Review of the Organization of the Society's Rules for Machinery (Electronically-controlled Engines)

Amended Rules and Guidance

Rules for the Survey and Construction of Steel Ships Part D
Rules for High Speed Craft
Rules for the Survey and Construction of Inland Waterway Ships
Guidance for the Survey and Construction of Steel Ships Part D
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

ClassNK typically specifies requirements for relatively new equipment with insufficiently established service histories in annexes to the ClassNK Guidance instead of as formal requirements in the ClassNK Rules so as to allow some flexibility in the use and installation of such equipment. For this reason, detailed requirements for electronically-controlled engines were originally specified in Annex D2.1.1, Part D of the Guidance back in 2004. Since that time, however, the reliability of such engines and the effectiveness of the Society's requirements for them has been more than sufficiently established.

With this is mind and as part of an ongoing comprehensive review of the organization of requirements for machinery, the Society decided to transfer the requirements of the annex to the Part D of the Rules.

Accordingly, relevant requirements were amended so as to transfer the requirements in Annex D2.1.1 to Part D of the Rules. This is being done as part of a comprehensive review of the ClassNK Rules.

Outline of Amendment

Transfered the requirements for electronically-controlled engines from the annexes of Part D of Guidance for the Survey and Construction of Steel Ships to Chapter 2 of Part D of the Rules for the Survey and Construction of Steel Ships.

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

Part D MACHINERY INSTALLATIONS

Chapter 2 RECIPROCATING INTERNAL COMBUSTION ENGINES

2.1 General

2.1.1 General*

Sub-paragraph -4 has been deleted.

~~**4** Electronically-controlled engines which are used as the main propulsion machinery are to be in accordance with the requirements specified otherwise by the Society in addition to those in this Chapter.~~

2.1.2 Terminology*

Sub-paragraph -3 has been renumbered to Sub-paragraph -4, and Sub-paragraph -3 has been added as follows.

3 For electronically-controlled engines, the terminology is as specified in the following **(1)** to **(10)**:

(1) "Electronically-controlled engines" are engines whose fuel injection and/or Exhaust valve operation etc. are electronically controlled.

(2) "Accumulators" are small pressure vessels fitted to cylinders which provide hydraulic oil to those actuators attached to fuel injection devices or exhaust valve driving gears.

(3) "Common accumulators" are pressure vessels common to all cylinders for providing hydraulic oil or pressurized fuel oil.

(4) "Control valves" are components to control the delivery of hydraulic oil to drive actuators. The name control valve is generic for on-off-controlled solenoid valves, proportional-controlled valves or variable-controlled valves, etc.

(5) "Fuel oil pressure pumps" are pumps which provide pressurized fuel oil for common accumulators.

(6) "Hydraulic oil pressure pumps" are pumps to provide hydraulic oil for equipment, e.g. fuel injection devices, exhaust valve driving gears or control valves, through common accumulators.

(7) "Functional blocks" are blocks used to classify by function all items making up whole systems into the groups of systems, sub-systems, components, assemblies and parts.

(8) "Reliability block diagrams" are logical figures showing the relationship between functional blocks on an analytic level.

(9) "Normal operation" of main propulsion machinery means those operations at normal out-put conditions, using governors and all safety devices.

(10) "High-pressure" piping means piping in the down-stream of fuel oil pressure pumps or hydraulic oil pressure pumps.

~~**3**~~**4** For low pressure gas-fuelled engines, the terminology is in accordance with the requirements

specified otherwise by the Society.

2.2 Materials, Construction and Strength

2.2.2 Construction, Installation and General*

Sub-paragraph -8 has been added as follows.

8 Essential components are to be so arranged that normal operation of main propulsion machinery is capable of being sustained or restored even though one of these components becomes inoperable, except in cases where special consideration and approval is given by the Society to the reliability of single arrangements. Single components provided for cylinders, which do not require a spare, may be acceptable in cases where any failed parts can be isolated.

2.5 Associated Installations

Paragraphs 2.5.7 to 2.5.11 have been added as follows.

2.5.7 Control Valves for Electronically-controlled Engines which are used as the Main Propulsion Machinery

1 Control valves are to be capable of retaining their expected ability to function properly for a period of time set by manufacturers.

