gas mode, diesel mode, etc.). This test is to be carried out at the maximum power available in gas mode (*See* **2.5.1-1(1) in Annex 4, Part GF** or **2.5.1-1.(1) in Annex 4, Part N**). The 110% load test is not required for the gas mode.

(10) To high pressure gas-fuelled engines, the requirements for low pressure gas-fuelled engines specified in **(9)** apply mutatis mutandis.

5 With respect to **2.3.1-1(6), Part B of the Rules**, each windlass is to be tested in accordance with the following **(1)** to **(3)** under working conditions after installation on board in order to demonstrate satisfactory operation and confirm that their construction and associated equipment are in good condition.

(1) Operation test

Each unit is to be independently tested for (a) to (h) below:

(a) Braking

(b) Clutch functioning

(c) Lowering and hoisting of the chain cable and the anchor

(d) Proper riding of the chain cable over the cable lifter

(e) Proper transit of the chain cable through the hawse pipe and the chain pipe

(f) Effecting proper stowage of the chain cable and the anchor

(g) Proper seating of the anchors in the stored position

(h) Proper function of the chain cable stoppers if fitted

(2) Load test

Initially with 3 shots of chain cable (82.5 *m* or 45 *fathoms* in length) and the anchor submerged and hanging free, the test is to be carried out in accordance with the manner specified in (a) to (c) below. For (a) and (b), it is to be measured and verified that the mean hoisting speed is not less than 0.15 *m/s*. Where it is difficult to have 3 shots of chain cable kept submerged due to the ship's locale, an alternative test approved by the Society may be employed.

(a) Hoisting up 2 shots of chain cable on one side

(b) Hoisting up 2 shots of chain cable on the other side of (a)

(c) Hoisting up one shot of chain cable together on both sides

(3) Cable lifter brake capacity test

The braking capacity is to be tested by intermittently paying out and holding the chain cable by means of the application of the brake at every 1/2 shot of chain cable.

Table B2.3.1-5 Sea Trials of Reciprocating Internal Combustion Engines

Test items		Use of engines		
		Main engines of ships in which reciprocating internal combustion engines are used as main propulsion machinery (excluding electric propulsion ships) (1)	Reciprocating internal combustion engines driving generators (including main engines of electric propulsion ships) (2)	Reciprocating internal combustion engines driving auxiliaries (excluding auxiliary machinery for specific use etc.)
Load test	110% power run	—	10 *minutes* at n_0 (n_0 is the rated engine speed.) (3)	—
	100% power (rated power) run	4 *hours* at engine speed in accordance with propeller curve (4) (5) (6)	1 *hour* at n_0 (3)	30 *minutes* at n_0
Overspeed run		30 *minutes* at 1.032n_0 or more (7) (8)	—	—
Minimum revolution test of main engine (9)		○ (7)	—	—
Intermittent overload (10)		○		○

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, excluding propulsion engines for which intermittent overload is approved as well as propulsion engines also driving generators.

(2) The tests are to be performed based on the rated electrical powers of the driven generators.

(3) This may, if possible, be done during the electrical propulsion plant test, which is tested at 100% propulsion power (i.e., total electric motor capacity for propulsion) by distributing the power on as few generators as possible. The duration of this test is to be sufficient to reach the stable operating temperatures of all rotating machines or for at least 4 hours. When some of the generator set(s) cannot be tested due to insufficient time during the propulsion system test mentioned above, those required tests are to be carried out separately.

(4) In the case of controllable pitch propellers, the test is to be performed at rated engine speed n_0 at a propeller pitch leading to 100% power, or to the maximum achievable power if 100% power cannot be reached.

(5) In the case of propulsion engines also driving generators, tests are to be also carried out for 2 hours at 100% propeller branch power (unless already covered in the test at 100% power) and 1 hour with 100% power take off branch power at rated engine speed n_0 in addition to the test for 4 hours at 100% power.

(6) For ships in which the tests specified in **2.2.5-2(1), Rules for Automatic and Remote Control Systems** are performed for not less than 4 hours at 100% power, the 100% power test specified in this table may be omitted.

(7) Only for engines driving fixed pitch propellers.

(8) The test may be omitted if a 100% power test is performed at $1.032n_0$ or more. In cases where engine speed cannot reach the specified speed due to the planned propeller curve, etc., an overspeed test may be performed at maximum achievable continuous revolution (i.e., maximum engine speed within the range of torque limit, etc.).

(9) The test is to be carried out to identify the minimum working revolution of the main engine when the ship is steered to the maximum rudder angle.

(10) Only for engines for which intermittent overload is approved. The test is to be performed for the duration agreed upon with the manufacturer.

6 Function tests of the control systems for main propulsion machinery or controllable pitch propellers, boilers and electric generating sets required by **2.3.1-1(7), Part B of the Rules** are to be carried out in accordance with the following **(1)** to **(5)**. However, where these tests have been carried out when the ship was anchored or at dockside, some of these tests may be dispensed with at the sea trial.

(1) The control systems for main propulsion machinery and controllable pitch propellers are to be subjected to the following **(a)** to **(d)**.

(a) The main propulsion machinery or the controllable pitch propellers are to be subjected to starting tests, ahead-astern tests and running tests in the whole range of output, by means of the remote control devices in the main control station or the main control station on the bridge.

(b) In addition to output increase and decrease tests, the operation tests of the main propulsion machinery or the controllable pitch propellers using the bridge control devices are to be carried out. Where operation tests were carried out for the entire output range by the bridge control devices, consideration may be given to reduction of the test items with the exception of the starting test.

