CHAPTER 19

ELECTRICAL ASPECTS OF DAMAGE CONTROL

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CHAPTER 19

ELECTRICAL ASPECTS OF DAMAGE CONTROL

SECTION 1 - ELECTRICAL SYSTEMS AND EQUIPMENT

1901. General

In warships, the continued supply of electrical power under all conditions is essential for maximum fighting efficiency and may well be a deciding factor in a ships survival. Some of the important services and equipment that depend on electrical power are:

a. Control and operation of weapons and sensors.

b. Internal and external communications.

c. Steering gear.

d. Aids to navigation.

e. Ventilation and lighting.

f. HPSW and salvage pumps.

g. Lubricating oil and controlled pitch propeller pumps.

h. Ships propulsion.

i. Chilled water.

j. HP and LP air.

1902. Main Supply System

a. Many important main-engine auxiliaries, ancillary equipment and ventilation fans are electrically driven. Several features in the electrical system of a ship are designed to limit the effects of damage on essential power supplies and to enable supplies to be restored with minimum delay. They include:

(1) Enough generator capacity to allow for possible failure of some generators.

(2) Dispersal of generators to obviate the risk of complete failure of electrical power from one hit.

(3) Secondary generation of power from diesel generators when primary generators are steam driven.

(4) Alternative supplies, and in some cases emergency supplies, immediately available to important services.

(5) Fuses and overcurrent protection in switchgear to isolate circuits and prevent damage to generators and equipment in the event of a short circuit.

(6) Shock-tested mountings and fittings to prevent the displacement of equipment, switchgear, fuses, etc, by underwater shock.

(7) Duplication of conversion machinery.

(8) Provision of an emergency generator in certain classes of ship.

b. Main electrical supplies in ships are generally derived from diesel driven generators, however some older classes of ship may have steam driven generators, or a combination of both. The type of generator prime mover, generator output, and the number of generators are determined by the functions, general characteristics and operational role of the ship. The generators will meet the maximum ships load (usually the action load) with an adequate margin to allow for generator damage, defects and maintenance. A reserve of generation capacity is also allowed for, to meet any growth in electrical demands during the life of the ship.

c. In the majority of warships, electrical power is generated at 440 volts (V), 3 phase (Ph), 60 hertz (Hz) AC. However, certain classes of ship (eg Type 23 and LPD(R)) generate at a higher system voltage to supply the propulsion motors. Conversion machinery is employed to convert the higher voltage to the normal 440V working level. Detailed information regarding the generation and distribution of the main supply system can be found in the CBRNDC Class Book for the particular ship, or in the main electrical system BRs.

1903. Distribution Systems

There are 3 different types of power and distribution systems commonly fitted in ships:

a. A simple system in which all the generators supply a common switchboard.

b. An extension of the above system, whereby the switchboard is divided, with each generator supplying its own independent switchboard section. A DD/FF normally has two such switchboards, each board having two sections. Breakers interconnect all the switchboards and sections.

c. In modern warships, major services are no longer supplied directly from a switchboard section. Equipments located in a particular section of the ship, and fitted for a particular purpose are grouped together and supplied from either an electrical distribution centre (EDC), or an electrical distribution panel (EDP). Services are fed from these EDCs/EDPs via moulded case circuit breakers (MCCBs). Hence these may be considered to be sub-switchboards.

1904. Circuit Breakers

Each generator is connected to its associated switchboard or switchboard section through a supply breaker contained in the switchboard. A breaker is fundamentally a hand-operated or electrically operated switch. The difference between switches and breakers is that breakers incorporate protection and safety devices that enable them to open automatically should a fault condition arise. Breakers are therefore normally fitted for the protection of main generators, for all main interconnections between switchboards, and all major feeders, where switch and fuse units cannot be used. In modern ships, each EDC/EDP consists of a number of MCCBs.

1905. Main Switchboards

A ships main switchboard provides facilities for controlling the voltage and frequency of generators, and their synchronisation when needed for parallel running. In ships with remote machinery control from an MCR or SCC the switchboard is normally located in the MCR/SCC. In some instances where the main switchboard is remote from the generator, local control panels (LCPs) are provided. Secondary switchboards are also normally provided. All switchboards are 'dead-fronted' to prevent any exposure to the system voltage.