2 Control valves are to be independently provided for each function (e.g. fuel injection, exhaust valve driving).

3 Means are to be provided to prevent fuel oil from continuously flowing into cylinders due to control valve failure.

2.5.8 Accumulators and Common Accumulators for Electronically-controlled Engines which are used as the Main Propulsion Machinery

1 Accumulators and common accumulators are to comply with the requirements in **Chapter 10**. However, notwithstanding this requirement, materials and non-destructive tests as well as surface inspections and dimension inspections are to be in accordance with **Table D2.1** and hydrostatic tests are to be in accordance with **Table D2.6**.

2 Accumulators are to be capable of retaining their expected ability to function properly for a period of time set by manufacturers.

3 In principle, at least two common accumulators are to be provided. However, in cases where results of fatigue analysis upon fluctuating stress are submitted and approved by the Society, a single arrangement may be acceptable.

2.5.9 Fuel Oil Piping Systems and Hydraulic Oil Piping Systems for Electronically-controlled Engines which are used as the Main Propulsion Machinery

1 At least two fuel oil pressure pumps and hydraulic oil pressure pumps are to be provided for their respective lines and are to be capable of supplying a sufficient amount of oil at the maximum continuous output of main propulsion machinery. In such cases, even though a single one of these pumps may become inoperable, the remaining pumps are to be capable of supplying a sufficient amount of fuel under normal service conditions. In cases where one or more of these pumps are provided as a stand-by pump, the pumps are to always be connected and ready for use.

2 Piping arrangements from fuel oil pressure pumps to the fuel injection devices and from hydraulic oil pressure pumps to exhaust valve driving gears are to be protected with jacketed piping

systems or oil tight enclosures, to prevent any spread of oil from igniting.

3 Two common piping arrangements from fuel oil pressure pumps or a hydraulic oil pressure pumps to common accumulators, from one common accumulator to another common accumulator and from common accumulators to those positions where distribution to cylinders are to be respectively provided. In cases where results of fatigue analysis upon fluctuating stress are submitted and approved by the Society, a single arrangement may be acceptable.

4 Valves or cocks provided on piping connected to equipment, e.g. accumulators or pumps, are to be located as close to such equipment as practicable.

5 In high-pressure piping, high-pressure alarms are to be provided. Relief valves are also to be provided at proper positions, so as to lead any released oil to lower-pressure sides.

6 In cases where pressure gauges using bourdon-tubes are provided in high-pressure piping, such gauges are to be ones that comply with recognized industrial standards, e.g. *JIS*, and be vibration-proof and heat-resistant types.

2.5.10 Electronic Control Systems for Electronically-controlled Engines which are used as the Main Propulsion Machinery

1 Systems are to be so arranged that the function of an entire system is capable of being sustained or restored in cases where there is a single failure in any equipment part or circuit.

2 Controllers for systems are to comply with the following:

(1) At least two main controllers which are integrated to control every function, e.g. fuel injection, exhaust valve drive, cylinder lubrication and supercharge, are to be provided.

(2) Notwithstanding the requirement in **(1)** above, a single main controller may be acceptable, in cases where normal operation of main propulsion machinery is available by using control systems independent from main controllers.

3 At least two sensors essential for the operation of main propulsion machinery, e.g. for the following uses, are to be independently provided. In cases where normal operation of main propulsion machinery is available without any feedback from such sensors, single arrangements may be acceptable.

(1) Number of revolutions

(2) Crank angles

(3) Fuel pressure in common accumulators

4 Power for control systems is to be supplied from two independent sources, one of which is to be supplied from a battery, and through two independent circuits.

5 Power for driving solenoid valves is to be supplied from two independent sources, and through two independent circuits.

6 Electronic-control systems of main propulsion machinery which comply with the requirements given in **-1** through **-5** above are regarded as the same as those which comply with the following requirements.

(1) **18.2.4-5(1)**

(2) **18.3.2-3(3)**

2.5.11 Failure Mode Effect Analysis for Electronically-controlled Engines which are used as the Main Propulsion Machinery

Failure Mode Effect Analysis (FMEA) is to be carried out, for electronic control systems, in order to confirm that any one equipment or circuits in such systems which lose function may not cause any malfunction or deterioration in other equipment or circuits, in accordance with the following:

(1) Systems are to be divided into functional blocks and drawn out in reliability block diagrams in which such functional blocks are systematically organized.

