20 WORK ON MACHINERY AND POWER SYSTEMS

20.1 Introduction

20.1.1 Based on the findings of the risk assessment, before any maintenance work is carried out, appropriate control measures should be put in place to protect those seafarers concerned and others who may be affected. This chapter identifies some areas that may require attention.

20.2 General

20.2.1 No maintenance work or repair that may affect the supply of water to the fire main or sprinkler system should be started without the prior permission of the master and chief engineer.

20.2.2 No alarm system should be isolated without the permission of the master and chief engineer.

20.2.3 Means of access to firefighting equipment, emergency escape routes and watertight doors should never be obstructed.

20.2.4 Safety guards on machinery or equipment should only be removed when the machinery is not operating. If removal is essential for maintenance or examination of the equipment, the following precautions should be taken:

- Removal should be authorised by a responsible person, and only a competent person should carry out the work or examination.
- There should be adequate clear space and lighting for the work to be done.
- Anyone working close to the machinery should be told what the risks are and instructed in safe systems of work and precautions to take.
- A warning notice should be conspicuously posted.

20.2.5 Whenever floor plates or handrails are removed, warning notices should be posted, the openings should be effectively fenced or guarded and the area well illuminated. Floor

plates and handrails should be secured in place on completion of the work being undertaken.

20.2.6 Lifting handles should be used when a floor plate is removed or replaced. When lifting handles are not provided, the plate should be levered up with a suitable tool and a chock inserted before lifting. On no account should fingers be used to prise up the edges.

20.2.7 Solvents used for cleaning can be toxic and they should always be used in accordance with the manufacturer's instructions. The area should be well ventilated, and smoking prohibited.

20.3 Work in machinery spaces

20.3.1 Every dangerous part of a ship's machinery or other equipment should have guards or protection devices to prevent access to danger zones or to halt movements of dangerous parts before the danger zones are reached. Guidance is given in marine guidance note MGN 331(M+F).

S.I. 2006/2183 and MGN 331(M+F)

20.3.2 All steam pipes, exhaust pipes and fittings, which by their location and temperature present a hazard, should be adequately lagged or otherwise shielded. The insulation of hot surfaces should be properly maintained, particularly in the vicinity of oil systems. This can be monitored through thermographic survey or the use of infra-red thermometers to ensure that surface temperatures do not exceed 220°C.

SOLAS II-2 Reg. 4.2.2.6

20.3.3 Seafarers required to work in machinery spaces that have high noise levels should wear suitable hearing protection (see section 8.6).

20.3.4 Where a high noise level in a machinery space, or the wearing of ear protectors, may mask an audible alarm, a visual alarm of suitable intensity should be provided, where practicable, to attract attention and indicate that an audible alarm is sounding. This should preferably take the form of a light or lights with rotating reflectors. Guidance may be found in the International Maritime Organization (IMO) Code on Alerts and Indicators.

20.3.5 The source of any oil leakage should be located and repaired as soon as practicable.

20.3.6 Waste oil should not be allowed to accumulate in the bilges or on tank tops. Any leakage of fuel, lubricating or hydraulic oil should be disposed of in accordance with Merchant Shipping (Prevention of Oil Pollution) Regulations 1996 at the earliest opportunity. Tank tops and bilges should, wherever practicable, be painted a light colour and kept clean and well illuminated in the vicinity of pressure oil pipes so that leaks may be readily located.

S.I. 1996/2154

20.3.7 Extreme caution is required when filling any settling or other oil tank to prevent it overflowing, especially in an engine room where exhaust pipes or other hot surfaces are directly below. Manholes or other openings in the tanks should always be secured so that if a tank is overfilled the oil is directed to a safe place through the overflow arrangements.

20.3.8 Particular care should be taken when filling tanks that have their sounding pipes in the machinery spaces to ensure that weighted cocks are closed. In no case should a weighted cock on a fuel or lubricated oil tank sounding pipe or on a fuel, lubricating or hydraulic oil tank gauge be secured in the open position.

20.3.9 Engine room bilges should at all times be kept clear of rubbish and other substances so that mud-boxes are not blocked and the bilges may be readily and easily pumped.

20.3.10 Remote controls fitted for stopping machinery or pumps, or for operating oil-tank quick-closing valves in the event of fire, should be tested regularly to ensure that they are functioning satisfactorily. This also applies to the controls on fuel storage daily service tanks (other than double bottoms) and lubricating oil tanks.

20.3.11 Cleaning solvents should always be used in accordance with manufacturers' instructions and in an area that is well ventilated.

20.3.12 Care should be taken to ensure that spare gear is properly stowed and items of machinery under overhaul are safely secured so that they do not break loose and cause injury or damage even in the heaviest weather.

20.3.13 Procedures should be in place to identify defects caused by vibration, fatigue, poor components and poor fitting of the fuel system and ensure that protection of hot surfaces is maintained.

MSC.1/Circ.1321

20.3.14 A supply of tools necessary for the tasks expected of personnel working in the engine room should be maintained in a location that minimises the distance a loaded tool box is likely to need transporting and, as much as possible, avoids the necessity of carrying tools up and down ladders.

20.3.15 A supply of personal protective equipment and consumables (such as light bulbs, flashlights, batteries, rags, log books and stationery) should be maintained close to the engine room for the use of the personnel working there.

MSC/Circ.834

20.4 Unmanned machinery spaces

20.4.1 Seafarers should never enter or remain in an unmanned machinery space alone, unless they have received permission from or been instructed by the engineer officer in charge at the time. They may only be sent to carry out a specific task that they may be expected to complete in a comparatively short time. Before entering the space, at regular intervals whilst in the space and on leaving the space, they must report by telephone, or other means provided, to the duty deck officer (see also section 20.4.4). Before they enter the space, the method of reporting should be clearly explained. Consideration should be given in appropriate instances to using a permit to work (see section 14.2).

