PART II RULES FOR THE CONSTRUCTION AND CLASSIFICATION OF VESSELS IDENTIFIED BY THEIR MISSIONS

TITLE 25 HIGH SPEED CRAFT

SECTION 5 ENGINES AND MECHANICS

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A1. INCORPORATIONOF THE INTERNATIONAL CODE OF SAFETY FOR HIGH SPEED VESSELS BY THE RBNA RULES

100. Incorporation of the Code

101. The present Part II, Title 25 of the Rules incorporate the International Code of Safety of High Speed Vessels in its entirety.

102. The original terminology of the Code has been maintained.

103. Under the conditions of A1.101 and A1.102 above and in those provisions of the HSC Code that are being used for classification purposes the words “Administration” and “Code”, wherever mentioned, are to be understood as equivalent to the words “Society” and “Rules”, respectively. The RBNA “Rules for the Construction and Classification of Ships destined to Open Sea Navigation” are referred to below simply as “Society Rules”.

104. Equipment and arrangements dealt with in the parts of the Code such as those concerning life-saving appliances, radio communications and operational aspects, which are not subject to control by the Society, have been maintained to keep the integrity of the Code, and are to be covered by the relevant certification.

105. All the original texts from the code have been identified by a vertical line on the right side of the text, as demonstrated here.

106. Additional requirements and comments are inserted at the relevant Part of the Code are identified by the words “RBNA comment” before the text.

A2. APPLICATION

100. Application

101. The present Section 5 of Part II, Title 25, applies to:

a. passenger craft which do not proceed in the course of their voyage more than four hours at operational speed from a place of refuge; and

b. cargo craft of 500 gross tonnage and upwards which do not proceed in the course of their voyage more than 8 h at operational speed from a place of refuge when fully laden.

102. RBNA comment: In addition these Rules also apply as far as appropriate to cargo craft of less than 500 tons gross tonnage.

200. Application for vessel with GT ≥ 500 engaged in international voyages

201. 1.4 This Code applies to high speed craft engaged in international voyages the keels of which are laid or which are at a similar stage of construction on or after 1 July 2002.

300. RBNA comment: Application for vessels with GT < 500 engaged in national or international voyages

301. In addition, these Rules also apply to:

a. high speed craft engaged in national voyages;

b. high speed craft having GT < 500.

302. Exemptions from some of the requirements of the Rules may be granted when particular circumstances (e.g. restricted services) warrant this, in the opinion of the RBNA.

CHAPTER B
DOCUMENTS, REGULATIONS AND STANDARDS

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B2. REGULATIONS AND STANDARDS

100. Application

101. For Brazilian flag vessels with GT < 500 rhe regulations of NORMAN 01 (Brazilian Maritime Authority Standards for Navigation in Open Seas) are applicable as relevant to the equipment and systems covered by this Section 3.

102. For vessel having GT ≥ 500, the requirements of the IMO Code of Safety for High Speed Craft are applicable as relevant to the equipment and systems covered by this Section 3.

B3. STANDARDS

100. National and International Standards

101. Whenever there are not specific requirements in the Rules related to any system, the national and international standards are to be researched and applied.

102. Specific Chapters of this Section 3 are based on national and international standards. Where this is the case, such standards are clearly stated.

CHAPTER D
PRINCIPLES OF INSTALLATION

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D1. SPECIFIC CONDITIONS

100. Ambient conditions [IACS UR M40]

101. All equipment and systems on board must be designed and cosntructed to withstand the ambient conditions found on board such as temperature, ship's motions, vibrations, corrosive environment.

102. The ambient condition requirements of the present Chapter D1 are to be applied to the layout, selection and arrangement of all shipboard machinery, equipment and appliances as to ensure proper operation.

200. Ambient conditions: temperatures [IACS M40.2]

201. The ambient conditions specified under Table T.D1.201.1 are to be applied to the layout, selection and arrangement of all shipboard machinery, equipment and appliances as to ensure proper operation.

300. Ambient conditions – Inclinations [IACS UR M46]

301. All equipment and systems on board must be designed and cosntructed to resist to the ambient conditions found on board such as temperature, ship's motions, vibrations, corrosive environment:

302. The ambient conditions specified under the present chapter in Table T.D1.302.1 are to be applied to the layout, selection and arrangement of all shipboard machinery, equipment and appliances to ensure proper operation.

TABLE T.D1.201.1 – AIR TEMPERATURES

Installations, components	Location, arrangement	Temperature range (°C)
Machinery and electrical installations [1]	In enclosed spaces	0 to +45[2]
	On machinery components, boilers, In spaces subject to higher and lower temperatures	According to specific local conditions
	On the open deck	–25 to +45[2]

TABLE T.D1.201.1 – WATER TEMPERATURES

Coolant	Temperature (°C)
Seawater Charge air coolant inlet to charge air cooler	+32[2] See Item D1.400 below

NOTES
1. Electronic appliances are to be suitable for proper operation even with an air temperature of +55°C.
2. The RBNA may approve other temperatures in the case of ships not intended for unrestricted service.

TABLE T.D1.302.1 – ANGLE OF INCLINATION

Installations, components	Angle of inclination [°][2]			
	Athwartships		Fore-and-aft	
	static	dynamic	static	dynamic
Main and auxiliary machinery	15	22,5	5[4]	7,5
Safety equipment, e.g. emergency power installations, emergency fire pump and their devices Switch gear, electrical and electronic appliances[1] and remote control systems	22,5[3]	22,5[3]	10	10

NOTES:
1. Up to an angle of inclination of 45° no undesired switching operations or operational changes may occur.
2. Athwartships and fore-end-aft inclinations may occur simultaneously.
3. In ships for the carriage of liquefied gases and of chemicals the emergency power supply must also remain operable with the ship flooded to a final athwartships inclination up to maximum of 30°.
4. Where the length of the ship exceeds 100m, the fore-and-aft static angle of inclination may be taken as 500/L degrees where L = length of the ship, in metres, as defined in Part II, Title 11, Section 1, Chapter A, Item A2.150.

400. Design reference conditions [IACS UR M28]

401. For the design of the machinery installations and for the purpose of determining the power of main and auxiliary reciprocating internal combustion engines the following ambient reference conditions apply for ships of unrestricted service

a. Total barometric pressure 1000 mbar

b. Air temperature +45°C

c. Relative humidity 60%

d. Sea water temperature 32°C (charge air coolant-inlet)

402. NOTE: The engine manufacturer shall not be expected to provide simulated ambient reference conditions at a test bed

403. The temperature of any surface in the Engine Room, regardless of isolation, is not to exceed 200 ºC under any circumstances. The measurement of the temperature of the Engine Room surfaces may be determined by one of the following processes:

a. Control thermometer on the surface

b. Laser heat trackers

c. Infrared Thermoscan with video

404. The lowest water temperature should be considered as 5^{o} C, except at the Amazon River, where it may be considered to be 10 °C.

405 The ambient Engine Room temperature is not to exceed 45^{o} C.

406. NOTE: The engine manufacturer shall not be expected to provide simulated ambient reference conditions at a test bed.

500. Fuels

501. These Rules apply to liquid fuels for operation of machinery and boilers, with flash point above 60 º C. Where fuels of a lower flash point are employed, they will be subjected to special analysis by RBNA. See Part II, Title 11, Section 6 of the Rules.