(2) Analytic levels are to be sufficient up to the extent of those functional blocks regarding

sub-systems and components.

(3) FMEA results are to be created in table form as shown in **Table D2.6** or be of equivalent forms thereto.

(4) If FMEA results show that corrective action is demanded, then FMEA is to be carried out again after the corrective action to confirm the effectiveness of the corrective action.

(5) For failure modes, every possible failure from minor to catastrophic is to be considered.

Table D2.6 has been renumbered to Table D2.7, and Table D2.6 has been added as follows.

Table D2.6 Failure Mode Effect Analysis Table for Electronically-controlled Engines which are used as the Main Propulsion Machinery

Systems					Elements								
ID Number	Component	Sub-system	Operating mode	Failure mode	Failure cause	Failure detection Means	Alarm / Notification Means	Effect of failure: On component	Effect of failure: On sub-system	Effect of failure: On system	Failure severity	Corrective action	Remarks

Examples of Operating Mode: ack-up operations, fuel cost priority operations, NOx reduction operations, etc.

Examples of Failure Mode: piston pin stuck, connecting rod broken, lubricating oil leaked out, etc. (Failed parts are to be shown.)

Failure Severity:
(a) Catastrophic: loss of complete function, explosion, loss of life (Design change is to be compulsory.)
(b) Major: loss or deterioration of part of the ability to function properly (Possible design change is to be investigated.)
(c) Minor: negligible affect on ability to function properly (Design change may not be required.)

2.6 Tests

2.6.1 Shop Tests*

Sub-paragraph -1 has been amended as follows.

1 For components or accessories specified in **Table D2.~~6~~7**, hydrostatic tests are to be carried out on the water or oil side of the component at the pressures shown in the Table. In cases deemed necessary by the Society, tests may also be required for any components not specified in **Table D2.~~6~~7**.

Table D2.~~6~~7 Hydrostatic Test Pressure

(Table is omitted.)

Chapter 24 SPARE PARTS, TOOLS AND INSTRUMENTS

Table D24.1 has been amended as follows.

Table D24.1 Spare Parts for Reciprocating Internal Combustion Engines Used as Main Propulsion Machinery

Item	Spare parts	Number required
Main bearings Cylinder liner Cylinder cover Cylinder valves Connecting rod bearings Pistons Piston rings Pistons cooling devices Chain for camshaft drives Cylinder lubricator Fuel injection pumps Fuel injection piping Scavenge blowers (including turbo chargers) Scavenging system Reduction and or reversing gear Gaskets and packings	(Omitted)	(Omitted)
Parts for electronically-controlled engines	Control valves	1 of each type
	Accumulator diaphragms	2 of each type
	Sensors provided for each cylinder *Note: Spare parts may be omitted in cases where normal operation of main propulsion machinery is available without these sensors.	1 of each type*

Note:
The spare parts for scavenge blowers (including turbo chargers) may be omitted where it has been demonstrated, at the builder's test bench, for one engine of the type concerned, that the engine can be manoeuvred satisfactorily with one blower out of action. However, in this case the requisite blanking and blocking arrangements for running with one blower out of action are to be available on board.

“Rules 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 -3 has been deleted.

~~**3** Electronically-controlled engines which are used as the main propulsion machinery are to be in accordance with the requirements specified otherwise by the Society in addition to those in this Chapter.~~

2.1.2 Terminology

Sub-paragraph -3 has been added as follows.

3 For electronically-controlled engines, the terminology is as specified in the following **(1)** to **(10)**:

(1) “Electronically-controlled engines” are engines whose fuel injection and/or Exhaust valve operation etc. are electronically controlled.

(2) “Accumulators” are small pressure vessels fitted to cylinders which provide hydraulic oil to those actuators attached to fuel injection devices or exhaust valve driving gears.

(3) “Common accumulators” are pressure vessels common to all cylinders for providing hydraulic oil or pressurized fuel oil.

(4) “Control valves” are components to control the delivery of hydraulic oil to drive actuators. The name control valve is generic for on-off-controlled solenoid valves, proportional-controlled valves or variable-controlled valves, etc.

(5) “Fuel oil pressure pumps” are pumps which provide pressurized fuel oil for common accumulators.

(6) “Hydraulic oil pressure pumps” are pumps to provide hydraulic oil for equipment, e.g. fuel injection devices, exhaust valve driving gears or control valves, through common accumulators.