20.4.2 If it is the engineer officer in charge who enters the machinery space alone, they too should report to the deck officer before entry, at regular intervals whilst in the space and on leaving the space.

20.4.3 Notice of safety precautions to be observed by seafarers working in unmanned machinery spaces should be clearly displayed at all entrances to the space. Warning should be given that in unmanned machinery spaces there is a likelihood of machinery suddenly starting up.

20.4.4 If there is a personnel alarm system in place, reporting at regular intervals may be omitted. A personnel alarm is a system that will indicate a person's presence and their well-being in unmanned machinery spaces. Vessels without a personnel alarm system should have additional guidance recorded in the safety management system.

20.4.5 Unmanned machinery spaces should be adequately illuminated at all times.

20.4.6 When machinery is under bridge control, the bridge should always be advised when a change in machinery setting is contemplated by the engine room staff, and before a reversion to engine room control of the machinery.

20.5 Maintenance of machinery

20.5.1 Before machinery is serviced or repaired, measures should be taken to prevent it being turned on or started automatically or from a remote-control system.

- Electrically operated machinery should be isolated from the power supply.
- Steam-operated machinery should have both steam and exhaust valves securely closed, the valves locked or tied shut or some other means employed to indicate that the valves should not be opened. The same care is required when dealing with heated water under pressure as is required when working on steam-operated machinery or pipework.
- In all cases, warning notices should be posted at or near the controls giving warning that the machinery concerned is not to be used.
- Hydraulic-operated machinery should have its own oil supply valve isolated and the oil return valve if fitted.

20.5.2 The cleaning or replacement of fuel or lubricating filter elements on engines or turbines should, so far as practicable, only be undertaken with the engine or turbine in the stopped condition. Where valves or filter covers have to be removed or similar operations have to be performed on pressurised systems, that part of the system should be isolated by closing the appropriate valves. The position of a duplex filter change over cock does not guarantee that the 'out of service' filter chamber has been isolated. The drain and/or vent cocks should be opened gradually to ensure that pressure is off the system before any other fastenings of bolts are slackened off.

20.5.3 When joints of pipes, fittings, etc. are being broken, the fastenings should not be completely removed until the joint has been broken and it has been established that no pressure remains within.

20.5.4 Before a section of a steam pipe system is opened to the steam supply, all drains should be opened. Steam should be admitted very slowly and the drains kept open until all the water has been expelled.

20.5.5 Maintenance or repairs to, or immediately adjacent to, moving machinery should be permitted only in circumstances where no danger exists or where it is impracticable for the machinery to be stopped. Close-fitting clothing should be worn and long hair should be covered (see section 8.5.5). The officer in charge should consider whether it is necessary in the interests of safety for a second person to be in close attendance whilst the work is being carried out.

20.5.6 Heavy parts of dismantled machinery temporarily put aside should be firmly secured against movement in a seaway and, as far as practicable, be clear of walkways. Sharp projections on them should be covered when reasonably practicable.

20.5.7 Spare gear, tools and other equipment or material should never be left lying around, especially near to stabiliser or steering gear rams, switchboards and batteries.

20.5.8 A marlin spike, steel rod or other suitable device should be used to align holes in machinery being reassembled or mounted; fingers should never be used.

20.5.9 When guards or other safety devices have been removed from machinery, they should be replaced immediately once the work is completed and before the machinery or equipment is tested.

20.5.10 An approved safety lamp should always be used for illuminating spaces where oil or oil vapour is present. Vapour should be dispersed by ventilation before work is done.

20.6 Boilers and thermal oil heaters

20.6.1 Boilers should be opened only under the direction of an engineering officer. Care should be taken to check, after emptying, that the vacuum is broken before manhole doors are removed. Even if an air cock has been opened to break the vacuum, the practice should always be to loosen the manhole door nuts and break the joint before the removal of the

dogs and knocking in the doors. The top manhole doors should be removed first. Seafarers should stand clear of hot vapour when doors are opened.

20.6.2 Seafarers should not enter any boiler, boiler furnace or boiler flue until it has cooled sufficiently to make work in such places safe.

20.6.3 Before entry is permitted to a boiler that is part of a range of two or more boilers, the engineer officer in charge should ensure that either:

- all inlets through which steam or water might enter the boiler from any other part of the range have been disconnected, drained and left open to atmosphere; or
- where that is not practicable, all valves or cocks, including blowdown valves controlling entry of steam or water, have been closed and securely locked, and notices posted to prevent them being opened again until authorisation is given.

The above precautions should be maintained as long as seafarers remain in the boiler.

20.6.4 Seafarers cleaning tubes, scaling boilers and cleaning backends should wear appropriate protective clothing and equipment including respirators. The Company should also ensure that seafarers familiarise themselves with the accompanying datasheet to any chemical agents they may use in the course of their work. They should also be aware of the potentially hazardous gaseous by-products that may be produced from the reaction of the cleaner/de-scaling product and the object itself or from products used together, because this may result in an asphyxiating, explosive or other hazardous atmosphere.

20.6.5 A boiler is enclosed and, therefore, potentially a dangerous space. Special care should be exercised before entry is made in a boiler that has not been in use for some time or where chemicals have been used to prevent rust forming. The atmosphere may be deficient in oxygen and tests should be carried out before any person is allowed to enter. See Chapter 15 for advice on entering dangerous (enclosed) spaces.

20.6.6 A notice should be displayed at each boiler setting out operating instructions. Information provided by the manufacturers of the oil-burning equipment should be displayed in the boiler room.