D2. MACHINERY ARRANGEMENT [CHAPTER 9]

For High-Speed Crafts constructed from 2002-07-01 See Contents for this Code

100. 9.1 General

101. 9.1.1 The machinery, associated piping systems and fittings relating to main machinery and auxiliary power units shall be of a design and construction adequate for the service for which they are intended and shall be so installed and protected as to reduce to a minimum any danger to persons on board, due regard being paid to moving parts, hot surfaces and other hazards. The design shall have regard to materials used in construction, the purpose for which the equipment is intended, the working conditions to which it will be subjected and the environmental conditions on board.

102. 9.1.2 All surfaces with temperatures exceeding 220°C where impingement of flammable liquids may occur as a result of a system failure shall be insulated. The insulation shall be impervious to flammable liquids and vapours.

103. 9.1.3 Special consideration shall be given to the reliability of single essential propulsion components and a separate source of propulsion power sufficient to give the craft a navigable speed, especially in the case of unconventional arrangements, may be required.

104. 9.1.4 Means shall be provided whereby normal operation of propulsion machinery can be sustained or restored even though one of the essential auxiliaries becomes inoperative. Special consideration shall be given to the malfunctioning of:

a. agenerating set which serves as a main source of electrical power;

b. the fuel oil supply systems for engines;

c. the sources of lubricating oil pressure;

d. the sources of water pressure;

e. an air compressor and receiver for starting or control purposes;

f. the hydraulic, pneumatic or electrical means for control in main propulsion machinery, including controllable-pitch propellers.

However, having regard to overall safety considerations, a partial reduction in propulsion capability from normal operation may be accepted.

105. 9.1.5 Means shall be provided to ensure that the machinery can be brought into operation from the dead craft condition without external aid.

Guidance

From SOLAS Interpretations as approved by IMO 2008-10-30, also issued as MSC/Circ.1177 of 25 May 2005, the following unified interpretation was made:

Machinery installations: dead craft condition
Dead craft condition for the purpose of D1.105 should be understood to mean a condition under which the main propulsion plant and auxiliaries are not in operation and, in restoring the propulsion, no stored energy is assumed to be available for starting and operating the propulsion plant, the main source of electrical power and other essential auxiliaries. It is assumed that means are available at all times to start the emergency generator or one of the main generators when the main source is arranged according to paragraph of the PII, T25, S7, F5.300.

Where the emergency source of power is an emergency generator which complies with section PII, T25, S7, F5.300 or a main generator meeting the requirements of paragraph PII, T25, S7, F5.300.is assumed that means are available to start this generator and, consequently, this generator may be used for restoring operation of the main propulsion plant and auxiliaries where any power supplies necessary for engine operation are also protected to a similar level as the starting arrangements.

Where there is no emergency generator installed or an emergency generator the does not comply with the PII, T25, S7, F5.300. the arrangements for bringing main and auxiliary machinery into operation should be such that the initial charge of starting air or initial electrical power and any power supplies for engine operation can be developed on board the craft without external aid. If for this purpose an emergency air compressor or electric generator is required, these units should be powered by a hand-starting oil engine or a hand-operated compressor. The arrangements for bringing main and auxiliary machinery into operation should have a capacity such that the starting energy and any power supplies for engine operation are available within 30 min of a dead craft condition.

End of guidance

106. 9.1.6 All parts of machinery, hydraulic, pneumatic and other systems and their associated fittings which are under internal pressure shall be subjected to appropriate tests including a pressure test before being put into service for the first time.

107. 9.1.7 Provision shall be made to facilitate cleaning, inspection and maintenance of main propulsion and auxiliary machinery including boilers and pressure vessels.

108. 9.1.8 The reliability of machinery installed in the craft shall be adequate for its intended purpose.

109. 9.1.9 The Administration may accept machinery which does not show detailed compliance with the Code where it has been used satisfactorily in a similar application, provided that it is satisfied:

a. that the design, construction, testing, installation and prescribed maintenance are together adequate for its use in a marine environment; and

b. that an equivalent level of safety will be achieved.

110. 9.1.10 A failure mode and effect analysis shall include machinery systems and their associated controls.

111. 9.1.11 Such information as is necessary to ensure that machinery can be installed correctly regarding such factors as operating conditions and limitations shall be made available by the manufacturers.

112. 9.1.12 Main propulsion machinery and all auxiliary machinery essential to the propulsion and the safety of the craft shall, as fitted in the craft, be designed to operate when the craft is upright and when inclined at any angle of list up to and including 15° either way under static conditions and 22.5° under dynamic conditions (rolling) either way and simultaneously inclined by dynamically (pitching) 7.5° by bow or stern. The Administration may permit deviation from these angles, taking into consideration the type, size and service conditions of the craft.

113. 9.1.13 All boilers, and pressure vessels and associated piping systems shall be of a design and construction adequate for the purpose intended and shall be so installed and protected as to minimise danger to persons on board. In particular, attention shall be paid to the materials used in the construction and the working pressures and temperatures at which the item will operate and the need to provide an adequate margin of safety over the stresses normally produced in service. Every boiler, pressure vessel and associated piping systems shall be fitted with adequate means to prevent over-pressures in service and be subjected to a hydraulic test before being put into service, and where appropriate at subsequent specified intervals, to a pressure suitably in excess of the working pressure.

114. 9.1.14 Arrangements shall be provided to ensure that, in the event of failure in any liquid cooling system, it is rapidly detected and alarmed (visual and audible) and means instituted to minimise the effects of such failures on machinery serviced by the system.

200. 9.2 Engine (general)

201. 9.2.1 The engines shall be fitted with adequate safety monitoring and control devices in respect of speed, temperature, pressure and other operational functions. Control of the machinery shall be from the craft' s operating compartment. Category B craft and cargo craft shall be provided with additional machinery controls in or close to the machinery space. The machinery installation shall be suitable for operation as in an unmanned machinery space, including automatic fire detection system, bilge alarm system, remote machinery instrumentation and alarm system. Where the space is continuously manned, this requirement may be varied in accordance with the requirements of the Administration.

Refer to part E of chapter II-1 of the Convention.

202. 9.2.2 The engines shall be protected against overspeed, loss of lubricating oil pressure, loss of cooling medium, high temperature, malfunction of moving parts and overload. Safety devices shall not cause complete engine shutdown without prior warning, except in cases where there is a risk of complete breakdown or explosion. Such safety devices shall be capable of being tested.

203. 9.2.3 At least two independent means of stopping the engines quickly from the operating compartment under any operating conditions shall be available. Duplication of the actuator fitted to the engine shall not be required.

204. 9.2.4 The major components of the engine shall have adequate strength to withstand the thermal and dynamic conditions of normal operation. The engine shall not be damaged by a limited operation at a speed or at temperatures exceeding the normal values but within the range of the protective devices.

205. 9.2.5 The design of the engine shall be such as to minimise the risk of fire or explosion and to enable compliance with the fire precaution requirements of chapter 7.

206. 9.2.6 Provision shall be made to drain all excess fuel and oil to a safe position so as to avoid a fire hazard.

207. 9.2.7 Provision shall be made to ensure that, whenever practical, the failure of systems driven by the engine shall not unduly affect the integrity of the major components.

208. 9.2.8 The ventilation arrangements in the machinery spaces shall be adequate under all envisaged operating conditions. Where appropriate, arrangements shall ensure that enclosed engine compartments are forcibly ventilated to the atmosphere before the engine can be started.

209. 9.2.9 Any engines shall be so installed as to avoid excessive vibration within the craft.