(7) “Functional blocks” are blocks used to classify by function all items making up whole systems into the groups of systems, sub-systems, components, assemblies and parts.

(8) “Reliability block diagrams” are logical figures showing the relationship between functional blocks on an analytic level.

(9) “Normal operation” of main propulsion machinery means those operations at normal out-put conditions, using governors and all safety devices.

(10) “High-pressure” piping means piping in the down-stream of fuel oil pressure pumps or hydraulic oil pressure pumps.

2.1.5 Materials, Construction and Strength*

Sub-paragraph -7 has been added as follows.

7 Essential components are to be so arranged that normal operation of main propulsion machinery is capable of being sustained or restored even though one of these components becomes inoperable, except in cases where special consideration and approval is given by the Society to the reliability of single arrangements. Single components provided for cylinders, which do not require a spare, may be acceptable in cases where any failed parts can be isolated.

2.3 Associated Installations

Paragraphs 2.3.6 to 2.3.10 have been added as follows.

2.3.6 Control Valves for Electronically-controlled Engines which are used as the Main Propulsion Machinery

1 Control valves are to be capable of retaining their expected ability to function properly for a period of time set by manufacturers.

2 Control valves are to be independently provided for each function (e.g. fuel injection, exhaust valve driving).

3 Means are to be provided to prevent fuel oil from continuously flowing into cylinders due to control valve failure.

2.3.7 Accumulators and Common Accumulators for Electronically-controlled Engines which are used as the Main Propulsion Machinery

1 Accumulators and common accumulators are to comply with the requirements in **Chapter 10, Part D of the Rules for the Survey and Construction of Steel Ships**. However, notwithstanding this requirement, materials and non-destructive tests as well as surface inspections and dimension inspections are to be in accordance with **Table D2.1, Part D of the Rules for the Survey and Construction of Steel Ships** and hydrostatic tests are to be in accordance with **Table D2.6, Part D of the Rules for the Survey and Construction of Steel Ships**.

2 Accumulators are to be capable of retaining their expected ability to function properly for a period of time set by manufacturers.

3 In principle, at least two common accumulators are to be provided. However, in cases where results of fatigue analysis upon fluctuating stress are submitted and approved by the Society, a single arrangement may be acceptable.

2.3.8 Fuel Oil Piping Systems and Hydraulic Oil Piping Systems for Electronically-controlled Engines which are used as the Main Propulsion Machinery

1 At least two fuel oil pressure pumps and hydraulic oil pressure pumps are to be provided for their respective lines and are to be capable of supplying a sufficient amount of oil at the maximum continuous output of main propulsion machinery. In such cases, even though a single one of these pumps may become inoperable, the remaining pumps are to be capable of supplying a sufficient amount of fuel under normal service conditions. In cases where one or more of these pumps are provided as a stand-by pump, the pumps are to always be connected and ready for use.

2 Piping arrangements from fuel oil pressure pumps to the fuel injection devices and from hydraulic oil pressure pumps to exhaust valve driving gears are to be protected with jacketed piping systems or oil tight enclosures, to prevent any spread of oil from igniting.

3 Two common piping arrangements from fuel oil pressure pumps or a hydraulic oil pressure

pumps to common accumulators, from one common accumulator to another common accumulator and from common accumulators to those positions where distribution to cylinders are to be respectively provided. In cases where results of fatigue analysis upon fluctuating stress are submitted and approved by the Society, a single arrangement may be acceptable.

4 Valves or cocks provided on piping connected to equipment, e.g. accumulators or pumps, are to be located as close to such equipment as practicable.

5 In high-pressure piping, high-pressure alarms are to be provided. Relief valves are also to be provided at proper positions, so as to lead any released oil to lower-pressure sides.

6 In cases where pressure gauges using bourdon-tubes are provided in high-pressure piping, such gauges are to be ones that comply with recognized industrial standards, e.g. *JIS*, and be vibration-proof and heat-resistant types.

2.3.9 Electronic Control Systems for Electronically-controlled Engines which are used as the Main Propulsion Machinery

1 Systems are to be so arranged that the function of an entire system is capable of being sustained or restored in cases where there is a single failure in any equipment part or circuit.