(c) Where there are two or more control stations for main propulsion machinery or controllable pitch propellers, the test on transfer of control is to be carried out while the ship is running ahead and when it is running astern. Where the remote devices for main propulsion machinery or controllable pitch propellers is in accordance with **18.3.2-2(3)(b), Part D of the Rules**, the above-mentioned test may be carried out while the main propulsion machinery is stopped.

(d) After completion of the test on transfer of control specified in **(c)**, a demonstration that the main propulsion machinery or the controllable pitch propellers can be smoothly operated from the respective control stations is to be conducted.

(2) Boilers

Function tests of the control systems for boilers are to be carried out in accordance with the following **(a)** to **(c)**.

(a) It is to be confirmed that devices such as for feed water control and combustion can operate stably in response to load variations of the main boilers, and the main boilers can supply steam stably to main propulsion machinery, electric generating sets and auxiliary machinery essential for main propulsion of the ship without local manual operation.

(b) With respect to essential auxiliary boilers, it is to be confirmed that they can supply steam stably to auxiliary machinery essential for main propulsion of the ship without manual operation.

(c) Where an exhaust gas economizer is used as a source of steam for driving a generator and the boiler supplies extra steam automatically during power loss, operation tests of the automatic control devices for this system are to be carried out.

(3) Electric Generation Sets

Where generators supply electrical power to the loads necessary for propulsion of the ship, their motive power is relying upon the propulsion systems, tests of functioning of the systems of automatic or remote control of electric generating sets are to be carried out.

(4) For the electric generating sets specified in **3.2.1-3, Part H of the Rules** the following items are to be confirmed while the main propulsion machinery is operating in normal continuous cruise output. However, in cases where the main propulsion machinery is operating at an output other than normal continuous cruising output, the tests may be carried out while main propulsion machinery is operating at said output on the condition that all active peripheral equipment are operating at outputs that are the same as the normal continuous cruising output of the main propulsion machinery.

(a) Where only one electric generating set is normally used, the standby generator, air circuit breakers, and important auxiliary machinery start up automatically when the main source of electrical power is stopped by tripping a circuit breaker

(b) Where two electric generating sets are normally used, preference tripping of unnecessary loads is performed and propulsion and steering of the ship are maintained, when the circuit breaker of one of the sets is tripped

(5) The "electric generating sets specified in **3.2.1-3, Part H of the Rules**" mentioned in (4) above, refer to the application of **6.2.11-1** and **-3, Part H of the Rules** for the ships specified in **6.1.1, Part H of the Rules**.

7 The accumulation tests of boilers required by **2.3.1-1(8), Part B of the Rules**, are to be carried out in accordance with the following (1) to (3).

(1) The accumulation test is to be conducted as specified in (a) and (b) below while the boiler is under the maximum firing condition. However, where data on the evaporation of the boiler submitted to the Society has been approved, the accumulation test specified in (a) may be dispensed with.

(a) When the safety valves of the boiler blow with all the stop valves closed, except for the valves for steam supply to machinery necessary to operate the boiler, the accumulation of pressure in the boiler drum is not to exceed 110% of the approved working pressure. However, the feed water necessary to maintain a safe water level may be supplied.

(b) For boilers with a superheater, where the accumulation test might overheat the superheater, the operation test of the means specified in **9.9.3-8, Part D** of the Rules may be carried out as an alternative after shutting off the main steam supply. In this case, the lift of each safety valve is to be checked beforehand.

(2) The accumulation test specified in (1) may be carried out at an appropriate time when the ship is anchored or at dockside.

(3) For boilers which are capable of refiring while using an exhaust gas economizer, in principle, the accumulation test is to be carried out in accordance with the methods specified in (1)(a) and (b) under the maximum firing condition and at the maximum continuous output of the main engine.

8 The measurements of the torsional vibration for shafting systems required by **2.3.1-1(9), Part B of the Rules** are to be carried out in accordance with the following (1) to (3).

(1) Measurements are to be carried out in accordance with the requirements of **8.1.3, Part D of the Rules**.

In cases where the confirmation of engine running conditions specified in **8.1.3-2, Part D of the Rules** is performed at the estimated upper and lower borders by calculation, it is

~~recommended that the fuel index around estimated borders also be confirmed with consideration given to possible differences between estimated borders and actual borders confirmed through measurements.~~

~~(2) For low pressure (i.e. pressure less than 1 *MPa*) gas-fuelled dual fuel engines, the measurements specified in (1) are to be carried out for both the diesel and gas mode. However, measurements in either diesel mode or in the gas mode (but not both modes) may be omitted where considered appropriate by the Society based upon relevant torsional vibration calculation sheets of diesel and gas mode.~~

~~(3) For high pressure gas-fuelled dual fuel engines, the requirements for low pressure gas-fuelled dual fuel engines specified in (2) apply mutatis mutandis.~~

~~**9** With respect to the measurement of the sound pressure levels of fixed fire detection and fire alarm systems specified in **2.3.1-1(10), Part B of the Rules**, the sound levels specified in **29.2.5-1(9), Part B of the Rules** are to be carried out by suitable instrument.~~

~~**10** "Verification of Total Harmonic Distortion (THD) calculation report" stipulated in **2.3.1-1(12), Part B of the Rules** refers to the measuring of the Total Harmonic Distortion (THD) value of the main busbar so as to confirm that said value does not exceed the acceptable limit given in the report.~~

~~**11**~~**1** "Tests where deemed necessary by the Society" in **2.3.1-1(13), Part B of the Rules**, refers to the tests and examinations mentioned in the following **(1)** to **(8)**.