20.6.7 To avoid the danger of a blowback when lighting boilers, the correct flashing-up procedure should always be followed:

- There should be no loose oil on the furnace floor.
- The oil should be at the correct temperature for the grade of oil being used; if not, the temperature of the oil must be regulated before lighting is attempted.
- The furnace should be blown through with air to clear any oil vapour.
- The torch, specially provided for the purpose, should always be used for lighting a burner unless an adjacent burner in the same furnace is already lit; other means of ignition, such as the introduction of loose burning material into the furnace, should not be used. An explosion may result from attempts to relight a burner from the hot brickwork of the furnace.
- If all is in order, the operator should stand to one side, and the lighted torch should be inserted and fuel turned on. Care should be taken that there is not too much oil on the torch that could drip and possibly cause a fire.
- If the oil does not light immediately, the fuel supply should be turned off and the furnace ventilated by allowing air to blow through for two or three minutes to clear any oil vapour before a second attempt to light is made. During this interval the burner should be removed and the atomiser and tip inspected to verify that they are in good order.
- If there is a total flame failure while the burner is alight, the fuel supply should be turned off.

20.6.8 The avenues of escape from the boiler fronts and firing spaces should be kept clear.

20.6.9 Where required to be fitted, the gauge glass cover should always be in place when the glass is under pressure. If a gauge glass or cover needs to be replaced or repaired, the gauge should be shut off and drained before the cover is removed.

20.6.10 The same isolating and maintenance principles should be applied to thermal oil heaters and systems as those required for boilers. However, as the venting and drainage systems are closed systems to the thermal oil header tank or thermal oil drain tank respectively, additional care must be taken when isolating heaters to ensure that the system is fully drained and no residual pressure remains, before fittings are removed or pipes disconnected.

20.6.11 On completion of work on thermal systems, care must be taken to prevent water and moisture being introduced to the system. The steam produced, its sudden expansion and the significantly greater volume occupied may cause damage to equipment and significant disruption to the system as a whole. Before the system is refilled from the thermal oil header tank, the header tank drain should be tested for the presence of water. This should also be done whenever the header tank is refilled from the thermal oil drain tank or thermal oil storage tank.

20.7 Auxiliary machinery and equipment

20.7.1 Before starting work on an electric generator or auxiliary machine, the machine should be stopped and the starting air valve or similar device should be secured so that it cannot be operated. A notice should be posted warning that the machine is not to be started nor the turning gear used. To avoid the danger of motoring and electric shock to any person working on the machine, it should be isolated electrically from the switchboard or starter before work is commenced. The circuit breaker should be opened and a notice posted at the switchboard warning seafarers that the breaker is **not** to be closed. Where practicable, the circuit breaker should be locked open and/or access prevented.

20.7.2 No attempt should be made to start a diesel engine without first barring round with the indicator cocks open. The barring gear should then be disengaged before starting the engine.

20.7.3 Oily deposits of flammable material should never be allowed to build up in the way of diesel engine relief valves, crankcase explosion doors or scavenge belt safety discs.

20.7.4 Flammable coatings should never be applied to the internal surfaces of air starting reservoirs.

20.7.5 When testing a diesel engine fuel injector or other high-pressure parts of injection equipment, jets should be contained so that they are not allowed to spray onto any part of the body.

20.7.6 Oxygen should on no account be used for starting engines. To do so would probably cause a violent explosion.

20.8 Main engines

20.8.1 Where necessary, suitable staging, which is adequately secured, should be used to provide a working platform.

20.8.2 Before anyone is allowed to enter or work in the main engine crankcase or gear case, the engine-starting system must be in local control and fully isolated with starting air drains opened to atmosphere. Turning gear should be engaged and a warning notice posted at the start position and turning gear local control. Turning gear should be under the control of the person carrying out the work. The spaces should be well ventilated and the atmosphere tested.

20.8.3 Before the main engine turning gear is used, a check should be made to ensure that all seafarers are clear of the crankcase and any moving part of the main engine, and that the duty deck officer has confirmed that the propeller is clear.

20.8.4 If a hot bearing has been detected in a closed crankcase, the crankcase should not be opened until sufficient time has been allowed for the bearing to cool down; otherwise the entry of air could create an explosive air/oil vapour mixture.

20.8.5 The opened crankcase or gear case should be well ventilated to expel all flammable gases before any source of ignition, such as a portable lamp (unless of an approved safety type), is brought near to it.

20.8.6 Before the main engine is restarted, a responsible engineer officer should check that the shaft is clear and inform the duty deck officer who should confirm that the propeller is clear.

20.9 Refrigeration machinery and refrigerated compartments

20.9.1 No one should enter a refrigerated chamber for maintenance activities without first informing a responsible officer.

20.9.2 Seafarers charging or repairing refrigeration plants should fully understand the precautions to be observed when handling the refrigerant. Adequate information should be available on each vessel, laying down the operation and maintenance safeguards of the

refrigeration plant, the particular properties of the refrigerant and the precautions for its safe handling.

20.9.3 The compartment or flat in which refrigeration machinery is fitted should be adequately ventilated and illuminated. Where fitted, both the supply and exhaust fans to and from compartments in which refrigeration machinery is situated should be kept running at all times. Inlets and outlets should be kept unobstructed. When there is any doubt as to the adequacy of the ventilation, a portable fan or other suitable means should be used to assist in the removal of toxic gases from the immediate vicinity of the machine.

20.9.4 Should it be known or suspected that the refrigerant has leaked into any compartments, no attempt should be made to enter those compartments until a responsible officer has been advised of the situation. If it is necessary to enter the space, the procedures for entry into dangerous (enclosed) spaces should be followed (see Chapter 15, Entering dangerous (enclosed) spaces).

20.9.5 When refrigerant plants are being charged through a charging connection in the compressor suction line, it is sometimes the practice to heat the cylinder to evaporate the last of the liquid refrigerant. This should only be done by placing the cylinder in hot water or some similar indirect method and never by heating the cylinder directly with a blow lamp or other flame. Advice on the handling and storage of gas cylinders is given in section 24.8.

20.9.6 If it is necessary for repair or maintenance to apply heat to vessels containing refrigerant, appropriate valves should be opened to prevent build-up of pressure within the vessels.