300. 9.3 Gas turbines

9.3.1 Gas turbines shall be designed to operate in the marine environment and shall be free from surge or dangerous instability throughout its operating range up to the maximum steady speed approved for use. The turbine installation shall be arranged to ensure that the turbine cannot be continuously operated within any speed range where excessive vibration, stalling, or surging may be encountered.

9.3.2 The gas turbines shall be designed and installed such that any reasonably probable shedding of compressor or turbine blades will not endanger the craft, other machinery, occupants of the craft or any other persons.

303. 9.3.3 Requirements of D2.206 shall apply to gas turbines in respect of fuel which might reach the interior of the jet pipe or exhaust system after a false start or after stopping.

304. 9.3.4 Turbines shall be safeguarded as far as practicable against the possibility of damage by ingestion of contaminants from the operating environment. Information regarding the recommended maximum concentration of contamination shall be made available. Provision shall be made for preventing the accumulation of salt deposits on the compressors and turbines and, if necessary, for preventing the air intake from icing.

305. 9.3.5 In the event of a failure of a shaft or weak link, the broken end shall not hazard the occupants of the craft, either directly or by damaging the craft or its systems. Where necessary, guards may be fitted to achieve compliance with these requirements.

306. 9.3.6 Each engine shall be provided with an emergency overspeed shutdown device connected, where possible, directly to each rotor shaft.

307. 9.3.7 Where an acoustic enclosure is fitted which completely surrounds the gas generator and the high pressure oil pipes, a fire detection and extinguishing system shall be provided for the acoustic enclosure.

308. 9.3.8 Details of the manufacturers' proposed automatic safety devices to guard against hazardous conditions arising in the event of malfunction in the turbine installation shall be provided together with the failure mode and effect analysis.

309. 9.3.9 The manufacturers shall demonstrate the soundness of the casings. Intercoolers and heat exchangers shall be hydraulically tested on each side separately.

400. 9.4 Diesel engines for main propulsion and essential auxiliaries

401. 9.4.1 Any main diesel propulsion system shall have satisfactory torsional vibration and other vibrational characteristics verified by individual and combined torsional and other vibration analyses for the system and its components from power unit through to propulsor.

402. 9.4.2 All external high-pressure fuel delivery lines between the high-pressure fuel pumps and fuel nozzles shall be protected with a jacketed tubing system capable of containing fuel from a high-pressure line failure. The jacketed tubing system shall include a means for collection of leakages and arrangements shall be provided for an alarm to be given of a fuel line failure.

403. 9.4.3 Engines of a cylinder diameter of 200 mm or a crankcase volume of 0.6 m³ and above shall be provided with crankcase explosion relief valves of an approved type with sufficient relief area. The relief valves shall be arranged with means to ensure that discharge from them is directed so as to minimise the possibility of injury to personnel.

404. 9.4.4 The lubrication system and arrangements shall be efficient at all running speeds, due consideration being given to the need to maintain suction and avoid the spillage

of oil in all conditions of list and trim and degree of motion of the craft.

405. 9.4.5 Arrangements shall be provided to ensure that visual and audible alarms are activated in the event of either lubricating oil pressure or lubricating oil level falling below a safe level, considering the rate of circulation of oil in the engine. Such events shall also cause automatic reduction of engine speed to a safe level, but automatic shutdown shall only be activated by conditions leading to a complete breakdown, fire or explosion.

406. 9.4.6 Where diesel engines are arranged to be started, reversed or controlled by compressed air, the arrangement of the air compressor, air receiver and air starting system shall be such as to minimise the risk of fire or explosion.

500. 9.5 Transmissions

501. 9.5.1 The transmission shall be of adequate strength and stiffness to enable it to withstand the most adverse combination of the loads expected in service without exceeding acceptable stress levels for the material concerned.

502. 9.5.2 The design of shafting, bearings and mounts shall be such that hazardous whirling and excessive vibration could not occur at any speed up to 105% of the shaft speed attained at the designed overspeed trip setting of the prime mover.

503. 9.5.3 The strength and fabrication of the transmission shall be such that the probability of hazardous fatigue failure under the action of the repeated loads of variable magnitude expected in service is extremely remote throughout its operational life. Compliance shall be demonstrated by suitably conducted tests, and by designing for sufficiently low stress levels, combined with the use of fatigue resistant materials and suitable detail design. Torsional vibration or oscillation likely to cause failure may be acceptable if it occurs at transmission speeds which would not be used in normal craft operation, and it is recorded in the craft operating manual as a limitation.

504. 9.5.4 Where a clutch is fitted in the transmission, normal engagement of the clutch shall not cause excessive stresses in the transmission or driven items. Inadvertent operation of any clutch shall not produce dangerously high stresses in the transmission or driven item.

505. 9.5.5 Provision shall be made such that a failure in any part of the transmission, or of a driven component, will not cause damage which might hazard the craft or its occupants.

506. 9.5.6 Where failure of lubricating fluid supply or loss of lubricating fluid pressure could lead to hazardous conditions, provision shall be made to enable such failure to be indicated to the operating crew in adequate time to enable them as far as practicable to take the appropriate action before the hazardous condition arises.

600. 9.6 Propulsion and lift devices

601. 9.6.1 The requirements of this section are based on the premise that:

a. Propulsion arrangements and lift arrangements may be provided by separate devices, or be integrated into a single propulsion and lift device. Propulsion devices may be air, or water propellers or water jets and the requirements apply to all types of craft.

b. Propulsion devices are those which directly provide the propulsive thrust and include machinery items and any associated ducts, vanes, scoops and nozzles, the primary function of which is to contribute to the propulsive thrust.

c. The lift devices, for the purposes of this section, are those items of machinery which directly raise the pressure of the air and move it for the primary purpose of providing lifting force for an air-cushion vehicle.

602. 9.6.2 The propulsion and lift devices shall be of adequate strength and stiffness. The design data, calculations and trials, where necessary, shall establish the ability of the device to withstand the loads which can arise during the operations for which the craft is to be certificated, so that the possibility of catastrophic failure is extremely remote.

603. 9.6.3 The design of propulsion and lift devices shall pay due regard to the effects of allowable corrosion, electrolytic action between different metals, erosion or cavitation which may result from operation in environments in which they are subjected to spray, debris, salt, sand, icing, etc.

604. 9.6.4 The design data and testing of propulsion and lift devices shall pay due regard, as appropriate, to any pressure which could be developed as a result of a duct blockage, to steady and cyclic loadings, to loadings due to external forces and to the use of the devices in manoeuvring and reversing and to the axial location of rotating parts.

605. 9.6.5 Appropriate arrangements shall be made to ensure that:

D3. REQUIREMENTS FOR PASSENGER CRAFT

100. 9.7 Independent means of propulsion for category B craft

101. Category B craft shall be provided with at least two independent means of propulsion so that the failure of one engine or its support systems would not cause the failure of the other engine or engine systems and with additional machinery controls in or close to the machinery space.

200. 9.8 Means for return to a port of refuge for category B craft

201. Category B craft shall be capable of maintaining the essential machinery and control so that, in the event of a fire or other casualties in any one compartment on board, the craft can return to a port of refuge under its own power.

D4. REQUIREMENTS FOR CARGO CRAFT

100. Essential machinery and control

101. Cargo craft shall be capable of maintaining the essential machinery and control in the event of a fire or other casualties in any one compartment on board. The craft need not be able to return to a place of refuge under its own power.