(1) For ships having multiple propellers or multiple main engines, sea trials are to be carried out under the assumption that one propeller or engine is inoperable due to failure to confirm that the ship can be manoeuvred properly in that condition.

(2) For propulsion gears where the total face width (in case of double helical gears, the central gap is included) exceed 300 *mm* or where the ratio of the total face width to pitch circle diameter of the pinion exceeds 2, the contact marking of the teeth is to be verified by coating thinly and uniformly with suitable paint on the tooth flank.

(3) When the ship is provided with supplementary means for manoeuvring or stopping, performance tests of such means are to be carried out.

(4) Open-up inspection of cylinders may be required after sea trials when considered necessary by the Society.

(5) Sea trials for ships with electrical propulsion plants are to be carried out in accordance with the test procedures deemed appropriate by the Society. For the test of ship manoeuvrability, refer to the test procedures shown in **Annex 2.3.1-1**.

(6) In addition to the tests specified in ~~**B2.3.1-5**~~**2.3.1-1(5), Part B of the Rules**, the Society may require other tests found in *JIS F* 0801 "Test Code of Propelling Machinery at Sea Trials" or other documents considered equivalent thereto.

(7) For ships carrying liquefied gases in bulk, ships carrying dangerous chemicals in bulk and other ships whose length is not less than 100 *m*, sea trials to ascertain initial turning ability, yaw, and course keeping abilities are to be carried out. However, this test need not be carried out for ships whose manoeuvring characteristics are confirmed by sufficient data on the ship and test type, as well as information from sources such as the sea trials of sister ships and model tests. For other ships, this test is recommended.

(8) For ships having exhaust gas recirculation systems, running tests of engines are to be carried out with exhaust gas recirculation systems in operation, and the satisfactory operation of the engine and exhaust gas recirculation system is to be confirmed.

~~**12**~~**2** In applying **2.3.1-2(1), Part B of the Rules**, if the rudder cannot be fully submerged at even keel, the draught that the rudder is fully submerged (at zero speed waterline) in which the vessel is in an acceptable trim condition can be accepted.

~~**13**~~**3** In applying **2.3.1-2(3), Part B of the Rules**, the following **(1)** or **(2)** is to be applied. Alternatively, the designer or builder may use computational fluid dynamic (CFD) studies or

experimental investigations to predict the rudder stock moment (torque in the rudder stock) in the full load condition and at the service speed. These calculations or experimental investigations are to be verified by the Society.

(1) The rudder torque in the the full load condition and at the speed of ship defined in **2.1.8, Part A of the Rules** is to be predicted using the following extrapolation formula. There is, however, no need for extrapolation where A_T is greater than $0.95A_F$.

$Q_F = Q_T\alpha$

Q_F: the rudder stock moment (torque in the rudder stock) for the full load condition and the speed of ship defined in **2.1.8, Part A of the Rules**

Q_T: the rudder stock moment (torque in the rudder stock) for the trial condition

α : the extrapolation factor in accordance with the following formula:

$$\alpha = 1.25(\frac{A_F}{A_T})(\frac{V_F}{V_T})^2$$

A_F: the total immersed projected area of the movable part of the rudder in the full load condition

A_T: the total immersed projected area of the movable part of the rudder in the trial condition

V_F: the contractual design speed of the vessel corresponding to the maximum continuous revolutions of the main engine in the full load condition

V_T: the measured speed of the vessel (considering current) in the trial condition

(2) Where the rudder actuator system pressure is shown to have a linear relationship to the rudder stock torque, the above equation can be taken in accordance with the following formula. Where constant volume fixed displacement pumps are utilized, **15.2.2(1)** or **15.2.3(1), Part D of the Rules** can be deemed satisfied if the estimated steering actuator hydraulic pressure in the full load condition is less than the specified maximum working pressure of the rudder actuator. Where a variable delivery pump is utilized, pump data are to be supplied and interpreted to estimate the delivered flow rate corresponds to the full load condition in order to calculate the steering time and allow it to be compared to the required time.

$P_F = P_T\alpha$

P_F: the estimated steering actuator hydraulic pressure in the full load condition

P_T: the maximum measured actuator hydraulic pressure in the trial condition

~~**14**~~**4** "Otherwise stipulated by the Society" in **2.3.1-1(3), Part B of the Rules**, means following **(1)** and **(2)**. However, 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)** and **(2)** have been made after the previous tests and the Society deems it appropriate.

(1) For waterjet propulsion systems, the following tests are to be carried out. However, those tests required in **(c)** to **(g)** may be carried out either at dockside or in dry dock.

(a) Tests on steering capabilities specified in **19.5.1, Part D of the Rules**

(b) Tests on operation of controls for steering 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 **19.6.2, Part D of the Rules.**

(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 steering actuating systems

(g) Tests on the functioning of stoppers of reversers

(2) For azimuth thrusters, the following tests are to be carried out. However, those tests required in **(c)** to **(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 **20.5.1, Part D of the Rules**

(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 **20.6.2, Part D of the Rules**

(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

5 In applying **2.3.1-2(5), Part B of the Rules**, the details for such tests may be found in *JIS F* 0801 “Test Code of Propelling Machinery at Sea Trials” or other documents considered equivalent thereto.