2 Controllers for systems are to comply with the following:

(1) At least two main controllers which are integrated to control every function, e.g. fuel injection, exhaust valve drive, cylinder lubrication and supercharge, are to be provided.

(2) Notwithstanding the requirement in **(1)** above, a single main controller may be acceptable, in cases where normal operation of main propulsion machinery is available by using control systems independent from main controllers.

3 At least two sensors essential for the operation of main propulsion machinery, e.g. for the following uses, are to be independently provided. In cases where normal operation of main propulsion machinery is available without any feedback from such sensors, single arrangements may be acceptable.

(1) Number of revolutions

(2) Crank angles

(3) Fuel pressure in common accumulators

4 Power for control systems is to be supplied from two independent sources, one of which is to be supplied from a battery, and through two independent circuits.

5 Power for driving solenoid valves is to be supplied from two independent sources, and through two independent circuits.

6 Electronic-control systems of main propulsion machinery which comply with the requirements given in **-1** through **-5** above are regarded as the same as those which comply with the following requirements.

(1) **18.2.4-5(1), Part D of the Rules for the Survey and Construction of Steel Ships**.

(2) **18.3.2-3(3), Part D of the Rules for the Survey and Construction of Steel Ships**.

2.3.10 Failure Mode Effect Analysis for Electronically-controlled Engines which are used as the Main Propulsion Machinery

Failure Mode Effect Analysis (FMEA) is to be carried out, for electronic control systems, in order to confirm that any one equipment or circuits in such systems which lose function may not cause any malfunction or deterioration in other equipment or circuits, in accordance with the following:

(1) Systems are to be divided into functional blocks and drawn out in reliability block diagrams in which such functional blocks are systematically organized.

(2) Analytic levels are to be sufficient up to the extent of those functional blocks regarding sub-systems and components.

(3) FMEA results are to be created in table form as shown in **Table 9.2.1** or be of equivalent

forms thereto.

(4) If FMEA results show that corrective action is demanded, then FMEA is to be carried out again after the corrective action to confirm the effectiveness of the corrective action.

(5) For failure modes, every possible failure from minor to catastrophic is to be considered.

Table 9.2.1 has been added as follows.

Table 9.2.1 Failure Mode Effect Analysis Table for Electronically-controlled Engines which are used as the Main Propulsion Machinery

Systems					Elements								
ID Number	Component	Sub-system	Operating mode	Failure mode	Failure cause	Failure detection Means	Alarm / Notification Means	Effect of failure			Failure severity	Corrective action	Remarks
								On component	On sub-system	On system			

Examples of Operating Mode: ack-up operations, fuel cost priority operations, NOx reduction operations, etc.

Examples of Failure Mode: piston pin stuck, connecting rod broken, lubricating oil leaked out, etc. (Failed parts are to be shown.)

Failure Severity:

(a) Catastrophic: loss of complete function, explosion, loss of life (Design change is to be compulsory.)

(b) Major: loss or deterioration of part of the ability to function properly (Possible design change is to be investigated.)

(c) Minor: negligible affect on ability to function properly (Design change may not be required.)

Chapter 13 SPARE PARTS, TOOLS AND INSTRUMENTS

13.2 Spare Parts, Tools and Instruments

13.2.1 Spare Parts

Sub-paragraph -5 has been added as follows.

5 The following parts are to be provided as the spare parts for electronically-controlled engines used as main propulsion machinery.
(1) Control valves: 1 of each type
(2) Accumulator diaphragms: 2 of each type
(3) Sensors provided for each cylinder (Spare parts may be omitted in cases where normal operation of main propulsion machinery is available without these sensors.): 1 of each type

Sub-paragraphs -5 and -6 have been amended as follows.

~~**5**~~**6** The spare parts for the machinery installations specified in **-1** to ~~**-4**~~**5** are those required for each one set of the machinery installations. In the case where the craft is installed with two or more sets of the machinery installations of the same type for the same service, only one set of spare parts for the machinery installations may be acceptable.

However, the number of water gauge glasses of round type and flat type is required to be the number specified in **-3** for each boiler, and the number of flat type water gauge frames is required to be one for each two boilers.

~~**6**~~**7** Notwithstanding the requirement specified in ~~**-5**~~**6** no spare parts are required for the machinery installations specified in following **(1)** to **(4)**.
((1) to (4) are omitted.)