1906. Supplies to Services

All services are supplied through breakers or, for more lightly loaded circuits, by switch and fuse units. These breakers and switches are known as feeder breakers and feeder switches, and the circuits are feeder circuits.

1907. Alternative Supplies

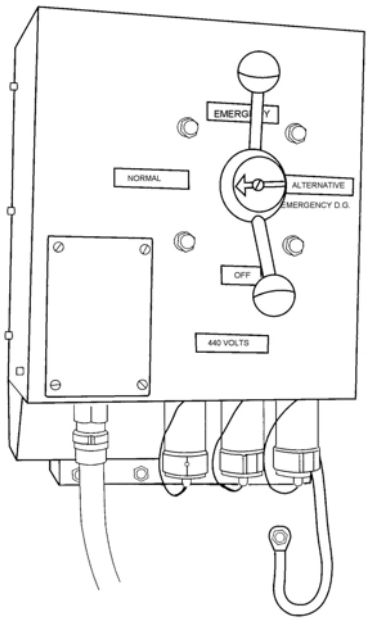
Some electrically driven equipment in HM ships is considered to be of sufficient importance to justify the provision of 2 or more power supplies. These are fed via changeover switches to allow the connection of an alternative supply if the normal supply should fail. Changeover switches are sited as close to the equipment as possible to minimise the risk of power failure due to local circuit damage:

a. **Automatic Changeover Switch (ACOS).** These are provided for equipment considered vital to the safety of the ship. They will automatically change the incoming supply from normal to alternative should the normal voltage drop to 80% of nominal, and will revert automatically to the normal supply should the normal supply be restored.

b. **Hand Changeover Switch (HCOS).** Automatic changeover switches must be limited in number otherwise remaining generators could be loaded beyond their capacity. If a short delay in restoring power to particular equipment is acceptable, then a hand changeover switch is fitted (see Fig 19-1). Examples of equipments fitted with changeover switches are:

AUTOMATIC	HAND
Forced lubrication pumps	Ventilation
Conversion machinery	HPSW pumps

Fig 19-1. Hand Changeover Switch



c. **Electrical Distribution Panel (EDP).** EDPs that are fitted in certain classes of ships are divided into three different types:

(1) **Remotely Operated Changeover Switch (ROCOS).** This type is remotely controlled and allows an operator to select the Normal or Alternative supply from a remote position (normally the SCC), or locally at the EDP.

(2) **Automatic Changeover Switch (ACOS).** In this mode, the EDP operates as a normal ACOS.

(3) **Sheddable.** These EDPs are operated, either automatically as part of machinery operation, or manually from a remote position (SCC), forward or after switchboards or locally at the EDP.

Note. *ROCOS and ACOS EDPs have input and output emergency sockets, whereas sheddable panels have emergency output sockets only.*

1908. Converted Supplies

Lighting and small power services, including portable apparatus, lower voltage supplies at 115V, 3 phase and single phase, are provided by transformer conversion from the 440V system. Various services, eg radar and weapon control systems, need ac and dc supplies at voltages and frequencies different from those of the main supply. These are provided by conversion machinery, ie motor-driven generators, static frequency changers, transformers/rectifiers and batteries, as appropriate. Where the converted supply is peculiar to specific equipment the necessary conversion machinery is often sited nearby. It is usual to provide a common conversion machinery room at the load centre of all services concerned.

1909. System Operation

a. The distribution system should not normally be arranged so that the normal and alternative supplies are taken from the same generator, or generators sited in the same compartment.

b. Generators may fail at any time without warning. When this happens, all services being supported by a failing generator, through automatic changeover switches, will be transferred automatically to the generator providing the appropriate alternative supply. Therefore, each individual generator must not be fully loaded; a margin must be left to allow each generator to accept the load thrown over when automatic changeover switches operate as a result of the failure of another generator.

c. At higher states of Damage Control readiness, the main supply system must be manned and operated such that sudden failure of a generator does not hazard the ship.