20.10 Steering gear

20.10.1 Generally, work should not be done on steering gear when a ship is under way. If it is necessary to work on steering gear when the vessel is at sea, the ship should be stopped and suitable steps taken to immobilise the rudder by closing the valves on the hydraulic cylinders or by other appropriate and effective means.

20.11 Hydraulic and pneumatic equipment

20.11.1 Before repairs to or maintenance of hydraulic and pneumatic equipment is undertaken, any load should be removed or, if this is not practical, adequately supported by other means. All pressure in the system should be released. The part being worked upon should be isolated from the power source and a warning notice displayed by the isolating valve, which should be locked.

20.11.2 Precautions should be taken against the possibility of residual pressure being released when unions or joints are broken.

20.11.3 Absolute cleanliness is essential for the proper and safe operation of the hydraulic and pneumatic system; the working area and tools, as well as the system and its components, should be kept clean during servicing work. Care should also be taken to ensure that replacement units are clean and free from any contamination, especially fluid passages.

20.11.4 Only replacement components that comply with manufacturers' recommendations should be used. Any renewed or replacement item of equipment should be properly inspected or tested before being put into operation within the system.

20.11.5 Since vapours from hydraulic fluid may be flammable, naked lights should be kept away from hydraulic equipment that is being tested or serviced.

20.11.6 A jet of hydraulic fluid under pressure should never be allowed to spray onto parts of the body. If a person is subjected to hydraulic fluid under high pressure on unprotected skin, immediate medical assistance should be sought. Any hydraulic fluid spilt on the skin should be thoroughly washed off.

20.12 Electrical equipment

20.12.1 The risks of electric shock are much greater on board ship than they are normally ashore because wetness, high humidity and high temperature (including sweating) reduce the contact resistance of the body. In those conditions, severe and even fatal shocks may be caused at voltages as low as 60V. It should also be borne in mind that cuts and abrasions significantly reduce skin resistance.

20.12.2 A notice of instructions on the treatment of electric shock should be posted in every place containing electrical equipment and switchgear. Immediate on-the-spot treatment of an unconscious patient is essential.

20.12.3 Before any work is done on electrical equipment, fuses should be removed or circuit breakers opened to ensure that all related circuits are dead. If possible, switches and circuit breakers should be locked open or, alternatively, a 'not to be closed' notice attached. Where a fuse has been removed, it should be retained by the person working on the equipment until the job is finished. A check should be made that any interlocks or other safety devices are operative. Additional precautions are necessary to ensure safety when work is to be undertaken on high-voltage equipment (designed to operate at a nominal system voltage in excess of 1000V). The work should be carried out by, or under the direct supervision of, a competent person with sufficient technical knowledge and a permit to work system should be operated.

20.12.4 Some parts of certain types of equipment may remain live even when the equipment is switched off. Power should always be cut off at the mains.

20.12.5 Flammable materials should never be left or stored near switchboards.

20.12.6 Work on or near live equipment should be avoided if possible but when it is essential for the safety of the ship or for testing purposes, the following precautions should be taken:

- A second person, who should be competent in the treatment of electric shock, should be continually in attendance.
- The working position adopted should be safe and secure to avoid accidental contact with the live parts. Insulated gloves should be worn where practicable.
- Contact with the deck, particularly if it is wet, should be avoided. Footwear may **not** give adequate insulation if it is damp or has metal studs or rivets. The use of a dry insulating mat at all times is recommended.
- Contact with bare metal should be avoided. A hand-to-hand shock is especially dangerous. To minimise the risk of a second contact should the working hand accidentally touch a live part, one hand should be kept in a trouser pocket whenever practicable.

- Wrist watches, metal identity bracelets and rings should be removed. They provide low-resistance contacts with the skin. Metal fittings on clothing or footwear are also dangerous.

20.12.7 Any test meters used should be rated for the voltage being tested with meter probes having only minimum amounts of metal exposed and insulation of both probes should be in good condition. The probes should incorporate finger guards, which prevent contact with live conductors. Care should be taken that the probes do not short circuit adjacent connections. Where practicable, probes should be fitted with high breaking capacity fuse (typically 500mA) or a current limiting resistor and fuse. When measuring voltages that are greater than 250V, the probe should be attached and removed with the circuit dead.

20.12.8 The conducting tips of probes should have a maximum dimension of 4mm (and where possible 2mm or less and / or fitted with a retractable shield). Leads should be flexible and of sufficient length for the purpose but not so long as to be unwieldy. Meter sockets and lead plugs should not allow any possibility of finger contact being made with the conductor should the lead become detached from the socket.

20.12.9 Good practice should be followed and all seafarers should be made aware of the potential dangers in the space in which they are working. The test equipment should be suitable for the system under examination, checked for damage before use, proved to be operational before and after use.

20.13 Main switchboards

20.13.1 The internal cleaning and maintenance of the main switchboard must only be carried out while it is in a 'dead' condition; after a full risk assessment has been carried out, as described in Chapter 1, Managing occupational health and safety, and a formal permit to work issued, as described in Chapter 14, Permit to work systems.

20.13.2 The risk assessment will identify the actions and checks required to make the switchboard safe, and these actions and checks will be identified in the permit to work. The major checks to be listed on the permit to work will identify and verify that the necessary inter-connections to and from, and/or within, the main switchboard are disconnected. These will include but are not limited to:

- the shore power supply;

- the emergency generator; and
- the emergency power supply.

20.13.3 The internal cleaning and internal maintenance of the main switchboard would, in general, be an integral part of a ship's dry-dock programme or that of an extended maintenance programme.

20.14 High-voltage systems

20.14.1 Additional precautions are necessary to ensure safety when work is to be undertaken on high-voltage equipment (designed to operate at a nominal system voltage in excess of 1000V).

20.14.2 Definitions

The following list defines the terms used with respect to the high-voltage equipment/installations.

Additional earth: An earth connection applied to apparatus after the application of a circuit main earth, normally applied at the point of work if not already fitted with a circuit main earth.