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

Part 7 MACHINERY INSTALLATIONS

Chapter 2 RECIPROCATING INTERNAL COMBUSTION ENGINES

2.1 General

2.1.1 General*

Sub-paragraph -3 has been deleted.

~~**3** Electronically-controlled reciprocating internal combustion engines which are used as the main propulsion machinery are to be in accordance with the requirements specified otherwise by the Society in addition to those in this Chapter.~~

2.1.2 Terminology

Sub-paragraph -3 has been added as follows.

3 For electronically-controlled engines, the terminology is as specified in the following **(1)** to **(10)**:

(1) "Electronically-controlled engines" are engines whose fuel injection and/or Exhaust valve operation etc. are electronically controlled.

(2) "Accumulators" are small pressure vessels fitted to cylinders which provide hydraulic oil to those actuators attached to fuel injection devices or exhaust valve driving gears.

(3) "Common accumulators" are pressure vessels common to all cylinders for providing hydraulic oil or pressurized fuel oil.

(4) "Control valves" are components to control the delivery of hydraulic oil to drive actuators. The name control valve is generic for on-off-controlled solenoid valves, proportional-controlled valves or variable-controlled valves, etc.

(5) "Fuel oil pressure pumps" are pumps which provide pressurized fuel oil for common accumulators.

(6) "Hydraulic oil pressure pumps" are pumps to provide hydraulic oil for equipment, e.g. fuel injection devices, exhaust valve driving gears or control valves, through common accumulators.

(7) "Functional blocks" are blocks used to classify by function all items making up whole systems into the groups of systems, sub-systems, components, assemblies and parts.

(8) "Reliability block diagrams" are logical figures showing the relationship between functional blocks on an analytic level.

(9) "Normal operation" of main propulsion machinery means those operations at normal out-put conditions, using governors and all safety devices.

(10) "High-pressure" piping means piping in the down-stream of fuel oil pressure pumps or hydraulic oil pressure pumps.

2.2 Materials, Construction and Strength

2.2.2 Construction, Installation and General*

Sub-paragraph -8 has been added as follows.

8 Essential components are to be so arranged that normal operation of main propulsion machinery is capable of being sustained or restored even though one of these components becomes inoperable, except in cases where special consideration and approval is given by the Society to the reliability of single arrangements. Single components provided for cylinders, which do not require a spare, may be acceptable in cases where any failed parts can be isolated.

2.5 Associated Installations

Paragraphs 2.5.7 to 2.5.11 have been added as follows.

2.5.7 Control Valves for Electronically-controlled Engines which are used as the Main Propulsion Machinery

1 Control valves are to be capable of retaining their expected ability to function properly for a period of time set by manufacturers.

2 Control valves are to be independently provided for each function (e.g. fuel injection, exhaust valve driving).

3 Means are to be provided to prevent fuel oil from continuously flowing into cylinders due to control valve failure.

2.5.8 Accumulators and Common Accumulators for Electronically-controlled Engines which are used as the Main Propulsion Machinery

1 Accumulators and common accumulators are to comply with the requirements in **Chapter 10, Part D of the Rules for the Survey and Construction of Steel Ships**. However, notwithstanding this requirement, materials and non-destructive tests as well as surface inspections and dimension inspections are to be in accordance with **Table D2.1, Part D of the Rules for the Survey and Construction of Steel Ships** and hydrostatic tests are to be in accordance with **Table D2.6, Part D of the Rules for the Survey and Construction of Steel Ships**.

2 Accumulators are to be capable of retaining their expected ability to function properly for a period of time set by manufacturers.

3 In principle, at least two common accumulators are to be provided. However, in cases where results of fatigue analysis upon fluctuating stress are submitted and approved by the Society, a single arrangement may be acceptable.

2.5.9 Fuel Oil Piping Systems and Hydraulic Oil Piping Systems for Electronically-controlled Engines which are used as the Main Propulsion Machinery

1 At least two fuel oil pressure pumps and hydraulic oil pressure pumps are to be provided for their respective lines and are to be capable of supplying a sufficient amount of oil at the maximum continuous output of main propulsion machinery. In such cases, even though a single one of these pumps may become inoperable, the remaining pumps are to be capable of supplying a sufficient amount of fuel under normal service conditions. In cases where one or more of these pumps are provided as a stand-by pump, the pumps are to always be connected and ready for use.