1910. Breaker Colour Codes

In older ships switchboard switches and breaker controls are colour coded to indicate the importance of the service supplied by the switches and breakers, and to assist the watchkeeper in selecting priorities when load shedding. In modern ships with MCCBs and ECDs feeding multiple services, major services should be listed at the primary and secondary control positions adjacent to feeder breaker operating switches. Colour coding should be employed against each major service. The colours are:

a. **BLUE (Seagoing Efficiency).** Steering, gyro, machinery space lighting and power, navigation radar, etc.

b. **RED (Fighting Efficiency).** Turret/mounting/launcher supplies, magazine lighting, ammunition hoists, sensors, etc.

c. **GREEN (Damage Control Supplies).** HPSW/hangar spray/salvage pumps, air conditioning units and ventilation, etc.

d. **WHITE (Less Important Supplies).** Refrigerators, galley equipment, etc.

e. **YELLOW (Unimportant Supplies).** Unimportant lighting and ventilation, heaters, etc.

1911. Control of the Electrical System

The complexity of the ships electrical system requires a high degree of central control, so that the general state of supplies throughout the ship can be assessed and the supplies handled quickly and easily. This becomes increasingly important when damage is sustained and only limited supplies are available. In such circumstances the function of control is:

a. The even distribution of load among intact generators by the control of switchgear and the shedding of less important services.

b. The isolation of damage and the redirection of supplies to important services.

c. The cooperation of electricity supply and repair parties in the restoration of power to damaged areas.

1912. Switchboard Primary Control

In most modern warships the voltage and frequency of generators and the operation of supply, feeder, busbar linking and interconnecting breakers, are remotely controlled at a console in the MCR/SCC; this console is known as the Primary Control Position (PCP). In ships where more than one switchboard exists, communications are available between each switchboard, this communication usually being a combination of Rationalised Internal Communications Equipment (RICE), machinery space broadcast and telephone.

1913. Switchboard Secondary Control

In large ships with a second Damage Control headquarters (HQ2), a Secondary Control Position (SCP) is also fitted. Its function is to assume control if the PCP is out of action. The SCP is not necessarily provided with automatic indication or remote control arrangements but the state of the main supply system may be recorded, on a hand worked mimic diagram, from information received from the PCP while active, or otherwise from outlying stations. This information enables the SCP to coordinate the remaining switchboards and outlying electrical positions to direct and maintain power supplies. In more modern warships SCPs are situated adjacent to each main switchboard. From these positions local main switchboards can be operated in the event of failure of the PCP.

1914. Operation of the Main Supply System

Instructions for the operation of the Main and Emergency supply systems of the ship are outlined in the associated CBRNDC Control Class book, and are detailed in BR 2000(52) - Electrical Power, Distribution and Utilisation, BRd 300 - Fleet Weapons Engineering Manual and relevant main power supply system BRs. The electrical state of readiness should conform to the ships DC State. At DC State 1, all generators are to be proved by placing on load. Generators that are running should be independently supplying their own switchboard sections via supply breakers and/or bus bar linking breakers. The sub-division of the main supply system in this way minimises the effect of any damage to the system. Switchboard operations should be kept to a minimum. Where it is required to parallel generators to transfer load, then the operation should be completed as quickly as possible.

Care must be taken during the transfer to ensure that the generator frequencies do not deviate to a level likely to affect frequency conscious equipment. Consideration should be given to opening MCCBs/breakers that supply non-important services as part of State 1 preparations. This removes unnecessary 440V from compartments, thus reducing the risk of electrical shock to firefighters and faults to the primary electrical distribution system.

1915. Action Paralleling

In the event of a generator or its prime mover becoming damaged necessitating the quick removal of its load, then ‘action paralleling’ should be employed. This is where the affected generator is paralleled with an unaffected generator that has sufficient spare load capacity, such that it is able to accept the load from the failing generator. Once the 2 generators are in parallel, the off-going generators supply breaker is opened, this immediately transfers the load and allows for the immediate shut down of the affected generator.