E6. ENGINE INSTRUMENTATION FOR SHIPS WITH MANNED ENGINE ROOM

11.1 Definitions

11.1.1 “Remote control systems” comprise all equipment necessary to operate units from a control position where the operator cannot directly observe the effect of his actions.

11.1.2 “Back-up control systems” comprise all equipment necessary to maintain control of essential functions required for the craft's safe operation when the main control systems have failed or malfunctioned.

11.2 General

11.2.1 Failure of any remote or automatic control systems shall initiate an audible and visual alarm and shall not prevent normal manual control.

11.2.2 Manoeuvring and emergency controls shall permit the operating crew to perform the duties for which they are responsible in a correct manner without difficulty, fatigue or excessive concentration.

C11.2.2 The operation of the remote control from the craft's operation station is to be so designed and constructed that it does under normal conditions not require the operator's particular attention of the details of the machinery.

The remote control systems consisting of steel cable links or equivalent are to be submitted to the Society for special consideration.

The equipment, to which this Chapter applies, shall be of state of the art design and construction and shall have proved their reliability in marine service. If evidence on the required reliability cannot be given by relevant documentation, the equipment has to be subjected to an approval according to the Rules of the Society.

11.2.3 Where control of propulsion or manoeuvring is provided at stations adjacent to but outside the operating compartment, the transfer of control shall only be effected from the station which takes charge of control. Two-way voice communication shall be provided between all stations from which control functions may be exercised and between each such station and the look-out position. Failure of the operating control system or of transfer of control shall bring the craft to low speed without hazarding passengers or the craft.

11.2.4 For category B craft and cargo craft, remote control systems for propulsion machinery and directional control shall be equipped with back-up systems controllable from the operating compartment. For cargo craft, instead of a back-up system described above, a back-up system controllable from an engine control space, such as an engine control room outside the operating compartment, is acceptable.

C11.2.4 If provided so, the communication of machinery propulsion orders shall be effected by a telegraph system or equivalent means, which imply an optical indication at the such control positions of the machinery orders received from the craft's operating station.

C11.2.5 Under all sailing conditions (including manoeuvring), the propulsion machinery, including propellers, jets, flaps or other means which affect the speed and direction of thrust of all category high speed craft, is to be controllable from the craft's operating station.

C11.2.6 In principle the remote control is to be performed by a single control device for each independent propulsion unit with automatic performance of all associated services including, where necessary, means of preventing overload and prolonged running in critical speed ranges of the propulsion unit.

In cases where multiple propulsion units are designed to operate simultaneously, the command on their controls shall be designed for the possibility of being connected in one control device, in order to select individual or common control of the units, as necessary for the appropriate mode of operation.

Movement of the control device shall take place in the same direction as the desired motion of the ship.

C11.2.7 Each control position is to be provided with means to indicate which of them is in control.

At any control position, from which control of craft's manoeuvring is exercised, the operating effects caused by control inputs to the propulsion unit shall continuously be indicated.

C11.2.8 After restoration of normal conditions following an automatic shut-down, the machinery shall not start inadvertently before the control device has been reset to stop. Following an automatic slow-down−if provided−the propulsion of the craft shall not accelerate inadvertently before the control device has been reset to the actual step of speed, to which the power of the propulsion had been decreased.

Alternatively, other arrangements may be provided for the operator to consciously admit starting or acceleration of propulsion machinery.

Remote starting of a propulsion unit is to be automatically inhibited if conditions exist which may hazard the machinery, e.g. turning gear engaged, clutch engaged, shut-down activated, etc.

C11.2.9 The power for the control system is to be supplied from the same source which supplies the essential services for the propulsion units. As an alternative, the power for the control system may be supplied from other sources of power with backing-up facilities, which are sufficient for at least 15 minutes operation of the control system, in case of failure in its normal supply.

In case of category B craft, the control system of each propulsion unit shall have its individual source of power.

11.3 Emergency controls

11.3.1 In all craft, the station or stations in the operating compartment from which control of craft manoeuvring and/or of its main machinery is exercised shall be provided, within easy reach of the crew member at that station, with controls for use in an emergency to:

.1 activate fixed fire-extinguishing systems;

.2 close ventilation openings and stop ventilating machinery supplying spaces covered by fixed fireextinguishing systems, if not incorporated in .1;

.3 shut off fuel supplies to machinery in main and auxiliary machinery spaces;

.4 disconnect all electrical power sources from the normal distribution system (the operating control shall be guarded to reduce the risk of inadvertent or careless operation); and

.5 stop main engine(s) and auxiliary machinery.

C11.3.1 Unless it is considered impracticable, a single failure of the emergency controls shall not have an inadvertent effect on the system which it serves. In case of such a failure, an alarm shall be given in the craft's operating compartment. The stopping device for main engine(s) is to be independent from the remote control system at the craft's operating station.

11.3.2 Where control of propulsion and manoeuvring is provided at stations outside the operating compartment, such stations shall have direct communication with the operating compartment which shall be a continuously manned control station.

11.3.3 In addition, for category B craft, control of propulsion and manoeuvring, as well as emergency functions referred to in 11.3.1, shall be provided in a station outside the operating compartment. Such stations shall have direct communication with the operating compartment which shall be a continuously manned control station.

11.4 Alarm system

11.4.1 Alarm systems shall be provided which announce at the craft's control position, by visual and audible means, malfunction or unsafe conditions. Alarms shall be maintained until they are accepted and the visual indications of individual alarms shall remain until the fault has been corrected, when the alarm shall automatically reset to the normal operating condition. If an alarm has been accepted and a second fault occurs before the first is rectified, the audible and visual alarms shall operate again.

Alarm systems shall incorporate a test facility.

11.4.1.1 Emergency alarms giving indication of conditions requiring immediate action shall be distinctive and in full view of crew members in the operating compartment, and shall be provided for the following:

.1 activation of a fire detection system;

.2 total loss of normal electrical supply;

.3 overspeed of main engines;

.4 thermal runaway of any permanently

installed nickel-cadmium battery.

11.4.1.2 Alarms with a visual display distinct from that of alarms referred to in 11.4.1.1 shall indicate conditions requiring action to prevent degradation to an unsafe condition.

These shall be provided for at least the following:

.1 exceeding the limiting value of any craft, machinery or system parameter other than engine overspeed;

.2 failure of normal power supply to powered directional or trim control devices;

.3 operation of any automatic bilge pump;

.4 failure of compass system;

.5 low level of a fuel tank contents;

.6 fuel oil tank overflow;

.7 extinction of side, masthead or stern navigation lights;

.8 low level of contents of any fluid reservoir the contents of which are essential for normal craft operation;

.9 failure of any connected electrical power source;

.10 failure of any ventilation fan installed for ventilating spaces in which inflammable vapours may accumulate;

.11 diesel engine fuel line failure as required by 9.4.2.

11.4.1.3 All warnings required by 11.4.1.1 and 11.4.1.2 shall be provided at all stations at which control functions may be exercised.

11.4.2 The alarm system shall meet appropriate constructional and operational requirements for required alarms.

Note: Refer to the Code on Alarms and Indicators, 1995, adopted by the Organization by resolution A.830(19).

11.4.3 Equipment monitoring the passenger, cargo and machinery spaces for fire and flooding shall, so far as practicable, form an integrated sub-centre incorporating monitoring and activation controls for all emergency situations.

This sub-centre may require feed-back instrumentation to indicate that actions initiated have been fully implemented.