2 Piping arrangements from fuel oil pressure pumps to the fuel injection devices and from

hydraulic oil pressure pumps to exhaust valve driving gears are to be protected with jacketed piping systems or oil tight enclosures, to prevent any spread of oil from igniting.

3 Two common piping arrangements from fuel oil pressure pumps or a hydraulic oil pressure pumps to common accumulators, from one common accumulator to another common accumulator and from common accumulators to those positions where distribution to cylinders are to be respectively provided. In cases where results of fatigue analysis upon fluctuating stress are submitted and approved by the Society, a single arrangement may be acceptable.

4 Valves or cocks provided on piping connected to equipment, e.g. accumulators or pumps, are to be located as close to such equipment as practicable.

5 In high-pressure piping, high-pressure alarms are to be provided. Relief valves are also to be provided at proper positions, so as to lead any released oil to lower-pressure sides.

6 In cases where pressure gauges using bourdon-tubes are provided in high-pressure piping, such gauges are to be ones that comply with recognized industrial standards, e.g. *JIS*, and be vibration-proof and heat-resistant types.

2.5.10 Electronic Control Systems for Electronically-controlled Engines which are used as the Main Propulsion Machinery

1 Systems are to be so arranged that the function of an entire system is capable of being sustained or restored in cases where there is a single failure in any equipment part or circuit.

2 Controllers for systems are to comply with the following:

(1) At least two main controllers which are integrated to control every function, e.g. fuel injection, exhaust valve drive, cylinder lubrication and supercharge, are to be provided.

(2) Notwithstanding the requirement in **(1)** above, a single main controller may be acceptable, in cases where normal operation of main propulsion machinery is available by using control systems independent from main controllers.

3 At least two sensors essential for the operation of main propulsion machinery, e.g. for the following uses, are to be independently provided. In cases where normal operation of main propulsion machinery is available without any feedback from such sensors, single arrangements may be acceptable.

(1) Number of revolutions

(2) Crank angles

(3) Fuel pressure in common accumulators

4 Power for control systems is to be supplied from two independent sources, one of which is to be supplied from a battery, and through two independent circuits.

5 Power for driving solenoid valves is to be supplied from two independent sources, and through two independent circuits.

6 Electronic-control systems of main propulsion machinery which comply with the requirements given in **-1** through **-5** above are regarded as the same as those which comply with the following requirements.

(1) **18.2.4-5(1), Part D of the Rules for the Survey and Construction of Steel Ships**.

(2) **18.3.2-3(3), Part D of the Rules for the Survey and Construction of Steel Ships**.

2.5.11 Failure Mode Effect Analysis for Electronically-controlled Engines which are used as the Main Propulsion Machinery

Failure Mode Effect Analysis (FMEA) is to be carried out, for electronic control systems, in order to confirm that any one equipment or circuits in such systems which lose function may not cause any malfunction or deterioration in other equipment or circuits, in accordance with the following:

(1) Systems are to be divided into functional blocks and drawn out in reliability block diagrams in which such functional blocks are systematically organized.

(2) Analytic levels are to be sufficient up to the extent of those functional blocks regarding sub-systems and components.
(3) FMEA results are to be created in table form as shown in **Table 7.2.6** or be of equivalent forms thereto.
(4) If FMEA results show that corrective action is demanded, then FMEA is to be carried out again after the corrective action to confirm the effectiveness of the corrective action.
(5) For failure modes, every possible failure from minor to catastrophic is to be considered.

Table 7.2.6 has been renumbered to Table 7.2.7, and Table 7.2.6 has been added as follows.

Table 7.2.6 Failure Mode Effect Analysis Table for Electronically-controlled Engines which are used as the Main Propulsion Machinery

Systems					Elements								
ID Number	Component	Sub-system	Operating mode	Failure mode	Failure cause	Failure detection Means	Alarm / Notification Means	Effect of failure			Failure severity	Corrective action	Remarks
								On component	On sub-system	On system			

Examples of Operating Mode: ack-up operations, fuel cost priority operations, NOx reduction operations, etc.
Examples of Failure Mode: piston pin stuck, connecting rod broken, lubricating oil leaked out, etc.(Failed parts are to be shown.)
Failure Severity:
(a) Catastrophic: loss of complete function, explosion, loss of life (Design change is to be compulsory.)
(b) Major: loss or deterioration of part of the ability to function properly (Possible design change is to be investigated.)
(c) Minor: negligible affect on ability to function properly (Design change may not be required.)

