Chapter 9
Machinery

Part A - General

9.1 General

9.1.1 The machinery, associated piping systems and fittings relating to main machinery and auxiliary power units should be of a design and construction adequate for the service for which they are intended and should 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 should 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.

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

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

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

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

.2 the fuel oil supply systems for engines;

.3 the sources of lubricating oil pressure;

.4 the sources of water pressure;

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

.6 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.

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

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

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

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

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:

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

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

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

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

9.1.12 Main propulsion machinery and all auxiliary machinery essential to the propulsion and the safety of the craft should, 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.

9.1.13 All boilers, and pressure vessels and associated piping systems should be of a design and construction adequate for the purpose intended and should be so installed and protected as to minimise danger to persons on board. In particular, attention should 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 should 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.

9.1.14 Arrangements should 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.

9.2 Engine (general)

9.2.1 The engines should be fitted with adequate safety monitoring and control devices in respect of speed, temperature, pressure and other operational functions. Control of the machinery should be from the craft's operating compartment. Category B craft and cargo craft should be provided with additional machinery controls in or close to the machinery space. The machinery installation should be suitable for operation as in an unmanned machinery space [See footnote 23] 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.

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

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

9.2.4 The major components of the engine should have adequate strength to withstand the thermal and dynamic conditions of normal operation. The engine should 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.

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

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

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

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

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

9.3 Gas turbines

9.3.1 Gas turbines should be designed to operate in the marine environment and should be free from surge or dangerous instability throughout its operating range up to the maximum steady speed approved for use. The turbine installation should 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 should 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.

9.3.3 Requirements of 9.2.6 should 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.

9.3.4 Turbines should 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 should be made available. Provision should be made for preventing the accumulation of salt deposits on the compressors and turbines and, if necessary, for preventing the air intake from icing.

9.3.5 In the event of a failure of a shaft or weak link, the broken end should 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.

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

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 should be provided for the acoustic enclosure.

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 should be provided together with the failure mode and effect analysis.

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

9.4 Diesel engines for main propulsion and essential auxiliaries

9.4.1 Any main diesel propulsion system should 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.

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

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

9.4.4 The lubrication system and arrangements should 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.

9.4.5 Arrangements should 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 should also cause automatic reduction of engine speed to a safe level, but automatic shutdown should only be activated by conditions leading to a complete breakdown, fire or explosion.

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 should be such as to minimise the risk of fire or explosion.

9.5 Transmissions

9.5.1 The transmission should 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.

9.5.2 The design of shafting, bearings and mounts should 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.

9.5.3 The strength and fabrication of the transmission should 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 should 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.

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

9.5.5 Provision should 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.

9.5.6 Where failure of lubricating fluid supply or loss of lubricating fluid pressure could lead to hazardous conditions, provision should 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.

9.6 Propulsion and lift devices

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

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

.2 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.

.3 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.

9.6.2 The propulsion and lift devices should be of adequate strength and stiffness. The design data, calculations and trials, where necessary, should 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.

9.6.3 The design of propulsion and lift devices should 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.

9.6.4 The design data and testing of propulsion and lift devices should 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.

9.6.5 Appropriate arrangements should be made to ensure that:

.1 ingestion of debris or foreign matter is minimised;

.2 the possibility of injury to personnel from shafting or rotating parts is minimised; and

.3 where necessary, inspection and removal of debris can be carried out safely in service.

Part B
Requirements for Passenger Craft

9.7 Independent means of propulsion for category B craft

Category B craft should 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.

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

Category B craft should 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.

Part C
Requirements for Cargo Craft

9.9 Essential machinery and control

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