11.5 Safety system

11.5.1 Where arrangements are fitted for overriding any automatic shut-down system for the main propulsion machinery in accordance with 9.2.2, they shall be such as to preclude inadvertent operation.

When a shut-down system is activated, an audible and visual alarm shall be given at the control station and means shall be provided to override the automatic shut-down except in cases where there is a risk of complete breakdown or explosion.

100. Instruments

101. Indicators and tachometers are to be installed at any location where it may be possible to start up the engine, as indicated in what follows.

102. Pressure gauges and tachometers should be marked in red with the allowable pressures and the critical speed range.

103. Where the controls and instruments are part of a programmable electronic system, the requirements of Part II, Title 102, Section 5, Subchapter A6 are to be met.

104. Where the main or auxiliary engines are equipped with automation and control system, the requirements of Part II, Title 102, Section 5,Subchapter A7 are to be complied with.

105. For ships with AB ≥ 500, refer to the Code for Alarms and Indicators, IMO resolution A.1021 (26) as amended.

200. For propulsion engines

201. At least the following instruments are required to be mounted on a panel installed on the engine in an easily visible location, or when the engine is controlled remotely, installed in the engine control room.

a. Pressure gauges:

a.1. Lubricating oil

a.2. Fresh water cooling - air starting (if applicable), and

a.3. Control air (if applicable).

a.4. Fuel oil

b. Thermometers:

b.1. Lubricating oil

b.2. Fresh water cooling of the cylinder liner, inlet and outlet;

b.3. raw water cooling (when applicable).

b. tachometer;

c. hour meter;

d. ammeter.

202. The propeller speed and direction of rotation of the shaft are to be displayed on the bridge and Engine Control Room (if existent).

203. Visual and audible alarms are to be installed for:

a. Low lube oil pressure, and

b. High temperature fresh water cooling.

204. In case the oil pressure drops below the specified shut-off minimum requiring an immediate shut-off of the engine, an audible and visual alarm different from any other alarms is to be triggered, and the engine is to be stopped automatically.

205. The indicators, alarms and shut-offs are to be in accordance with the tables T.E6.400.1; T.E6.400.2; T.E6.400.3 and T.E6.400.4.

300. For auxilliary engines [IACS UR M2]

301. It is required at least the following instruments, which must be mounted on a panel installed on the engine in an easily visible:

a. Pressure gauges:

a.1. Lubricating oil

a.2. Fresh water cooling

a.3. Starting air (if applicable);

a.4. Air control (if applicable) and

a.5. Fuel oil.

b. Thermometers:

b.1. Lubricating oil

b.2. Fresh water cooling

b.3. Starting air (if applicable);

b.4. Air control (if applicable) and

b.5. Fuel oil.

c. Audible alarms for:

c.1. Lub oil low pressure; and

c.2. High and low cooling fresh water temperature.

d. Tachometer or equivalent instrument;

e. hour meter;

f. ammeter.

Vessels with class notation of automation or remote control from the bridge are to follow the requirements of Part II, Title 102, Section 5 - Automation in addition and / or replacement to those here presented

303. The indicators, alarms and shut-offs are to be in accordance with the tables T.E6.400.1; T.E6.400.2; T.E6.400.3 and T.E6.400.4.

400. Table of alarms and indicators

L: reading
A: high pressure or temperature alarm
B: low pressure or temperature alarm
P: Shut-off, stop
AL: Alarm

TABLE T.E6.400.1 – ALARMS AND INDICATORS 1

Description	**MCP's**	**MCA's**	**Emergência**
Rotation	L		
Over-speed (4)	Al, P	Al, P	Al, P
Operation hours	L	L	L

TABLE T.E6.400.2 – ALARMS AND INCICATORS 2

Description	**MCP's**	**MCA's**	**Emergency**
Lub Oil inlet pressure	L, B, P	L, B, P	L, B
Fuel Oil inlet pressure	L	L	
Fresh water jacket cooling outlet	L, B	L, B	L, B
Fresh water piston cooling outlet (1)	L, B	L, B	L, B (4)
Turbo feed air outlet pressure (2)	L		
Starting air preessure(3)	L, B		
Control air pressure	L, B		

TABLE T.E6.400.3 – ALARMS AND INDICADORS 3

Description	**MCP's**	**MCA's**	**Emer-gency**
OL inlet temperature	L, A	L, A (4)	L, A (4)
FO inlet temperature (5)	L	L	
Jacket fresh water cooling outlet temperature	L, A	L, A	L, A
Piston fresh water cooling outlet temperature (1)	L, A		
Feed air inlet temperature (5)	L		
Feed air outlet temperature (5)	L		
Exhaust gases temperature (6)	L, A (7)		

Other alarms and indicators:

TABLE – ALARMS AND INDICATORS 4

Description	**MCP's**	**MCA's**	**Emergency**
Fuel leak in the high pressure piping	Al	Al	Al
Crankcase oil mist detector (8), (9), (10)	L, A	L, A	L, A

(1) For engines fitted with piston cooling system separate from the jacket cooling system

(2) For turbo-powered engines

(3) For engines with compressed air starting

(4) For engines with power greater than or equal to 200 kWh

(5) For engines burning heavy oil

(6) Where the installation at each cylinder outlet and turbo inlet and outlet is feasible.

(7) Turbo outlet bo only

(8) For engines with a power greater than 2250 kW and cylinder diameter greater than 300 mm

(9) Alternative methods must be submitted to RBNA

(10) May be provided with engine shut-off as necessary

CHAPTER I
PROCEDURES FOR FAILURE MODE AND EFFECTS ANALYSIS
[Annex 4]

CHAPTER CONTENTS

I1. INTRODUCTION AND OBJECTIVES

100. A4.1 Introduction

101. A4.1.1 In the case of traditional craft, it has been possible to specify certain aspects of design or construction in some level of detail, in a way which was consistent with some level of risk which had over the years been intuitively accepted without having to be defined.

102. A4.1.2 With the development of large high-speed craft, this required experience has not been widely available. However, with the now broad acceptance of the probabilistic approach to safety assessments within industry as a whole, it is proposed that an analysis of failure performance may be used to assist in the assessment of the safety of operation of high-speed craft.

103. A4.1.3 A practical, realistic and documented assessment of the failure characteristics of the craft and its component systems shall be undertaken with the aim of defining and studying the important failure conditions that may exist.

104. A4.1.4 This Chapter I describes a failure mode and effects analysis (FMEA) and gives guidance as to how it may be applied by:

a. .1 explaining basic principles;

b. .2 providing the procedural steps necessary to perform an analysis;

c. .3 identifying appropriate terms, assumptions, measures and failure modes; and

d. .4 providing examples of the necessary worksheets.

105. A4.1.5 FMEA for high-speed craft is based on a single-failure concept under which each system at various levels of a system' s functional hierarchy is assumed to fail by one probable cause at a time. The effects of the postulated failure are analysed and classified according to their severity. Such effects may include secondary failures (or multiple failures) at other level(s). Any failure mode which may cause a catastrophic effect to the craft shall be guarded against by system or equipment redundancy unless the probability of such failure is extremely improbable For failure modes causing hazardous effects, corrective measures may be accepted in lieu. A test programme shall be drawn to confirm the conclusions of FMEA.

106. A4.1.6 Whilst FMEA is suggested as one of the most flexible analysis techniques, it is accepted that there are other methods which may be used and which in certain circumstances may offer an equally comprehensive insight into particular failure characteristics.