Part D MACHINERY INSTALLATIONS

D1 GENERAL

D1.3 General Requirements for Machinery Installations

D1.3.1 General

Sub-paragraph -2 has been amended as follows.

2 The unconventional machinery referred to in **1.3.1-2, Part D of the Rules** is the machinery with novel design features (e.g. gas only engines) specified in **1.1.3, Part D of the Rules**.

D2 RECIPROCATING INTERNAL CONBUSTION ENGINES

D2.1 General

D2.1.1 General

Sub-paragraph -2 has been deleted.

~~**2** The wording "the requirements specified otherwise by the Society" in **2.1.1-6, Part D of the Rules** means **Annex 3 "GUIDANCE FOR HIGH PRESSURE DUAL FUEL ENGINES"** or **Annex 4 "GUIDANCE FOR LOW PRESSURE DUAL FUEL ENGINES"** of **Part N** for gas-fuelled engines to which **Chapter 16, Part N of the Rules** apply, and **Annex 3 "GUIDANCE FOR HIGH PRESSURE GAS-FUELLED ENGINES"** or **Annex 4 "GUIDANCE FOR LOW PRESSURE GAS-FUELLED ENGINES"** of **Part GF** for gas-fuelled engines to which **Chapter 16, Part N of the Rules** does not apply (**Part GF of the Rules** apply instead).~~

Paragraph D2.1.2 has been deleted.

~~**D2.1.2 Terminology**~~

~~The wording "the requirements specified otherwise by the Society" in **2.1.2-4, Part D of the Rules** means **1.4 of Annex 4, Part GF** or **1.4 of Annex 4, Part N**.~~

D2.6 Tests

Paragraph D2.6.1 has been amended as follows.

D2.6.1 Shop Tests

~~**1** The purpose of the shop trials specified in **2.6.1-2, Part D of the Rules** is to verify design premises such as engine power, safety against fire, adherence to approved limits such as maximum pressure, and functionality as well as to establish reference values or base lines for later reference in the operational phase. The programme is to be in accordance with the following:~~

~~(1) The preparations specified in **B1.4.2-16** are to be made before any tests are carried out.~~

~~(2) For all stages of testing, the following **(a)** to **(c)** ambient conditions are to be recorded and the pertaining operation values (normally the following **(d)** to **(k)** items) for each load point 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. Calibration records for the instrumentation are to be presented to the attending surveyor. 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.~~

~~(a) Ambient air temperature~~

~~(b) Ambient air pressure~~

~~(c) Atmospheric humidity~~

~~(d) Power~~

~~(e) Speed~~

~~(f) Fuel index (or equivalent reading)~~

~~(g) Maximum combustion pressures (only when the cylinder heads installed are designed for such measurement)~~

(h) Exhaust gas temperature at the turbine inlet and from each cylinder
(i) Charge air temperature
(j) Charge air pressure
(k) Turbocharger speed

(3) All measurements conducted at the various load points are to be carried out under steady operating conditions. However, provision is to be made for time needed by the surveyor to carry out visual inspections for all load points. The readings for 100 % power (rated power at rated speed) are to be taken twice at an interval of at least 30 *minutes*.

(4) 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.

(5) The programme shown in **Table D2.6.1-1** is to be used for the shop trials of reciprocating internal combustion engines. In this case, refer to the *JIS* specified below or those considered equivalent thereto for more details on each respective testing procedure. However, additional tests may be requested by the Society depending on the engine application, service experience, or other relevant reasons. In addition, alternatives to the detailed tests may be agreed between the manufacturer and the Society when the overall scope of tests is found to be equivalent.

(a) In the case of reciprocating internal combustion engines used as main propulsion machinery (including those used as main propulsion machinery for electric propulsion ships);
JIS F 4304 "Shipbuilding - Internal combustion engines for propelling use-shop test code"

(b) In the case of reciprocating internal combustion engines driving other generators or essential auxiliary machinery;
JIS F 4306 "Shipbuilding - Water cooled four-cycle generator diesel engines"

(6) The following **(a)** to **(c)** are to be inspected. However, a part of or all of these inspections may be postponed until shipboard testing when agreed to by the Society.

(a) Jacketing of high-pressure fuel oil lines, including the system used for the detection of leakage

(b) Screening of pipe connections in piping containing flammable liquids

(c) Temperature of hot surface insulation
Random temperature readings are to be compared with corresponding readings obtained during the type test. This is to be done while running at the rated power of engine. If the insulation is modified subsequently to the type test, the Society may request temperature measurements as required by the type test.
In the case of reciprocating internal combustion engine with an application for approval of use dated before 1 July 2016 which is an engine type that does not have the results of temperature measurements required by the type test, temperature measurements are to be performed in accordance with **8.4.2-2(10), Part 8 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

(7) Category *C* turbochargers installed on reciprocating internal combustion engines used as main propulsion machinery are to be checked for surge margins in accordance with the following. However, if successfully tested earlier on an identical configuration of the engine and turbocharger (including the same nozzle rings), submission of this test report may be accepted instead.