Approved: A type of form sanctioned for use by the superintendent/senior electrical engineer.

Authorised person: An authorising officer is appropriately trained and appointed in writing by the superintendent/electrical engineer to carry out work as permitted by these rules.

Caution notice: A notice conveying a warning against interference with the apparatus to which it is attached.

Chief engineer: A senior engineer on board the vessel who is responsible for all vessel technical operations and maintenance.

Circuit main earth: An earth connection applied for the purpose of making apparatus safe to work on before a permit to work or sanction for test is issued, and which is nominated on the document.

Competent person: Someone who is appropriately trained and has sufficient technical knowledge or experience to enable them to avoid danger. It is the duty of the authorising officer issuing a permit to work covered by these rules to satisfy themselves that persons are competent to carry out the work involved.

Danger notice: A notice calling attention to the danger of approach or interference with the apparatus to which it is attached.

Dead: At or about zero voltage and disconnected from all sources of electrical energy.

Earthed: Connected to the general mass of earth in such a manner as will ensure at all times an immediate discharge of electrical energy without danger.

Electro-technical officer: A specialist electronic engineer who is competent to work on high-voltage systems.

High voltage: A voltage exceeding 1000 volts.

High-voltage apparatus: Any apparatus, equipment or conductors normally operated at a voltage higher than 1000 volts.

Isolated: The disconnection and separation of the electrical equipment from every source of electrical energy in such a way that the disconnection and separation are secure.

Key safe: A device for the secure retention of keys used to lock means of isolation, earthing or other safety devices.

Limitation of access: A form issued by an authorising officer to a competent person, defining the limits of the work to be carried out in the vicinity of, but not on, high-voltage electrical apparatus.

Live: Electrically charged from a supply of electricity.

Permit to work (in this section): A form of declaration signed and given by an authorising officer to a competent person in charge of the work to be carried out on or in close proximity to high-voltage apparatus, making known to the competent person the extent of the work, exactly what apparatus is dead, is isolated from all live conductors, has been discharged and earthed and, insofar as electric hazards are concerned, on which it is safe to work.

Safety lock: A lock used to secure points of isolation, safety devices and circuit earths, being unique from any other locks used on the system.

Sanction for test (in this section): A form of declaration, signed and given by an authorising officer to another authorising officer in charge of testing high-voltage apparatus, making known to the recipient what apparatus is to be tested and the conditions under which the testing is to be carried out.

Superintendent/senior electrical engineer: A senior electrical/mechanical engineer suitably qualified and appointed in writing by the Company to be responsible for compilation and administration of rules for high-voltage installations and operations.

Switching plan: A plan or programme, developed by the authorised person, which details the intended sequence of switching, isolation and earthing operations required to be carried out to isolate and make dead, or reinstate and make live, high-voltage equipment or installation. The plan must be agreed between the authorised person and the competent persons undertaking the task prior to executing the plan. If contractors are involved, then their agreement is also required.

20.14.3 Work on high-voltage equipment/installations

No work shall be carried out on high-voltage equipment/installations unless an agreed switching plan has been developed and implemented so that the equipment/installations are:

- dead;
- isolated and all practicable steps have been taken to lock off live conductors, voltage transformers (except where the connections are bolted) and dead conductors that may become live;
- earthed at all points of disconnection of high-voltage supply and caution notices attached in English and any other working language of the vessel; and
- released for work by the issue of a permit to work or a sanction for test.

Also, the competent person designated to carry out the work should fully understand the nature and scope of the work to be carried out and have witnessed a demonstration that the equipment/installation is dead at the point of work.

A limitation of access instruction should be used to give written instructions defining the limits of work to be carried out in the vicinity of **but not on** high-voltage equipment/installations.

On completion of work and on clearance and cancellation of the relevant permit to work, a switching plan should be developed for the removal of earthing and isolations leading to connecting to the high-voltage supply. It should be noted that a reversal of the plan used to isolate the equipment may lead to a dangerous or unsafe situation and it is always best practice to develop a plan for this considering the dead equipment or network as a starting point.

20.14.4 Operation of switchgear

Routine high-voltage switching shall only be carried out by a person competent to do so and in the normal course of their duties, using the equipment provided for the purpose.

High-voltage switching undertaken to isolate equipment for maintenance, inspection and/or testing, shall only be carried out by an authorised person or a competent person acting in the presence of and to the instructions of a person so authorised. The sequence of switching, isolation and earthing is to be carried out in accordance with an agreed switching plan.

In an emergency, high-voltage switching to cut off supply may be carried out by any person competent to do so.

Any message relating to the operation of the high-voltage system that has been transmitted by telephone/radio shall be repeated in full by the recipient and confirmed by the sender to ensure that the message has been accurately received.

Making live or dead by signals or a pre-arranged understanding after an agreed time interval is not permitted.

20.14.5 Withdrawn apparatus

High-voltage apparatus that has been isolated and removed from its normal operating position may be worked on without a permit to work or sanction for test, provided that:

- it has been discharged;
- it is prevented by barriers and locking from being restored to a live position; and
- access to high-voltage conductors on the switchboard is prevented.

20.14.6 Locking off

All spout (orifice) shutters not required for immediate work or operations shall be locked shut. (Exception: on certain types of switchgear, access to the shutters is restricted whilst the circuit breaker is still in the cubicle. Under these circumstances, it is acceptable to lock either the cubicle door or the racking mechanism, whichever is appropriate, which must prevent further withdrawal of the circuit breaker, so long as the circuit breaker has been withdrawn from its normal operating position.)

20.14.7 Protective equipment

Protective equipment associated with the high-voltage equipment/installations and forming part of the system shall not be adjusted or put into or taken out of commission without the sanction of the chief engineer or superintendent/senior electrical engineer.

High-voltage equipment/installations shall not be commissioned or re-commissioned (after major work) until the protective devices have been proved to be functioning correctly.