1916. Electrical Supplies to HPSW Pumps

a. HPSW pumps are provided with both normal and alternative supplies; some classes of ship are capable of providing a third supply from an emergency generator. Under standard operating conditions the HPSW pumps should be fed from their normal supply to ensure maximum diversity of supplies. Every effort must be made to ensure electrical supplies are maintained to the HPSW pumps. In the event of possible interruptions to these supplies due to load transfer, battle damage etc it is essential that the DCO(L), via the DCO, keep the FRPPs informed of any possible interruptions. For peacetime emergencies the Senior Rating I/C of the firefighting team will be kept informed by the DCO. In the event of a fire that requires re-configuration of the main supply system, care must be taken to ensure that, wherever possible, HPSW pumps in use are fed from separate generators or supplies.

b. All HPSW pump starters are fitted with a lockable switch known as the 'Battle Override' switch. The purpose of this switch is to prevent the operation of the electrical safety devices fitted within the starter and thus prevents the pump from tripping under fault conditions. This switch is to be unlocked in DC State 2 and made in DC State 1.

1917. Ships Lighting

Almost without exception, some lighting will fail when action damage is sustained. General lighting is not provided with alternative supplies but, to prevent a complete blackout:

a. In important spaces, and in gangways, two electrically separate and widely dispersed sources each supply half the lighting.

b. In some generator and switchboard rooms, a proportion of the lighting is supplied directly from the live side of generator supply breakers.

c. Switchboard rooms, radar offices, HQ1/SCC and other operational spaces may also be provided with battery-operated secondary lighting. This is in addition to the automatic emergency lights.

1918. Automatic Emergency Lights (AEL)

AELs are normally fitted adjacent to doorways and hatchways to indicate their position in the event of a power loss affecting lighting. AELs are also sited adjacent to some machinery controls, in hazardous areas such as galleys and on escape routes. They are battery fed and are operated by relays connected to the main supply system. They switch on automatically if power in the space fails but give only enough illumination for movement between decks. AELs are fitted with a special battery which is trickle charged, thus ensuring the emergency lighting is available at all times. A neon lamp indicates the charging supply.

1919. Emergency Lighting for Repair Parties

a. When normal lighting fails, the provision of emergency lighting for repair parties and others to carry out their duties is of paramount importance. Various items of equipment, details of which are in BRd 2170(3), are provided for this purpose. The principal items are:

(1) Moulded strip lighting circuits (DC ‘necklaces’) which can be connected to a source of 115V emergency supplies.

(2) LED gangway lighting equipment which is available in 16, 26 and 50 m lengths complete with power packs.

(3) 115V floodlights (see Fig 19-2).

(4) Portable, battery-operated equipment comprising:

(a) Lanterns for general use of repair parties (see Fig 19-13). This equipment is splashproof but not watertight.

(b) Safety torches.

(c) Lamps for repair parties and medical parties.

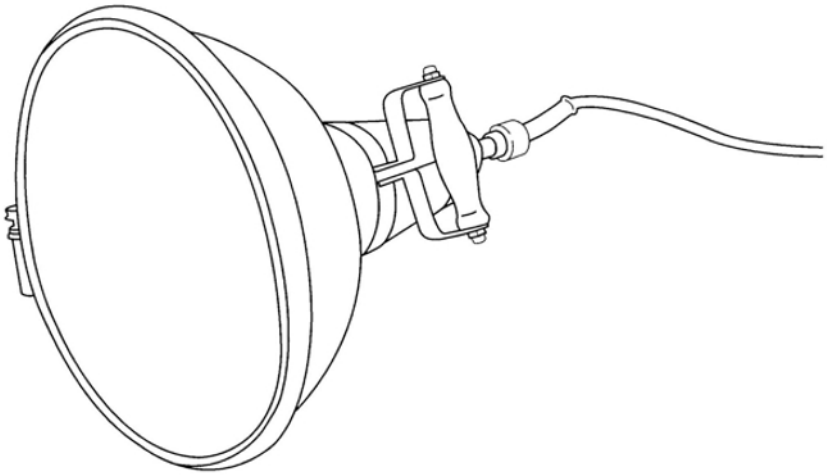
(d) Right angle torches.

(5) Cyalume chemical illuminators.