200. A4.2 Objectives

201. A4.2.1 The primary objective of FMEA is to provide a comprehensive, systematic and documented investigation which establishes the important failure conditions of the craft and assesses their significance with regard to the safety of the craft, its occupants and the environment.

202. A4.2.2 The main aims of undertaking the analysis are to:

a. .1 provide the Administration with the results of a study into the craft' s failure characteristics so as to assist in an assessment of the levels of safety proposed for the craft' s operation;

b. .2 provide craft operators with data to generate comprehensive training, operational and maintenance programmes and documentation; and

c. .3 provide craft and system designers with data to audit their proposed designs.

300. A4.3 Scope of application

301. A4.3.1 FMEA shall be conducted for each high-speed craft, before its entry into service, in respect of the systems as required under the provisions of D2.1

302. A4.3.2 For craft of the same design and having the same equipment, one FMEA on the lead craft will be sufficient, but each of the craft shall be subject to the same FMEA conclusion trials.

I2. SYSTEM MODE AND EFFECTS ANALYSIS

100. A4.4 System failure mode and effects analysis

101. A4.4.1 Before proceeding with a detailed FMEA into the effects of the failure of the system elements on the system functional output it is necessary to perform a functional failure analysis of the craft' s important systems. In this way only systems which fail the functional failure analysis need to be investigated by a more detailed FMEA.

102. A4.4.2 When conducting a system FMEA the following typical operational modes within the normal design environmental conditions of the craft shall be considered:

a. .1 normal seagoing conditions at full speed;

b. .2 maximum permitted operating speed in congested waters; and

c. .3 manoeuvring alongside.

106. A4.4.3 The functional interdependence of these systems shall also be described in either block diagrams or fault-tree diagrams or in a narrative format to enable the failure effects to be understood. As far as applicable, each of the systems to be analysed is assumed to fail in the following failure modes:

a. .1 complete loss of function;

b. .2 rapid change to maximum or minimum output;

c. .3 uncontrolled or varying output;

d. .4 premature operation;

e. .5 failure to operate at a prescribed time; and

f. .6 failure to cease operation at a prescribed time.

Depending on the system under consideration, other failure modes may have to be taken into account.

104. A4.4.4 If a system can fail without any hazardous or catastrophic effect, there is no need to conduct a detailed FMEA into the system architecture. For systems whose individual failure can cause hazardous or catastrophic effects and where a redundant system is not provided, a detailed FMEA as described in the following paragraphs shall be followed. Results of the system functional failure analysis shall be documented and confirmed by a practical test programme drawn up from the analysis.

105. A4.4.5 Where a system, the failure of which may cause a hazardous or catastrophic effect, is provided with a redundant system, a detailed FMEA may not be required provided that:

a. .1 the redundant system can be put into operation or can take over the failed system within the time-limit dictated by the most onerous operational I.200 without hazarding the craft;

b. .2 the redundant system is completely independent from the system and does not share any common system element the failure of which would cause failure of both the system and the redundant system. Common system element may be acceptable if the probability of failure complies with Part II, Title 25, Section 8; and

c. .3 the redundant system may share the same power source as the system. in such case an alternative power source shall be readily available with regard to the requirement of I2.104.1.

The probability and effects of operator error to bring in the redundant system shall also be considered.

200. A4.5 Equipment failure mode and effects analysis

201. The systems to be subject to a more detailed FMEA investigation at this stage shall include all those that have failed the system FMEA and may include those that have a very important influence on the safety of the craft and its occupants and which require an investigation at a deeper level than that undertaken in the system functional failure analysis. These systems are often those which have been specifically designed or adapted for the craft, such as the craft' s electrical and hydraulic systems.

I3. A4.6 PROCEDURES

100. Necessary steps to perform FMEA

101. The following steps are necessary to perform FMEA:

a. .1 to define the system to be analysed;

b. .2 to illustrate the interrelationships of functional elements of the system by means of block diagrams;

c. .3 to identify all potential failure modes and their causes;

d. .4 to evaluate the effects on the system of each failure mode;

e. .5 to identify failure detection methods;

f. .6 to identify corrective measures for failure modes;

g. .7 to assess the probability of failures causing hazardous or catastrophic effects, where applicable;

h. .8 to document the analysis;

i. .9 to develop a test programme;

j. .10 to prepare FMEA report.

200. A4.7 System definition

201. The first step in an FMEA study is a detailed study of the system to be analysed through the use of drawings and equipment manuals. A narrative description of the system and its functional requirements shall be drawn up including the following information:

a. .1 general description of system operation and structure;

b. .2 functional relationship among the system elements;

c. .3 acceptable functional performance limits of the system and its constituent elements in each of the typical operational modes; and

d. .4 system constraints.

300. A4.8 Development of system block diagrams

301. A4.8.1 The next step is to develop block diagram(s) showing the functional flow sequence of the system, both for technical understanding of the functions and operation of the system and for the subsequent analysis. As a minimum the block diagram shall contain:

a. .1 breakdown of the system into major sub-systems or equipment;

b. .2 all appropriate labelled inputs and outputs and identification numbers by which each sub-system is consistently referenced; and

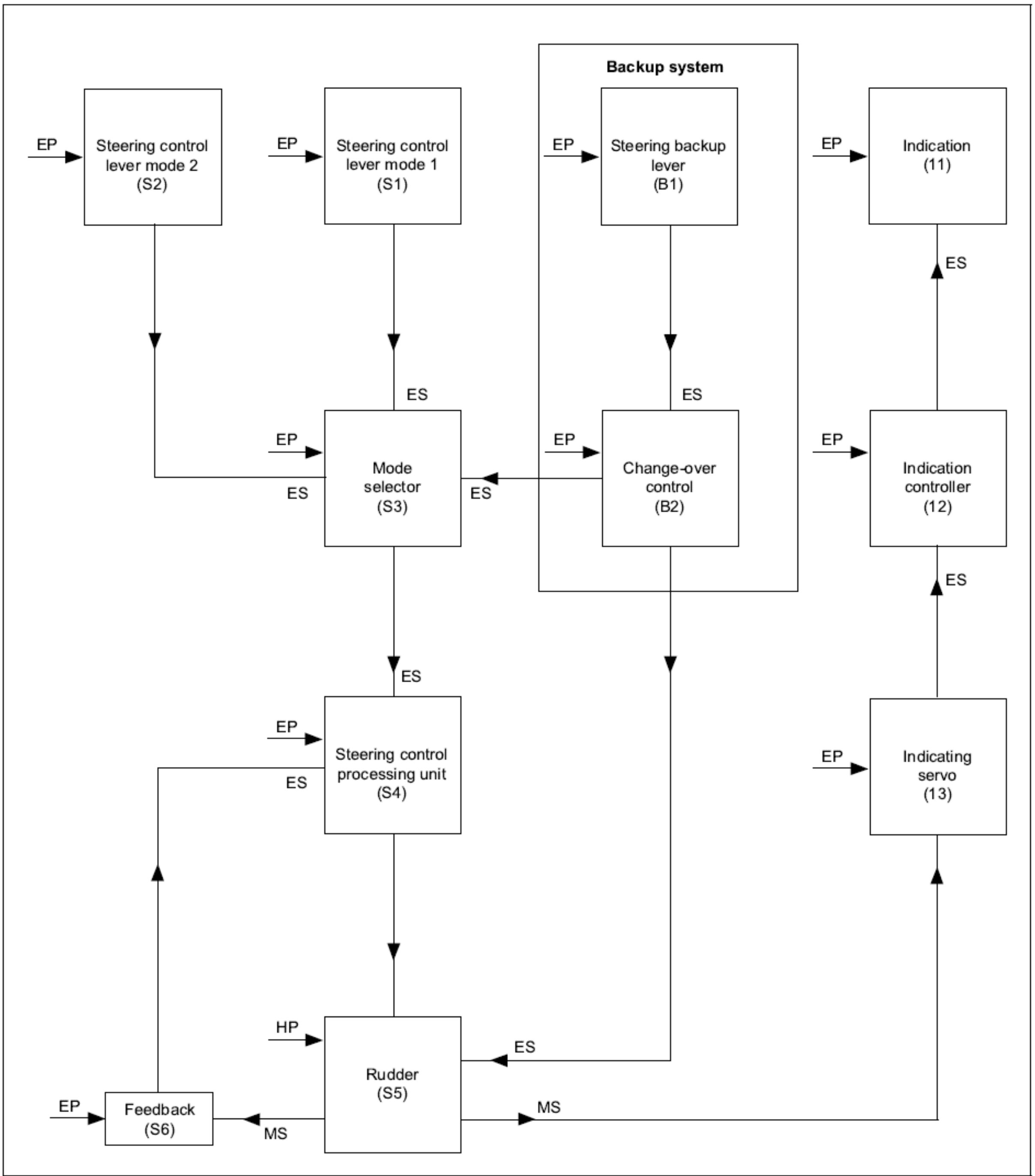
c. .3 all redundancies, alternative signal paths and other engineering features which provide "fail-safe" measures.