2.6 Tests

2.6.1 Shop Tests*

Sub-paragraph -1 has been amended as follows.

1 For components or accessories specified in **Table 7.2.~~6~~7**, hydrostatic tests are to be carried out on the water or oil side of the component at the pressures shown in the Table. In cases deemed necessary by the Society, tests may also be required for any components not specified in **Table 7.2.~~6~~7**.

Table 7.2.~~6~~7 Hydrostatic Test Pressure
(Table is omitted.)

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

Part D MACHINERY INSTALLATIONS

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 2.1.1-4, Part D of the Rules means “GUIDANCE FOR THE ADDITIONAL REQUIREMENTS ON ELECTRONICALLY-CONTROLLED ENGINES” in Annex D2.1.1.**~~

Sub-paragraph -3 has been amended as follows.

~~**3**~~**2** The wording “the requirements specified otherwise by the Society” in **2.1.1-~~7~~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 amended as follows.

D2.1.2 Terminology

The wording “the requirements specified otherwise by the Society” in **2.1.2-~~3~~4, Part D of the Rules** means **1.4 of Annex 4, Part GF** or **1.4 of Annex 4, Part N**.

D10 PRESSURE VESSELS

D10.9 Tests

D10.9.1 Shop Tests

Sub-paragraph -2 has been amended as follows.

2 Notwithstanding the requirements in **10.9.1, Part D of the Rules**, hydrostatic tests of heat exchangers fitted to engines having cylinder bores of 300 *mm* or less may be omitted. (see **Table D2.~~6~~7 of the Rules**)

Annex D2.1.1 has been deleted.

~~**Annex D2.1.1 GUIDANCE FOR THE ADDITIONAL REQUIREMENTS ON ELECTRONICALLY CONTROLLED ENGINES**~~

~~**(Omitted)**~~

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

Part 9 MACHINERY INSTALLATIONS

2.1 General

2.1.1 General

Sub-paragraph -2 has been deleted.

~~**2 The wording “the requirements specified otherwise by the Society” in 2.1.1-3, Part 9 of the Rules means “GUIDANCE FOR THE ADDITIONAL REQUIREMENTS ON ELECTRONICALLY-CONTROLLED ENGINES” in Annex D2.1.1, Part D of the Guidance for the Survey and Construction of Steel Ships.**~~

Sub-paragraph -3 has been amended as follows.

~~3~~**2** The wording “the requirements specified otherwise by the Society” in **2.1.1-~~6~~5, Part 9 of the Rules** means **Annex 3** “**GUIDANCE FOR HIGH PRESSURE GAS-FUELLED ENGINES**” or **Annex 4** “**GUIDANCE FOR LOW PRESSURE GAS-FUELLED ENGINES**” **of Part GF**.

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

Part 7 MACHINERY INSTALLATIONS

Chapter 2 RECIPROCATING INTERNAL COMBUSTION ENGINES

2.1 General

2.1.1 General

Sub-paragraph -2 has been deleted.

~~**2 The wording “the requirements specified otherwise by the Society” in 2.1.1-3, Part 7 of the Rules means “GUIDANCE FOR THE ADDITIONAL REQUIREMENTS ON ELECTRONICALLY-CONTROLLED ENGINES” in Annex D2.1.1, Part D of the Guidance for the Survey and Construction of Steel Ships.**~~

Sub-paragraph -3 has been amended as follows.

~~**3**~~**2** The wording “the requirements specified otherwise by the Society” in **2.1.1-~~6~~5, Part 7 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).

“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

8.5 Approval Tests

8.5.2 Details of Tests

Sub-paragraph -2(7) 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 (6) are omitted.)

(7) For electronically-controlled engines, integration tests are to verify that the response of the complete mechanical, hydraulic and electronic system is as predicted for all intended operational modes.

The scope of these tests is to be agreed upon with the Society for selected cases based upon the FMEA required in ~~**Annex D2.1.1, Part D of the Guidance for the Survey and Construction of Steel Ships**~~ **2.5.11, Part D of the Rules for the Survey and Construction of Steel Ships**.