# CHAPTER 9

# MACHINERY

***EU Directive on Electromagnetic Compatibility (89/336/EEC, repealed by 2004/108/EC of 15 December 2004)***

*Electrical and electronic equipment that may either generate or be affected by electromagnetic disturbance shall meet the requirements of EC Directive 89/336/EEC, repealed by 2004/108/EC of 15 December 2004. Equipment complying with this directive should have an EC mark or CE marking in accordance with EC Directives 2004/108/EC of 15 December 2004, or 93/68/EEC (with Corrigendum dated 30 August 1993), as amended.*

***EU Directive on Electrical Equipment designed for use within certain voltage limits (73/23/EEC repealed by 2006/95/EC of 12 December 2006)***

*Electrical Equipment designed for use with a voltage rating of between 50 and 1000 volts for alternating current and between 75 and 1500 volts for direct current shall meet the requirements of EU Directive 73/23/EEC repealed by 2006/95/EC of 12 December 2006, except for specialised electrical equipment, for use on ships, which comply with the safety provisions drawn up by international bodies in which the Member States participate.*

***MARPOL 73/78 – Annex VI***

*Diesel engines of more than 130 kW output which are installed in Craft constructed after 1st January 2000 shall be certificated as complying with the Control of Emission of Nitrogen Oxides ($NO_X$) requirements as outlined in Marine Guidance Note MGN 142 (M+F), and MARPOL 73/78 - ANNEX VI: Control of Emission of Nitrogen Oxides (NOx) from Marine Diesel Engines.*

*Refer also to S.I. 2008 No. 2924 The Merchant Shipping Prevention of Air Pollution from Ships Regulations, MSN 1819(M+F) Prevention of Air Pollution from Ships, MGN381(M+F) Survey and Certification Requirements for The Merchant Shipping (Prevention of Air Pollution from Ships) Regulations 2008 and MGN386(M+F) - additional guidance.*

# PART A – GENERAL

## 9.1 General

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.

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.

*The insulation provided shall be such that the surface temperature of the insulation covering is no more than 220°C.*

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.

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:

.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; and

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

*For the meaning of "dead craft condition" refer to the Unified interpretation to the 2000 HSC Code (MSC/Circ.1177).*

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.

9.1.7 Provision shall 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 shall 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 shall include machinery systems and their associated controls.

*The FMEA shall comply with the requirements of Annex 3 and Annex 4. Normally compliance will be achieved by provision of redundant systems as detailed in 4.5 of Annex 4,*

*and numerical assessment will not be required. Consideration should be given to the independence of redundant systems as required by 4.5.2 of Annex 4. It is recommended that FMEA's should be forwarded to MCA Headquarters for advice, particularly those which comply by means of numerical assessment.*

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.

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.

*Consideration may be given to reduced static angles of inclination, provided these are not less than the residual inclination angles resulting from the application of the damage specified in Chapter 2, excluding the extreme damage case of 2.13.2.*

*Consideration may also be given to reduced dynamic inclinations where it can be shown that either the craft is large relative to the worst intended operating conditions, or the behaviour of the specific craft type may merit this, for example amphibious hovercraft or SWATH catamarans. Model test or full-scale measurements may be used to support such special consideration.*

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.

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.

## 9.2 Engine (general)

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 *for "additional requirements for periodically unattended machinery spaces".*

*"Operating compartment" is defined in section 1.4.42.*

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.

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.

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.

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.

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.

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.

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.

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

## 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.

*A torsional vibration analysis should be conducted for gas turbine driven propulsion systems in order to determine if there are any speed ranges where vibration 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.

*It is not considered a requirement to protect against bursting of the disks to which the compressor and turbine blades are attached. The energy released during such a burst cannot practically be contained on a high-speed craft.*

9.3.3 Requirements of 9.2.6 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.

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.

*Air intake icing should include consideration of preventing accumulation of ice within the inlet system that may come loose and enter the engine and also of the inlet filtration system that may become clogged causing a high inlet depression.*

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.

*If a flailing guard is fitted calculations should be provided to prove its strength under these conditions.*

9.3.6 Each engine shall 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 shall be provided for the acoustic enclosure.

*A fire detection and extinguishing system should also be provided where the enclosure is not of the acoustic type.*

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.

*See Annex 3 and Annex 4 for details of the FMEA.*

9.3.9 The manufacturers shall demonstrate the soundness of the casings. Intercoolers and heat exchangers shall 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 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.

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.

*This applies for vessels with power outputs of 375 kW or more, operating around the UK, but not to lifeboats or to diesel fire pumps. For guidance on high pressure fuel pipes and guidance on vessels with power output <375 kW, domestic passenger vessels on seagoing voyages and those in categorized waters see the latest MCA internal guidance on Sheathed Fuel Lines which should, if practicable, be followed in conjunction with IMO Resolutions MSC.31(63) (effective 1 January 1996 and 1 July 1998) and MSC.201(81) (effective 1 January 2010). Retrospective application is not required.*

9.4.3 Engines of a cylinder diameter of 200 mm or a crankcase volume of 0.6 $m^3$ 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.

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.

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.

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.

## 9.5 Transmissions

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.

*Compliance with the requirements of a recognised Classification Society would be deemed adequate to meet this requirement. Propulsion systems utilizing waterjets may need to take account of the shock loadings imposed by aeration and emergence of the waterjet. See Appendix B for listing of recognised organisations.*

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.

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.

*Propulsion systems utilizing waterjets may need to take account of the shock loadings imposed by aeration and emergence of the waterjet, both in terms of fatigue and torsional vibrations.*

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.

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.

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.

## 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 device. 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 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.

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.

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.

*Due consideration should also be made for devices that alter the pressure in an ACV cushion in order to affect craft motion (ride control systems).*

9.6.5 Appropriate arrangements shall 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 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.

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

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.

# PART C - REQUIREMENTS FOR CARGO CRAFT

## 9.9 Essential machinery and control

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.