d. An example of a system block diagram is given at Figure F.I3.301.1 below (appendix 1 of annex 4 of the Code).

302. A4.8.2 It may be necessary to have a different set of block diagrams prepared for each operational mode.

FIGURE F.I3.301.1 – EXAMPLE OF A SYSTEM BLOCK DIAGRAM

Steering control system .... *Date: ....* *Analyst:*



where:

EP : electric power

HP : hydraulic power

ES : electric signal

MS : mechanical signal

400. A4.9 Identification of failure modes, causes and effects

401. A4.9.1 Failure mode is the manner by which a failure is observed. It generally describes the way the failure occurs and its impact on the equipment or system. As an example, a list of failure modes is given in T.I3.401.1 The failure modes listed in T.I3.401.1 can describe the failure of any system element in sufficiently specific terms. When used in conjunction with performance specifications governing the inputs and outputs on the system block diagram, all potential failure modes can be thus identified and described. Thus, for example, a power supply may have a failure mode described as "loss of output" (29), and a failure cause "open (electrical)" (31).

402. A4.9.2 A failure mode in a system element could also be the failure cause of a system failure. For example, the hydraulic line of a steering gear system might have a failure mode of "external leakage" (10). This failure mode of the hydraulic line could become a failure cause of the steering gear system' s failure mode "loss of output" (29).

Refer to IEC Publication: IEC 812 (1985), Analysis techniques for system reliability - procedure for failure mode and effects analysis (FMEA):

TABLE T.I3.401.1 - EXAMPLE OF A SET OF FAILURE MODES

Refer to IEC Publication: IEC 60812 Analysis techniques for system reliability–procedure for failure mode and effects analysis (FMEA).

1	Structural failure (rupture)	18	False actuation
2	Physical binding or jamming	19	Fails to stop
3	Vibration	20	Fails to start
4	Fails to remain (in position)	21	Fails to switch
5	Fails to open	22	Premature operation
6	Fails to close	23	Delayed operation
7	Fails open	24	Erroneous input (increased)
8	Fails closed	25	Erroneous input (decreased)
9	Internal leakage	26	Erroneous output (increased)
10	External leakage	27	Erroneous output (decreased)
11	Fails out of tolerance (high)	28	Loss of input
12	Fails out of tolerance (low)	29	Loss of output
13	Inadvertent operation	30	Shorted (electrical)
14	Intermittent operation	31	Open (electrical)
15	Erratic operation	32	Leakage (electrical)
16	Erroneous indication	33	Other unique failure conditions as applicable to the system characteristics, requirements and operational constraints
17	Restricted flow		

403. A4.9.3 Each system shall be considered in a top-down approach, starting from the system's functional output, and failure shall be assumed by one possible cause at a time. Since a failure mode may have more than one cause, all potential independent causes for each failure mode shall be identified.

404 A4.9.4 If major systems can fail without any adverse effect there is no need to consider them further unless the failure can go undetected by an operator. To decide that there is no adverse effect does not mean just the identification of system redundancy. The redundancy shall be shown to be immediately effective or brought on line with negligible time lag. In addition, if the sequence is:

"failure - alarm => operator action => start of back up => back up in service",

the effects of delay shall be considered.

500. A4.10 Failure effects

501. A4.10.1 The consequence of a failure mode on the operation, function, or status of an equipment or a system is called a "'*failure effect*". Failure effects on a specific sub-system or equipment under consideration are called "*local failure effects*". The evaluation of local failure effects will help to determine the effectiveness of any redundant equipment or corrective action at that system level. In certain instances, there may not be a local effect beyond the failure mode itself.

502. A4.10.2 The impact of an equipment or sub-system failure on the system output (system function) is called an "end effect". End effects shall be evaluated and their severity classified in accordance with the following categories:

a. .1 catastrophic;

b. .2 hazardous;

c. .3 major; and

d. .4 minor.

The definitions of these four categories of failure effects are given in Section 2, K1.203.

503. A4.10.3 If the end effect of a failure is classified as hazardous or catastrophic, back-up equipment is usually required to prevent or minimize such effect. For hazardous failure effects corrective operational procedures may be accepted.

600. A4.11 Failure detection

601. A4.11.1 The FMEA study in general only analyses failure effects based on a single failure in the system and therefore a failure detection means, such as visual or audible warning devices, automatic sensing devices, sensing instrumentation or other unique indications shall be identified.

602. A4.11.2 Where the system element failure is non-detectable (i.e. a hidden fault or any failure which does not give any visual or audible indication to the operator) and the system can continue with its specific operation, the analysis shall be extended to determine the effects of a second failure, which in combination with the first undetectable failure may result in a more severe failure effect, e.g., hazardous or catastrophic effect.

700. A4.12 Corrective measures

701. A4.12.1 The response of any back-up equipment, or any corrective action initiated at a given system level to prevent or reduce the effect of the failure mode of a system element or equipment, shall also be identified and evaluated.

702. A4.12.2 Provisions which are features of the design at any system level to nullify the effects of a malfunction or failure, such as controlling or deactivating system elements to halt generation or propagation of failure effects, or activating back-up or standby items or systems, shall be described. Corrective design provisions include:

a. .1 redundancies that allow continued and safe operation;

b. .2 safety devices, monitoring or alarm provisions, which permit restricted operation or limit damage; and

c. .3 alternative modes of operation.

703. A4.12.3 Provisions which require operator action to circumvent or mitigate the effects of the postulated failure shall be described. The possibility and effect of operator error shall be considered, if the corrective action or the initiation of the redundancy requires operator input, when evaluating the means to eliminate the local failure effects.

704. A4.12.4 It shall be noted that corrective responses acceptable in one operational mode may not be acceptable at another, e.g., a redundant system element with considerable time lag to be brought into line, while meeting the operational mode "normal seagoing conditions at full speed" may result in a catastrophic effect in another operational mode, e.g., "maximum permitted operating speed in congested water".