Note. *In areas that are suspected or known to contain flammable or explosive vapours, only safety torches or cyalume illuminators may be used.*

b. When emergency lighting is being rigged, care must be taken to ensure that the cables do not breach watertight integrity. The closing of doors and hatches forming smoke or watertight boundaries should not be impeded by allowing cables to pass through them.

Fig 19-2. Damage Control Floodlight



1920. Emergency Supply Arrangements

a. Emergency supplies are distributed in two ways. Either via portable, flexible, cables, normally run along the communications deck, thus giving relatively free fore-and-aft access for repair parties, or by a hard wired system supplied from an emergency (salvage) generator via an emergency switchboard to a number of ships vital services eg HPSW pumps, steering gear and emergency portable pump sockets. In some classes of ships it can be a combination of these two methods. These cables are never to be rigged until required in an action/damage situation, unless ordered by HQ1 or their designate. In some ships, where there are passageways on both sides of the communication deck, facilities are provided for port and starboard systems.

b. In some ships with a large number of decks, provision is made for emergency supply systems to be run on two deck levels; the communication deck and one other. Permanent cables are run to these decks from generators and switchboards. Where emergency cable runs are required to pass through watertight bulkheads, special through-bulkhead connection boxes are provided.

1921. Permanent Risers

Where it is necessary to transfer emergency power from one deck to another, two methods are used:

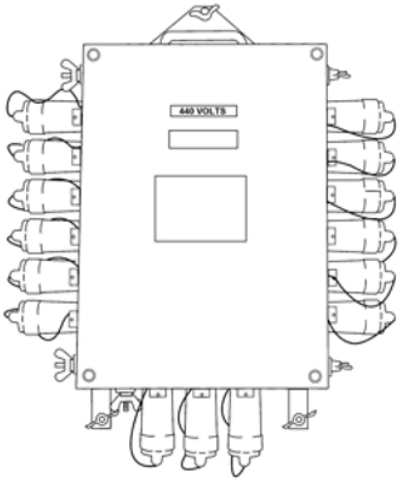
a. Short vertical lengths of cable are fitted permanently through watertight deck glands (where watertight or gastight integrity must be maintained). These permanent cables are called risers.

b. Deck tubes with removable caps are fitted for the passage of cables (where watertight or gastight integrity is not a prime consideration). The caps are painted white with a green cross.

1922. Emergency Supply to Fuse Panels

Some fuse panels supplying important services are fitted with normal/emergency changeover switches and emergency connections. In earlier ships the first fuse panels supplied from the switchboard breaker/switches were fitted with these arrangements. In later ships the panels fitted with emergency arrangements have been limited to those supplying important services. Only the necessary panels, which may not be the first after the switchboard breaker/switch, are so fitted.

Fig 19-3. Emergency Distribution Box



1923. Emergency Connections

Facilities for obtaining emergency power are provided at all main switchboards or generator LCPs in the form of emergency socket connections fed from the bus-bars through switch and fuse units. All ends of permanent risers are terminated by emergency connection boxes (ECBs) and so, by means of flexible cables having suitable connectors at each end, the main emergency run can be energised from available power sources. Similarly, at all important services there are facilities for accepting emergency power. The facilities comprise either an emergency switch and connection box fitted in the supply to the service or emergency socket connections in a fuse panel supplying a group of important services. Each type of facility includes a changeover switch to enable changeover from 'normal' to 'emergency' supply. Distribution for these services is by portable emergency link boxes or portable fused distribution boxes, normally bolted to bulkheads at positions near the main emergency run. They can easily be made portable but when so used they must be earthed to the ships structure by connection to the earthing terminal provided. Details of emergency connections and equipment are shown in Fig 19-3 to Fig 19-12.