(a) For 4-stroke engines, the operations given in the following **i)** and **ii)** are to be performed without any indication of surging.

i) While at maximum continuous rating (maximum continuous power and speed), speed is to be reduced with the constant torque (fuel index) down to 90 % power.

ii) While at 50 % power and 80 % speed, speed is to be reduced to 72 % while keeping

~~constant torque (fuel index).~~

~~(b) For 2-stroke engines, the surge margin is to be demonstrated by at least one of the following i) to iii):~~

~~i) The engine working characteristics established at shop tests of the engine is to be plotted into the compressor chart of the turbocharger (established in a test rig). There is to be at least a 10 % surge margin in the full load range, i.e., working flow is to be 10 % above the theoretical mass flow at the surge limit where there are no pressure fluctuations.~~

~~ii) A sudden fuel cut-off to at least one cylinder at the following 1) and 2) loads is not to result in continuous surging and the turbocharger is to be stabilised at the new loads within 20 *seconds*. For applications with more than one turbocharger, the fuel supply to the cylinders closest upstream to each turbocharger is to be cut off.~~

~~1) The maximum power permitted for one cylinder misfiring.~~

~~2) The engine load corresponding to a charge air pressure of about 0.06 *MPa*, but without auxiliary blowers running.~~

~~iii) No continuous surging and the turbocharger is to be stabilised at the new load within 20 *seconds* when the power is abruptly reduced from 100 % to 50 % of the maximum continuous power.~~

~~**2** For low pressure gas-fuelled engines (specified in **4.2.2 of Annex 4, Part GF** or **5.2.2 of Annex 4, Part N**), the following requirements are to be complied with.~~

~~(1) The requirements specified in -**1(1)** to **(7)** apply subject to following **(2)** to **(5)** requirements.~~

~~(2) For dual fuel engines, the tests specified in **Table D2.6.1-1** are to be carried out for both diesel and gas mode. Tests for the gas mode are to be carried out based on the maximum power available in the gas mode (see **2.5.1-1(1) of Annex 4, Part GF** or **2.5.1-1(1) of Annex 4, Part N**). The 110 % load test is not required for the gas mode.~~

~~(3) In addition to the preparations specified in -**1(1)**, measures to verify that gas fuel piping for the engine is gas tight are to be carried out prior to the start-up of the engine.~~

~~(4) In addition to -**1(2)** and **(3)**, the following engine data are to be recorded.~~

~~(a) The item listed in -**1(2)(f)** is to be measured and recorded for both gas and diesel, as applicable~~

~~(b) Gas pressure and temperature~~

~~(5) The engines are to undergo integration tests to verify that the responses of the complete mechanical, hydraulic and electronic systems are as predicted for all intended operational modes. The scope of these tests is to be agreed to with the Society for selected cases based upon risk analysis (see **8.3, Chapter 8, Part 6 of Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**) and is to at least include the following incidents. The tests may be carried out using simulation or other alternative methods, subject to special consideration by the Society.~~

~~(a) Failure of ignition (spark ignition or pilot injection systems)~~

~~(b) Failure of a cylinder gas supply valve~~

~~(c) Failure of combustion (to be detected by e.g. misfiring, knocking, exhaust temperature deviation, etc.)~~

~~(d) Abnormal gas pressure~~

~~(e) Abnormal gas temperature~~

~~**3** To shop trials of the high pressure gas-fuelled engines specified in **4.2.2 of Annex 3, Part GF** or **5.2.2 of Annex 3, Part N**, the requirements for the shop trials of low pressure gas-fuelled engines specified in -**2** apply mutatis mutandis.~~

~~**4** The wording "a procedure deemed appropriate by the Society" in **2.6.1-3, Part D of the Rules** means the tests specified in **Chapter 8, Part 6 of the Guidance for the Approval and Type**~~

~~**Approval of Materials and Equipment for Marine Use.**~~

1 The wording "a procedure deemed appropriate by the Society" **in 2.6.1-2(6)(c), Part D of the Rules** means the tests specified in **8.5.2-2(10), Part 6 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use.**

2 The wording "a procedure deemed appropriate by the Society" **in 2.6.1-3(5), Part D of the Rules** means the tests specified in **8.3, Part 6 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use.**

~~**5**~~**3** In cases where the manufacturer has a quality system deemed appropriate by the Society, dynamic balancing tests specified in **2.6.1-~~4~~6, Part D of the Rules** for category *B* turbochargers may be substituted by manufacturer tests. In such cases, the submission or presentation of test records may be required by the Society.

~~**6**~~**4** In cases where the manufacturer has a quality system deemed appropriate by the Society, the overspeed tests specified in **2.6.1-~~5~~7, Part D of the Rules** for categories *B* turbochargers may be substituted for by manufacturer tests. In such cases, the submission or presentation of test records may be required by the Society.

~~**7**~~**5** The wording "a procedure deemed appropriate by the Society" in **2.6.1-~~6~~8, Part D of the Rules** means the tests specified in **Chapter 11, Part 6 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

Table D2.6.1-1 has been deleted.

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

Test items		Use of engines		
		Reciprocating internal combustion engines used as main propulsion machinery(1)	Reciprocating internal combustion engines driving generators (including those used as main propulsion machinery of electric propulsion ships) (2)	Reciprocating internal combustion engines driving auxiliaries (excluding auxiliary machinery for specific use etc.) (1)
Load test	110 % power run	15 *minutes* or until steady conditions have been reached, which is shorter, at 1.032 n_0 (n_0 is the rated engine speed) or more.(3), (4)	15 *minutes* after having reached steady conditions at n_0	15 *minutes* after having reached steady conditions at n_0
	100 % power run	60 *minutes* at n_0	60 *minutes* at n_0	30 *minutes* at n_0
	90 % power run (or normal continuous cruise power) (5), (6)	30 *minutes* at engine speed in accordance with nominal propeller curve	—	—
	75% power (5), (6)		30 *minutes* at n_0	30 *minutes* in accordance with the nominal power consumption curve (7)
	50% power (5), (6)			
	25% power (5), (6)			
Idle run (5)		—	An adequate time at n_0	—
Reversing manoeuvres (8)		o	—	—
Intermittent overload (9)		o	—	o
Governor test		—	o	—
Performance of monitoring, alarm and safety devices		o	o	o
Open-up inspection		o	o	o

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, unless intermittent overload power is approved by the Society. In the case of propulsion engines also driving power take-off generators, the fuel delivery system is to be adjusted so that overload of generator (110 % power) can be given in service and the electrical protection of downstream system components is activated before the engine stalls.