20.14.8 Insulation testing

All high-voltage equipment/installations that are either new or have undergone substantial maintenance or alteration shall be subject to a high-voltage test in accordance with figures approved in writing by the chief engineer or superintendent/electrical engineer.

20.14.9 Failure of supply

During failures of supply, all apparatus, equipment and conductors shall be regarded as being live until isolated and proved dead.

20.14.10 Entry to enclosures containing high-voltage equipment/installations

Compartments and other enclosures containing high-voltage apparatus shall be locked except when entry or exit is necessary.

The keys giving normal access to such enclosures shall be accessible to authorising officers only.

No person except an authorising officer, or a competent person who is under the immediate supervision of an authorising officer, who shall be continuously present, shall enter any enclosure in which it is possible to touch exposed high-voltage conductors.

Entry to compartments or other enclosures containing high-voltage equipment/installations is limited to authorising officers or other persons only when accompanied by an authorising officer.

Entry to compartments containing high-voltage equipment/installations that are not protected by insulated covers should only be undertaken when the equipment/installations are isolated and earthed.

20.14.11 Earthing

Circuit mains earths shall be applied and removed only by an authorising officer or a person competent to do so in the authorising officer's presence and to their instructions.

When high-voltage equipment/installations have been made dead and isolated, the conductors to be earthed shall be proved dead if practicable using an approved potential indicator. The potential indicator should be in date for calibration and be tested immediately before and after use, to prove it is in good working order.

Where practicable, circuit main earths shall be applied through a circuit breaker or earthing switches.

Before closing to earth, the trip features shall be rendered inoperative unless this is impracticable. After closing, the circuit breaker shall be locked in the earth position and the trip features rendered inoperative with a caution notice attached.

Additional earths may be applied at the point of work after the issue of a permit to work by the competent person in charge of the work.

Circuit main earths/additional earths may also be removed/replaced at the point of work after the issue of a sanction for test by the authorised person conducting the test.

A circuit main earth applied at the point of work may be removed and replaced one phase at a time to facilitate the work, provided this instruction is recorded on the permit to work. If this is the only circuit main earth connected to the apparatus, then a person authorised to issue permits to work shall remain at the point of work and be responsible for the safety of all those engaged in the work whilst the circuit main earth is removed. No other simultaneous work shall be permitted on any part of the circuit during the validity of this permit to work.

20.14.12 Notices

Caution notices and danger notices shall be applied to all high-voltage equipment/installations covered by a permit to work or sanction for test calling attention to non-interference or danger as appropriate.

20.14.13 Work on high-voltage cables

No person shall touch the insulation that covers or supports any conductor subject to high voltage unless the conductor is earthed.

Before a permit to work is issued, a person authorised to issue permits shall identify the cable to be worked on and proven dead at the point of work. All cables shall be assumed to be live high-voltage cables until proven otherwise.

Before issuing a permit to work to cut into or disturb the insulation of a high-voltage cable (except as required below) the person who is to issue the permit to work shall ensure compliance with the following and, where practicable, shall involve the recipient of the permit to work:

- Check cable records.
- Visually trace the cable from the point of work to a point where the apparatus is clearly identified by permanent labelling and in such a way that there is no doubt about the cable identity.
- Where this is not practicable, then the cable shall be identified by signal injection methods; the cable shall be spiked with an approved spiking gun as near to the point of work as practicable. When practicable, the cable shall be cut with the spiking gun in position; tests shall be made to confirm the cable cut is the correct one. All this shall be carried out under a sanction for test.
- Where work is to be carried out on cables where the conductors and/or sheath may be subject to induced voltages from live equipment in close proximity, then where practicable the conductors and/or sheath shall be earthed and appropriate personal protective equipment (PPE) used.

Where the aforementioned procedures are not practicable, then a special procedure shall be written and approved by the chief engineer or electro-technical officer.

20.14.14 Work on transformers

When work is to be carried out on any connections up to a point of isolation or the windings of a transformer, all windings irrespective of voltage shall be isolated. Circuit main earths shall be applied at the points of isolation from high-voltage supply. Low-voltage points of isolation shall be locked open.

20.14.15 Work on ring main units

The design of ring main units usually prevents the use of a potential indicator, prior to earthing. It is, therefore, extremely important that before any earth is applied the appropriate remote end is isolated first.

The system diagram should be checked prior to any operations and the onsite labelling noted on an approved switching procedure prior to commencing operations.

All work and switching on ring main units must be carried out in strict accordance with the manufacturer's instructions.

Work within the switching chamber of the ring main unit may require the isolation and earthing of all remote ends of the ring main unit.

20.14.16 Work on busbars and directly connected busbar equipment.

Before any work commences on a busbar or section of busbar, including any directly connected equipment, the busbar shall be isolated from any point of supply, including voltage transformers; any directly connected cable shall be isolated and earthed at the remote end.

All switches on the busbar or section of busbar shall be withdrawn to their isolated position.

All isolating arrangements are to be locked with shutters covering high-voltage contacts. Contacts that may become alive and contacts where no work is to be done shall be locked shut and warning notices posted.

The busbar or section of the busbar to be worked on shall be proved dead with an approved potential indicator in accordance with the rules for earthing (section 20.14.11).

A circuit main earth shall be applied to the busbar on at least one switch panel on the section of busbar on which work is to be done. An additional circuit main earth shall be applied at any remote ends of directly connected equipment.

An additional circuit main earth shall be applied at any such other position necessary to ensure that the busbar remains earthed at all times while work is being carried out.

A separate permit to work or sanction for test shall be issued in respect of each section of busbar. No more than one permit to work or sanction for test shall be issued simultaneously in respect of any section of busbar or any electrical equipment directly connected to it.

Any orifices where work is to be done must be proved dead immediately beforehand by the use of an approved potential indicator.

20.15 Arc-flash associated with high- and low-voltage equipment

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20.15.1 An arc-flash occurs when an electric current flows through an air gap. The air is the conductor and an arc can form between phase-to-ground (neutral) or phase-to-phase and is accompanied by ionisation of the surrounding air.