Fig 19-4. Emergency Connection Box

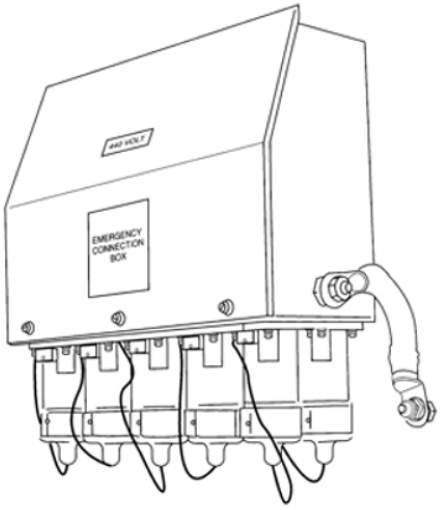
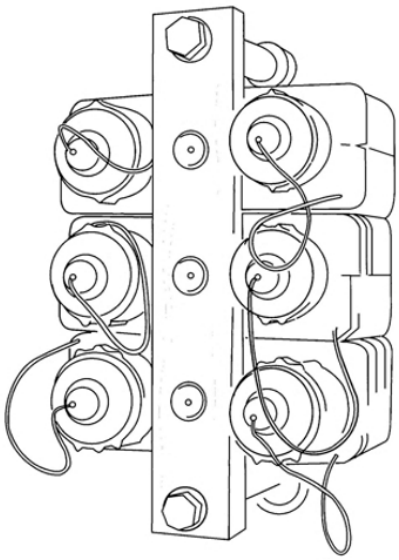


Fig 19-5. Emergency Through-Bulkhead Terminal



1924. Emergency 115V AC Supplies

These are taken from portable fused distribution boxes through portable 440/115V transformers (Fig 19-6) and distributed via portable fuse boards (Fig 19-7). Whenever portable equipment (eg lighting transformers, fuse boards, etc) is used, care should be taken to protect it from damage and, if possible, it should be kept out of the way of personnel and moving equipment. Earth connections, where applicable, must always be secured and warning notices placed before power is supplied. The stowage positions of all portable electrical equipment should be clean and dry. Portable fuse panels should carry the designated fuse links, and 115V panels must have rubber sheets attached to guard exposed live terminals.

Fig 19-6. Portable 440/115V Transformer

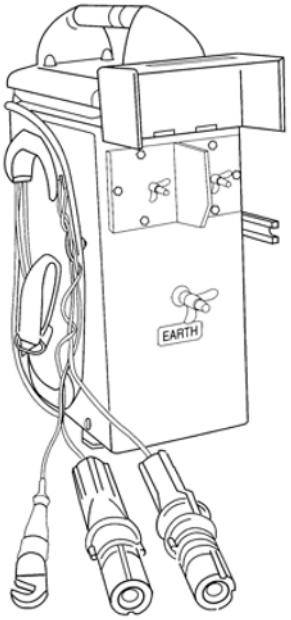
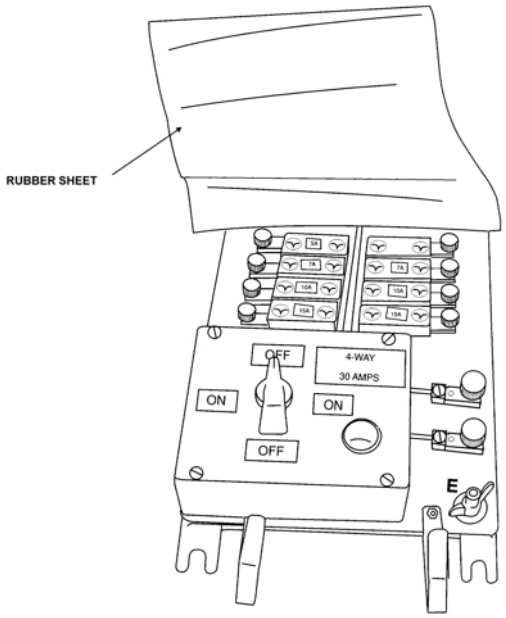