(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) Submission of a test report for identical engine and turbocharger configuration proving their compatibility for overloaded operation may be accepted as substitutions for the 110 % power run.

(4) In the case of propulsion engines also driving power take-off generators, the test is to be carried out at n_0 for 15 *minutes* after having reached a steady operating condition.

(5) The sequence is to be selected by the engine manufacturer.

(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) Only for variable speed engines.

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

(9) Only for engines for which intermittent overload is approved. The test is to be performed for the duration agreed upon with the manufacturer.

Part GF SHIPS USING LOW-FLASHPOINT FUELS

GF1 GENERAL

GF1.1 General

Paragraph GF1.1.3 has been amended as follows.

GF1.1.3 Approval of Systems and Equipment, etc.

1 The wording "to be approved as specified separately by the Society" specified in **1.1.3-1, Part GF of the Rules** means that an approval is to be obtained in accordance with **Annexes 1** to **4**.

2 In applying **1.1.3, Part GF of the Rules, Annex 1.1.3-2, Part GF of the Rules** is to be dealt with as follows:

(1) The wording "specified separately by the Society" specified in **2.4.3-5, Annex 1.1.3-2, Part GF of the Rules** refers to **Annex 1 "Guidance for Equipment and Fittings of Ships Using Low-flashpoint Fuels"**.

(2) The wording "specified separately by the Society" specified in **4.1, Annex 1.1.3-2, Part GF of the Rules** refers to **Chapter 8, Part 6 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

3 In applying **1.1.3, Part GF of the Rules, Annex 1.1.3-3, Part GF of the Rules** is to be dealt with as follows:

(1) The wording "specified separately by the Society" specified in **1.1-3, Annex 1.1.3-3, Part GF of the Rules** refers to **8.3(4)(i), Chapter 8, Part 6 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

(2) The wording "specified separately by the Society" specified in **2.4.4-4, Annex 1.1.3-3, Part GF of the Rules** refers to **Annex 1 "Guidance for Equipment and Fittings of Ships Using Low-flashpoint Fuels"**.

(3) The wording "specified separately by the Society" specified in **2.4.4-5(4)(a)ii), Annex 1.1.3-3, Part GF of the Rules** refers to **GF9.6.2, Part GF of the Guidance**.

(4) The wording "deemed appropriate by the Society" specified in **2.5.3** and **3.1-8, Annex 1.1.3-3, Part GF of the Rules** refers to **8.3, Chapter 8, Part 6 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

(5) The wording "specified separately by the Society" specified in **4.1, Annex 1.1.3-3, Part GF of the Rules** refers to **Chapter 8, Part 6 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

Annex 3 has been deleted.

~~**Annex 3 GUIDANCE FOR HIGH PRESSURE GAS-FUELLED ENGINES**~~

~~**(Omitted)**~~

Annex 4 has been deleted.

~~**Annex 4 GUIDANCE FOR LOW PRESSURE GAS-FUELLED ENGINES**~~

~~**(Omitted)**~~

Part N SHIPS CARRYING LIQUEFIED GASES IN BULK

N16 USE OF CARGO AS FUEL

N16.1 General

Paragraph N16.1.1 has been amended as follows.

N16.1.1 General

1 The requirements for gas fuel engines, gas fuel boilers and gas combustion units are to be in accordance with **Annex ~~3 "GUIDANCE FOR HIGH PRESSURE DUAL FUEL ENGINES"~~16.1.1-2, Part N of the Rules** or **Annex ~~4 "GUIDANCE FOR LOW PRESSURE DUAL FUEL ENGINES"~~16.1.1-3, Part N of the Rules**, **Annex 2 "G~~UIDANCE~~uidance ~~FOR~~for D~~UAL~~ual F~~UEL~~uel B~~OILERS~~oilers**" and **Annex 2A "G~~UIDANCE~~uidance ~~FOR~~for G~~AS~~as C~~OMBUSTION~~ombustion U~~NITS~~nits**" respectively. In addition, gas fuel turbines are to be as deemed appropriate by the Society.

2 Notwithstanding the requirements **-1** above, if other cargo gases are used as fuel in accordance with **16.9.1, Part N of the Rules**, gas fuel boilers, gas combustion units, gas fuel reciprocating internal combustion engines and gas turbines are to be approved by the Administration.