20.15.2 The incident energy associated with an arc-flash is measured in calories per square centimetre (cal/cm²). It is the amount of thermal energy from an arc flash that reaches a surface, such as a person's skin.

20.15.3 The greater the incident energy value is, the more severe the burn injury. The energy required to produce the onset of a second-degree burn is 1.2 cal/cm² and this is the benchmark for personal protection. (A second-degree burn affects both the outer and underlying layer of skin and causes pain and redness, swelling and blistering (National Institutes of Health (NIH), 2010).)

20.15.4 The goal of arc-flash protection is to minimise the likelihood of burn injury by providing an adequate thermal barrier that will limit the energy exposure of a person's skin to no more than 1.2 cal/cm². It is important to keep in mind that 1.2 cal/cm² is where the onset of a second-degree burn can occur, so there is still a possibility of being injured while protected.

20.16 Storage batteries: general

20.16.1 When a battery is being charged it 'gases', giving off both hydrogen and oxygen. As hydrogen is easily ignited in concentrations ranging from 4% to 75% in air, battery containers and compartments should be kept adequately ventilated to prevent an accumulation of dangerous gas.

20.16.2 Smoking and any type of open flame should be prohibited in a battery compartment. A conspicuous notice to this effect should be displayed at the entrance to the compartment.

20.16.3 Lighting fittings in battery compartments should be properly maintained at all times, with protective glasses in position and properly tightened. If cracked or broken glasses cannot be replaced immediately, the electric circuit should be isolated until replacements are obtained.

20.16.4 No unauthorised modifications or additions should be made to electrical equipment (including lighting fittings) in battery compartments.

20.16.5 Portable electric lamps and tools, and other portable power tools that might give rise to sparks, should not be used in battery compartments.

20.16.6 The battery compartment should not be used as a store for any materials or gear not associated.

20.16.7 A short circuit of even one cell may produce an arc or sparks that may cause an explosion of any hydrogen present. Additionally, the very heavy current that can flow in the short-circuiting wire or tool may cause burns due to rapid overheating of the metal.

20.16.8 Insulation and/or guarding of cables in battery compartments should be maintained in good condition.

20.16.9 All battery connections should be kept clean and tight to avoid sparking and overheating. Temporary clip-on connections should never be used because they may work loose due to vibration and cause a spark or short circuit.

20.16.10 Metal tools, such as wrenches or spanners, should never be placed on top of batteries because they may cause sparks or short circuits. The use of insulated tools is recommended.

20.16.11 Jewellery, watches and rings, etc. should be removed when working on batteries. A short circuit through any of these items will heat it rapidly and may cause a severe skin burn. If rings cannot be removed, they should be heavily taped in insulating material.

20.16.12 The battery chargers and all circuits fed by the battery should be switched off when leads are being connected or disconnected. If a battery is in sections, it may be possible to reduce the voltage between cells in the work area, and hence the severity of an accidental short circuit or electric shock, by removing the jumper leads between sections before work is begun. It should be appreciated that whilst individual cell voltages may not prevent a shock risk, dangerous voltages can exist when numbers of cells are connected together in series. A lethal shock needs a current of only tens of milliamps and particular care should be exercised when the voltage exceeds 50V.

20.16.13 The battery-charging systems should be checked to ensure that it is only possible to charge within the specified rate. Battery boxes should be checked for fixing and integrity as part of the planned maintenance.

20.16.14 Battery cell vent plugs should be screwed tight while connections are being made or broken.

20.16.15 The ventilation tubes of battery boxes should be examined regularly to ensure that they are free from obstruction.

20.16.16 Lids of battery boxes should be fastened while open for servicing and properly secured again when the work is finished.

20.16.17 Batteries should be kept battened into position to prevent shifting in rough weather.

20.16.18 Alkaline and lead-acid batteries should be kept in separate compartments or separated by screens. Where both lead-acid and alkaline batteries are in use, great care should be exercised to keep apart the materials and tools used in servicing each type, because contamination of the electrolyte may cause deterioration of battery performance and mixing of the two electrolytes produces a vigorous chemical reaction, which could be very dangerous.

20.16.19 Both acid and alkaline electrolytes are highly corrosive. Immediate remedial action should be taken to wash off any accidental splashes on the person or the equipment. Hands should always be washed as soon as the work is finished.

20.16.20 Batteries should always be transported in the upright position to avoid spillage of electrolyte. A sufficient number of people should be employed because the batteries are heavy and painful strains or injury can otherwise easily result (see Chapter 10, Manual handling).

20.17 Storage batteries: lead acid

20.17.1 When the electrolyte is being prepared, the concentrated sulphuric acid should be added **slowly** to the water. **If water is added to the acid, the heat generated may cause an explosion of steam, splattering acid over the person handling it.**

20.17.2 Goggles, rubber gloves and a protective apron should be worn when acid is handled.

20.17.3 To neutralise acid on skin or clothes, copious quantities of clean fresh water should be used.

20.17.4 An eyewash bottle should be to hand in the compartment for immediate use on the eyes in case of accident. This bottle should be clearly distinguishable by touch from acid or other containers, so that it may be easily located by a person who is temporarily blinded.

20.17.5 The corrosion products that form round the terminals of batteries are injurious to skin or eyes. They should be removed by brushing, away from the body. Terminals should be protected with petroleum jelly.

20.17.6 An excessive charging rate causes acid mist to be carried out of the vents onto adjacent surfaces. This should be cleaned off with diluted ammonia water or soda solution, and affected areas then dried.

20.18 Storage batteries: alkaline

20.18.1 The general safety precautions with this type of battery are the same as for the lead-acid batteries with the following exceptions.