800. 13 Use of probability concept

801. A4.13.1 If corrective measures or redundancy as described in preceding paragraphs are not provided for any failure, as an alternative the probability of occurrence of such failure shall meet the following criteria of acceptance:

a. .1 a failure mode which results in a catastrophic effect shall be assessed to be extremely improbable;

b. .2 a failure mode assessed as extremely remote shall not result in worse than hazardous effects; and

c. .3 a failure mode assessed as either frequent or reasonably probable shall not result in worse than minor effects.

802. A4. 13.2 Numerical values for various levels of probabilities are laid down in section 3 of annex 3 of this Code. In areas where there are no data from craft to determine the level of probabilities of failure other sources can be used such as:

a. .1 workshop test, or

b. .2 history of reliability used in other areas under similar operating conditions, or

c. .3 mathematical model if applicable.

I4. DOCUMENTATION, TEST PROGRAMME AND REPORT

100. A4.14 Documentation

101. a4.14.1 It is helpful to perform FMEA on worksheet(s) as shown in appendix 2.

102. a4.14.2 The worksheet(s) shall be organized to first display the highest system level and then proceed down through decreasing system levels.

200. A4.15 Test programme

201. a4.15.1 An FMEA test programme shall be drawn up to prove the conclusions of FMEA. It is recommended that the test programme shall include all systems or system elements whose failure would lead to:

a. .1 major or more severe effects;

b. .2 restricted operations; and

c. .3 any other corrective action.

For equipment where failure cannot be easily simulated on the craft, the results of other tests can be used to determine the effects and influences on the systems and craft.

202. 15.2 The trials shall also include investigations into:

a. .1 the layout of control stations with particular regard to the relative positioning of switches and other control devices to ensure a low potential for inadvertent and incorrect crew action, particularly during emergencies, and the provision of interlocks to prevent inadvertent operation for important system operation;

b. .2 the existence and quality of the craft' s operational documentation with particular regard to the pre-voyage checklists. It is essential that these checks account for any unrevealed failure modes identified in the failure analysis; and

c. .3 the effects of the main failure modes as prescribed in the theoretical analysis.

203. a4.15.3 The FMEA tests on board shall be conducted in conjunction with provisions specified in 5.3, 16.4 and 17.4 of this Code, before the craft enters into service.

300. A4.16 FMEA Report

301. The FMEA report shall be a self-contained document with a full description of the craft, its systems and their functions and the proposed operation and environmental conditions for the failure modes, causes and effects to be understood without any need to refer to other plans and documents not in the report.

302. The analysis assumptions and system block diagrams shall be included, where appropriate.

303. The report shall contain a summary of conclusions and recommendations for each of the systems analysed in the system failure analysis and the equipment failure analysis.

304. It shall also list all probable failures and their probability of failure, where applicable, the corrective actions or operational restrictions for each system in each of the operational modes under analysis.

305. The report shall contain the test programme, reference any other test reports and the FMEA trials.

CHAPTER T
TESTS

CHAPTER CONTENTS

T1. ENGINES AND OTHER MACHINERY EQUIPMENTS

100. Quay and sea trials

101. A Program of Surveys and Testing is to be submitted to RBNA for approval, with quay trials, for calibration of operation before shipping, and sea trials, from which will result in a Report of Survey and Testing, where the indexes and performance of engines and machinery equipment are recorded.

102. The assessment of performance of propulsion engines consists of four hours of uninterrupted operation at nominal power.

200. Temperature of the machinery spaces

201. Ambient temperatures at various locations of the machinery spaces are to be measured with the engine in normal working operation, after a minimum of one (1) hour, and openings closed. The temperatures are not to exceed 45^{o} C.

202. During the sea trial temperatures are to be measured at the exposed as well as isolated surfaces of combustion engines, boilers and their discharge pipelines to detect spots with temperatures above 220 ° C.

The most critical points to be examined are:

a. Engine casing;

b. Cylinder head lubricating valves;

c. cylinder head covers;

d. connections to the exhaust manifold;

e. exhaust pipes, specially overlap between metal plates and insulation;

f. bedplates and supports for exhaust manifold;

g. turbochargers, specially at their flanges;

h. output for temperature and pressure sensors;

i. surface of lighting reflectors; and

j. Most critical points that statistically have been the cause of fires.

300. Clearances and tolerances

301. The clearances of bearings and couplings are to be measured during sea trials.

T2. TRANSMISSION ELEMENTS

100. Bearings, liners and bearing bushings

101. In addition to the requirements of Part III of the Rules, liners and bronze bearings or other approved materials should have their composition identified and traced, free from porosity and / or harmful defects and tightness hydrostatically tested at a pressure of 20 N/mm² (2 Kgf/mm²).

102. The temperatures of bearings are to be taken during sea trials.

T3. STEERING GEAR TESTS

100. Testing at the manufacturer

101. See Part III, Title 62, Section5, Chapter I.

200. Trials

201. The steering gear should be tried out on the trial trip in order to demonstrate to the Surveyor's satisfaction that the requirements of the Rules have been met. The trial is to include the operation of the following:

a. the steering gear, including demonstration of the performances required by Regulation 29.3.2 and 29.4.2. For controllable pitch propellers, the propeller pitch is to be at the maximum design pitch approved for the maximum continuous ahead R.P.M. at the main steering gear trial.

a.1. If the vessel cannot be tested at the deepest draught, steering gear trials shall be conducted at a displacement as close as reasonably possible to full-load displacement as required by Section 6.1.2 of ISO 19019:2005 on the conditions that either the rudder is fully submerged (zero speed waterline) and the vessel is in an acceptable trim condition, or the rudder load and torque at the specified trial loading condition have been predicted and extrapolated to the full load condition. In any case for the main steering gear trial, the speed of ship corresponding to the number of maximum continuous revolution of main engine and maximum design pitch applies.

b. the steering gear power units, including transfer between steering gear power units.

c. the isolation of one power actuating system, checking the time for regaining steering capability.

d. the hydraulic fluid recharging system.

e. the emergency power supply required by Regulation 29.14.

f. the steering gear controls, including transfer of control and local control.

g. the means of communication between the wheelhouse, engine room, and the steering gear compartment.

h. the alarms and indicators required by regulations 29, 30 and K5.300 above, these tests may be effected at dockside.

i. where steering gear is designed to avoid hydraulic locking this feature shall be demonstrated.

T4. TESTING OF MASS PRODUCED I.C. ENGINES AT MANUFACTURER

See Part III, Title 62, Section 5, Chapter H.

T5. ADDITIONAL TESTS COMMON FOR ALL NOTATIONS OF AUTOMATION SYSTEMS

100. Qualification of the components.

101. Manufacturers of control systems must certify that the mechanical, electrical and the solid state components, made by them, were individually tested and have satisfactory results or that were passed through the batch tests of samples, in order to establish its suitability for the requested service, including compliance with conditions described in chapter C. above. See Part III,Title 63, Section 8 for the main tests of equipment.

200. Quay and sea trials

201. After the installation, the automation system is submitted to the quay and sea trials to demonstrate that the entire system operates satisfactorily during conditions of standby, maneuvers, continuous operation and transfer between stations.

T6. ADDITIONAL TESTS FOR THE AUTOMATION SYSTEM WITH NOTATION AUT-F

See Part II, Title 102, Section 5, Subchapter T3.

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