3 In applying **16.1.1, Part N of the Rules**, **Annex 16.1.1-2, Part N of the Rules** is to be dealt with as follows:

(1) The wording "specified separately by the Society" specified in **3.1.1-2, Annex 16.1.1-2, Part N of the Rules** refers to **Chapter 2** to **Chapter 4 of Annex 1 "Guidance for Equipment and Fittings of Ships Using Low-flashpoint Fuels".**

(2) The wording "requirements specified separately by the Society" and "tests specified separately by the Society" specified in **3.2.2-3, Annex 16.1.1-2, Part N of the Rules** mean to be in accordance with the following **(a)** and **(b)** respectively:

(a) The wording "requirements specified separately by the Society" refers to **Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use.**

(b) The wording "tests specified separately by the Society" refers to **Chapter 5** and **Chapter 7 of Annex 1, "Guidance for Equipment and Fittings of Ships Carrying Liquified Gases in Bulk".**

(3) The wording "specified separately by the Society" specified in **4.3(1)(a), Annex 16.1.1-2, Part N of the Rules** refers to **2.4.3 of Annex 1, "Guidance for Equipment and Fittings of Ships Carrying Liquified Gases in Bulk".**

(4) The wording "specified separately by the Society" specified in **4.3(2), Annex 16.1.1-2, Part N of the Rules** refers to **2.4.3 of Annex 1, "Guidance for Equipment and Fittings of Ships Carrying Liquified Gases in Bulk".**

(5) The wording "specified separately by the Society" specified in **5.1, Annex 16.1.1-2, Part N of the Rules** refers to **Chapter 8, Part 6 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use.**

4 In applying **16.1.1, Part N of the Rules**, **Annex 16.1.1-3, Part N of the Rules** is to be dealt with as follows:

(1) The wording "specified separately by the Society" specified in **1.1-3, Annex 16.1.1-3, Part N of the Rules** refers to **8.3(4)(i), Chapter 8, Part 6 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use.**

(2) The wording "deemed appropriate by the Society" specified in **2.5.3, Annex 16.1.1-3, Part N of the Rules** refers to **8.3, Chapter 8, Part 6 of the Guidance for the Approval and Type**

Approval of Materials and Equipment for Marine Use.

(3) The wording "specified separately by the Society" specified in **3.1.1-2, Annex 16.1.1-3, Part N of the Rules** refers to **Chapter 2** to **Chapter 4 of Annex 1 "Guidance for Equipment and Fittings of Ships Using Low-flashpoint Fuels".**

(4) The wording "deemed appropriate by the Society" specified in **4.1-9, Annex 16.1.1-3, Part N of the Rules** refers to **8.3, Chapter 8, Part 6 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use.**

(5) The wording "specified separately by the Society" specified in **4.3(1), Annex 16.1.1-3, Part N of the Rules** refers to **2.4.2 of Annex 1, "Guidance for Equipment and Fittings of Ships Carrying Liquified Gases in Bulk".**

(6) The wording "specified separately by the Society" specified in **4.3(2), Annex 16.1.1-3, Part N of the Rules** refers to **2.4.3 of Annex 1, "Guidance for Equipment and Fittings of Ships Carrying Liquified Gases in Bulk".**

Annex 3 has been deleted.

~~**Annex 3　　GUIDANCE FOR HIGH PRESSURE DUAL FUEL ENGINES**~~

~~**(Omitted)**~~

Annex 4 has been deleted.

~~**Annex 4　　GUIDANCE FOR LOW PRESSURE DUAL FUEL ENGINES**~~

~~**(Omitted)**~~

"Guidance for high speed craft" has been partly amended as follows:

Part 9 MACHINERY INSTALLATIONS

Chapter 2 RECIPROCATING INTERNAL COMBUSTION ENGINES

2.1 General

2.1.1 General*

Sub-paragraph -2 has been amended as follows.

2 The wording "the requirements specified otherwise by the Society" in **2.1.1-5, Part 9 of the Rules** means **Annex ~~3~~1.1.3-2 ~~"GUIDANCE FOR HIGH PRESSURE GAS-FUELLED ENGINES"~~** or **Annex ~~4~~1.1.3-3 ~~"GUIDANCE FOR LOW PRESSURE GAS-FUELLED ENGINES" of~~, Part GF of the Rules for the Survey and Construction of Steel Ships**.

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

Part 2 CLASS SURVEYS

Chapter 2 CLASSIFICATION SURVEYS

2.3 River Trials and Stability Experiments

2.3.1 River Trials

Sub-paragraph -1 has been amended as follows.

1 The Astern test required by **2.3.1-1(1), Part 2 of the Rules** is to be carried out in accordance with the following **(1)** to **(4)** below.
((1) and (2) are omitted.)
(3) For low pressure gas-fuelled dual fuel engines, the confirmation specified in **(2)** is to be carried out for all operating modes (gas mode, diesel mode, etc.). This test is to be carried out at the maximum power available in gas mode (*See* **2.5.1-1(1) in Annex ~~4~~1.1.3-3, Part GF** or **2.5.1-1(1) in Annex ~~4~~16.1.1-3, Part N of the ~~Guidance~~Rules for the Survey and Construction of Steel Ships**).
(4) To high pressure gas-fuelled dual fuel engines, the requirements for low pressure gas-fuelled dual fuel engines specified in **(3)** apply mutatis mutandis.

Sub-paragraph -3 has been amended as follows.