20.18.2 The electrolyte in these batteries is alkaline but is similarly corrosive. It should not be allowed to come into contact with the skin or clothing, but in the case of an accident the affected parts should be washed with plenty of clean fresh water. Burns should be treated with boracic powder or a saturated solution of boracic powder. Eyes should be washed out thoroughly with water, followed immediately with a solution of boracic powder (at the rate of one teaspoonful to 1/2 litre or one pint of water). This solution should always be readily accessible when electrolyte is handled.

20.18.3 Unlike lead-acid batteries, metal cases of alkaline batteries remain live at all times and care should be taken not to touch them or allow metal tools to come into contact.

20.19 Work on apparatus on extension runners or on the bench

20.19.1 Chassis on extension runners should be firmly fixed, either by self-locking devices or by use of chocks, before any work is done.

20.19.2 Where units are awkward or heavy for one person to handle easily, assistance should be sought (see Chapter 10, Manual handling). Strain, rupture or a slipped disc can result from a lone effort.

20.19.3 Any chassis on the bench should be firmly wedged or otherwise secured to prevent it overbalancing or moving. Should a live chassis overbalance, no attempt should be made to grab it.

20.19.4 Temporary connections should be soundly made. Flexible extension cables should have good insulation and adequate current carrying capacity.

20.20 Servicing radio and associated electronic equipment: general

20.20.1 Any precautions against exposure to dangerous levels of microwave radiation recommended by manufacturers should be strictly followed. Radar sets should not be operated with wave guides disconnected.

20.20.2 Work should not be taken within the marked safety radius of a satellite terminal antenna unless its transmitter has been rendered inoperative.

20.20.3 Eyes are particularly vulnerable to microwave and ultraviolet radiation. Do not look directly into a radar aerial and waveguide while it is in operation or where arcing or sparking is likely to occur.

20.20.4 Exposure to dangerous levels of X-ray radiation may occur in the vicinity of faulty high-voltage valves. Care should be exercised when fault tracing in the modulator circuits of radar equipment. An open-circuited heater of such valves can lead to X-ray radiation where the anode voltage is in excess of 5000V.

20.20.5 Vapours of some solvents used for degreasing are toxic, particularly carbon tetrachloride, which should never be used. Manufacturers' instructions should be followed.

20.20.6 Some dry recorder papers used in echo sounders and facsimile recorders give off toxic fumes in use. The equipment should be well ventilated to avoid inhalation of the fumes.

20.20.7 Radio transmitters and radar equipment should not be operated when people are working in the vicinity of aerials; the equipment should be isolated from mains supply and radio transmitters earthed. When equipment has been isolated, warning notices should be placed on transmitting and radar equipment and at the mains supply point, to prevent apparatus being switched on until clearance has been received from those concerned that they have finished the outside work.

20.20.8 Aerials should be rigged out of reach of seafarers standing at normal deck level or mounting easily accessible parts of the superstructure. If that is impractical, safety screens should be erected.

20.20.9 Notices warning of the danger of high voltage should be displayed near radio transmitter aerials and lead-through insulators.

20.21 Additional electrical hazards from radio equipment

20.21.1 Where accumulators are used they should be disconnected at source; otherwise, precautions should be taken to prevent the short circuiting of the accumulator, with consequent risk of burns.

20.21.2 Live chassis connected to one side of the mains are usually marked appropriately and should be handled with caution. Where the mains are AC and a transformer is interposed, the chassis is usually connected to the earth side of the supply, but this should be verified using an appropriate meter.

20.21.3 Modern equipment often embodies a master crystal enclosed in an oven; the supply to the oven is taken from an independent source and is not disconnected when the transmitter is switched off and the mains switch is off. Mains voltage will be present inside the transmitter and care should be taken.

20.21.4 Before work is begun on the extremely high-tension section of a transmitter or other high-tension apparatus, with the mains switched off, all high-tension capacitors should be discharged using an insulated jumper, inserting a resistor in the circuit to slow the rate of discharge. This precaution should be taken even where the capacitors have permanent discharge resistors fitted.

20.21.5 An electrolytic capacitor that is suspect, or shows blistering, should be replaced, because it is liable to explode when electrical supply is on. There is a similar risk when an electrolytic capacitor is discharged by a short circuit.

20.21.6 Work at or near live equipment should be avoided if possible but where it is essential for the safety of the ship or for testing purposes then the additional precautions described in section 20.12.6 should be taken.

20.22 Valves and semi-conductor devices

20.22.1 Valves being removed from equipment that has recently been operating should be grasped with a heat-resistant cloth; in the case of large valves (e.g. power amplifier, output valves and modulators, which reach a high temperature in operation), the cooling-down time should be allowed before they are removed. Severe burns can result if they touch bare skin.

20.22.2 Cathode ray tubes and large thermionic valves should be handled with care; although they implode when broken, there is still a risk of severe cuts from sharp-edged glass fragments. Some special purpose devices contain vapour or gas at high pressure (e.g.

Trigatron) but these are usually covered with a protective fibre network to contain the glass should they explode.

20.22.3 Beryllia (beryllium oxide) dust is very dangerous if inhaled or if it penetrates the skin through a cut or abrasion. It may be present in some electronic components. Cathode ray tubes, power transistors, diodes and thyristors containing it will usually be identified by the manufacturers' information provided, but lack of such information should not be taken as a positive indication of its absence. The heat sink washers that contain it are highly polished and look like dark brass. These items should be carefully stored in their original packaging until required.

20.22.4 Physical damage to components of this kind, whether they are new or defective, is likely to produce dangerous dust; abrasion should be avoided, they should not be worked by tools and encapsulations should be left intact. Excessive heat can be dangerous, but normal soldering with thermal shunt is safe. Damaged or broken parts should be separately and securely packed, following the manufacturer's instructions for return or disposal.

20.22.5 Seafarers handling parts containing beryllia should wear protective clothing, including gloves, to prevent the substance coming into contact with the skin. Tweezers should be used where practicable. If the skin does become contaminated with the dust, affected parts, particularly any cuts, should be cleaned without delay.