3 The performance tests of machinery installations required by **2.3.1-1(3), Part 2 of the Rules** are to include the following **(1)** to **(9)** in order to verify that the machinery installations have sufficient normal functions and reliability and are free from detrimental vibration within the numbers of revolutions used. However, these tests may be dispensed with where such tests have been conducted while the ship was anchored or at dockside. The details of these tests may be found in *JIS F* 0801 "Test Code of Propelling Machinery at Sea Trials" or other documents considered equivalent thereto. The preparations specified in **1.4.2-8** are to be made before tests are carried out.
((1) to (7) are omitted.)
(8) Low pressure (i.e. pressure less than 1 *MPa*) gas-fuelled engines are to comply with the requirements specified in **(1)** and **(5)**. For low pressure gas-fuelled dual-fuel engines, the output tests and governor tests are to be carried out for all operating modes (i.e. the gas mode, diesel mode, etc.). This test is to be carried out at the maximum power available in gas mode (*See* **2.5.1-1(1) in Annex ~~4~~1.1.3-3, Part GF** or **2.5.1-1(1) in Annex ~~4~~16.1.1-3, Part N of the ~~Guidance~~Rules for the Survey and Construction of the Steel Ships**). The 110% load test is not required for the gas mode.
(9) For high pressure gas-fuelled dual fuel engines, the requirements for low pressure gas-fuelled dual fuel engines specified in **(8)** apply mutatis mutandis.

Part 7 MACHINERY INSTALLATIONS

Chapter 2 RECIPROCATING INTERNAL COMBUSTION ENGINES

2.1 General

2.1.1 General

Sub-paragraph -2 has been amended as follows.

2 The wording "the requirements specified otherwise by the Society" in **2.1.1-5, Part 7 of the Rules** means **Annex ~~3~~16.1.1-2 ~~"GUIDANCE FOR HIGH PRESSURE DUAL FUEL ENGINES"~~** or **Annex ~~4~~16.1.1-3 ~~"GUIDANCE FOR LOW PRESSURE DUAL FUEL ENGINES"~~** of **Part N of the Rules for the Survey and Construction of Steel Ships** for gas-fuelled engines to which **Chapter 16, Part N of the Rules** apply, and **Annex ~~3~~1.1.3-2 ~~"GUIDANCE FOR HIGH PRESSURE GAS-FUELLED ENGINES"~~** or **Annex ~~4~~1.1.3-3 ~~"GUIDANCE FOR LOW PRESSURE GAS-FUELLED ENGINES"~~** of **Part GF of the Rules for the Survey and Construction of Steel Ships** for gas-fuelled engines to which **Chapter 16, Part N of the Rules** does not apply (**Part GF of the Rules** apply instead).

"Guidance for the approval and type approval of materials and equipment for marine use" has been partly amended as follows:

Part 6 MACHINERY

Chapter 8 APPROVAL OF USE OF RECIPROCATING INTERNAL COMBUSTION ENGINES

8.1 General

Paragraph 8.1.1 has been amended as follows.

8.1.1 General

1 The requirements in this chapter apply to the approval of use for the following **(1)** and **(2)**. In addition, requirements for low pressure gas-fuelled engines in this Chapter apply mutatis mutandis to the approval of use of high pressure gas fuelled engines (as required by **3.1 of Annex ~~3~~1.1.3-2, Part GF** or **4.1 of Annex ~~3~~16.1.1-2, Part N of the ~~Guidance~~Rules for the Survey and Construction of Steel Ships**).

(1) Approval of use of reciprocating internal combustion engines as required by **2.1.1-3** and **2.6.1-3, Part D of the Rules for the Survey and Construction of Steel Ships**, **2.1.1-2, Part 7 of the Rules for High Speed Craft** as well as **2.1.1-2** and **2.6.1-3, Part 7 of the Rules for the Survey and Construction of Inland Waterway Ships**; and

(2) Approval of use of low pressure gas-fuelled engines as required by **4.1 of Annex ~~4~~1.1.3-3, Part GF** or **5.1 of Annex ~~4~~16.1.1-3, Part N of the ~~Guidance~~Rules for the Survey and Construction of Steel Ships**.

8.1.2 Terminology

Sub-paragraph -5 has been amended as follows.

5 For low pressure gas-fuelled engines, the terminology is as specified in the **1.4 of Annex ~~4~~1.1.3-3, Part GF** or **1.4 of Annex ~~4~~16.1.1-3, Part N of the ~~Guidance~~Rules for the Survey and Construction of Steel Ships**.

8.5 Approval Tests

8.5.1 Test Stages

Sub-paragraph -6 has been amended as follows.

6 For low pressure gas-fuelled engines, the following are also to be applied.

(1) For dual fuel engines, the load tests specified in **8.5.2-1(1)** and **8.5.2-2(2)** are to be carried out in gas mode at the different percentages of the maximum power available in gas mode (see **2.5.1-1(1) of Annex ~~4~~16.1.1-3, Part N** or **2.5.1-1(1) of Annex ~~4~~1.1.3-3, Part GF of the ~~Guidance~~Rules for the Survey and Construction of Steel Ships**). The 110% load tests are not required in the gas mode.

((2) and (3) are omitted)

8.5.2 Details of Tests

Sub-paragraph -2 has been amended as follows.

2 During the stage *B*, the following items of tests are to be included. Deviations from the items, if any, are to be agreed with the Society.
((1) to (10) are omitted)
(11) For low pressure gas-fuelled engines, the following **(a)** to **(i)** are also to be applied.
((a) to (h) are omitted.)
(i) For gas only and pre-mixed engines which may be used as engines driving generator sets, the influences of *LHV*, methane number and ambient conditions on the governor test results are to be theoretically determined and specified in the test report. Referring to the limitations specified in **2.1-5(1)** and **(2) of Annex ~~4~~16.1.1-3, Part N** or **2.1-5(1)** and **(2) of Annex ~~4~~1.1.3-3, Part GF of the ~~Guidance~~Rules for the Survey and Construction of Steel Ships**, the margin for satisfying characteristics of governors are to be determined.
(12) Other test items deemed necessary by the Society