Fig 19-7. Portable 115V Fuse Board



1925. Emergency 440V Cables

a. In older ships, cables are pre-positioned, with fitted connectors. In newer ships (Type 23), cables are manufactured, as required, from rolls of colour coded cables (red, yellow and blue phases) and crimped onto tails that have connector plugs fitted. The crimped butt connectors should be insulated by wrapping insulating tape around them. The connectors and sockets have standard phase colouring and, to assist phase identification by touch, a number (one, two or three) of raised rings are moulded on the shroud of each cable connector and a corresponding number of raised lobes are on each socket. In addition, to make doubly sure, shrouds are moulded with one, two or three keyways to fit corresponding numbers of keys in the sockets. Cable connectors are shown in Fig 19-8. Emergency cables are stowed on special brackets or reels, where they make small targets for splinters. They should not be rigged in position until required. To enable certain important items of equipment to be connected to permanent risers, or to the main emergency run, they are provided with lengths of flexible cable that are stowed near the equipment. If long lengths of emergency cable are damaged and unusable, short lengths may be joined together by use of muff couplings (Fig 19-9). The cable tails used in Type 23 and later ships are shown in Fig 19-10. and the contents of the cable lockers are detailed in BR 4500(120) - Emergency and Converted Electrical Supply Systems Type 23 Frigates.

b. The stowages for all emergency cables are to be clearly marked, preferably with an embossed tally. Cables should be neatly stowed in their correct stowages with the connectors clear of the deck. The cables should be maintained strictly in accordance with the relevant MMS schedule.

Fig 19-8. Emergency Cable Connectors

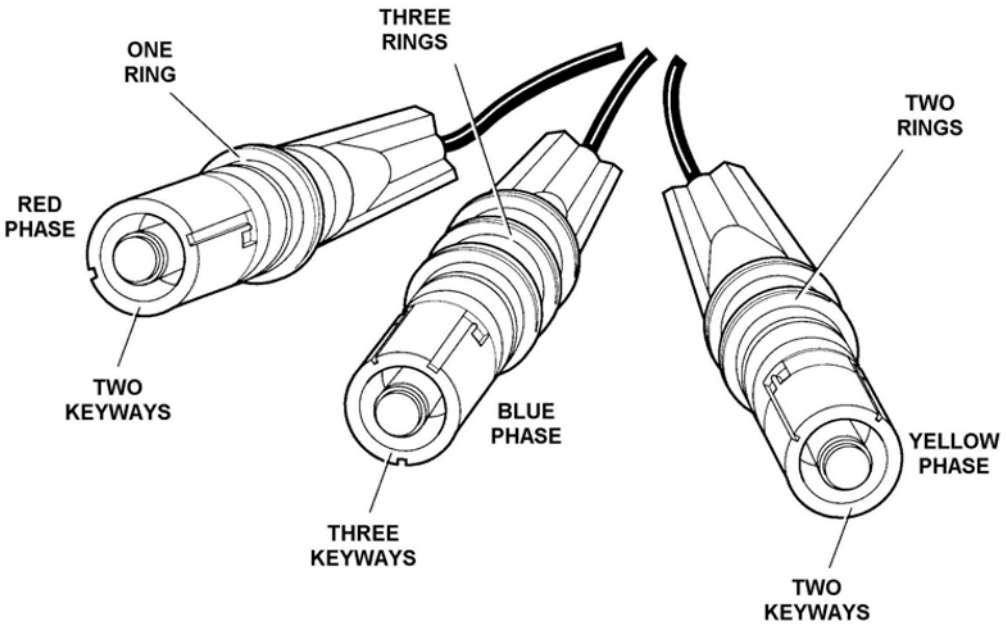


Fig 19-9. Muff Coupling

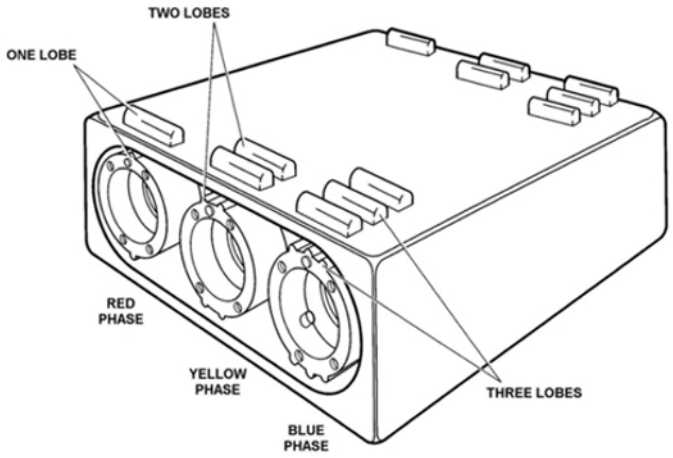
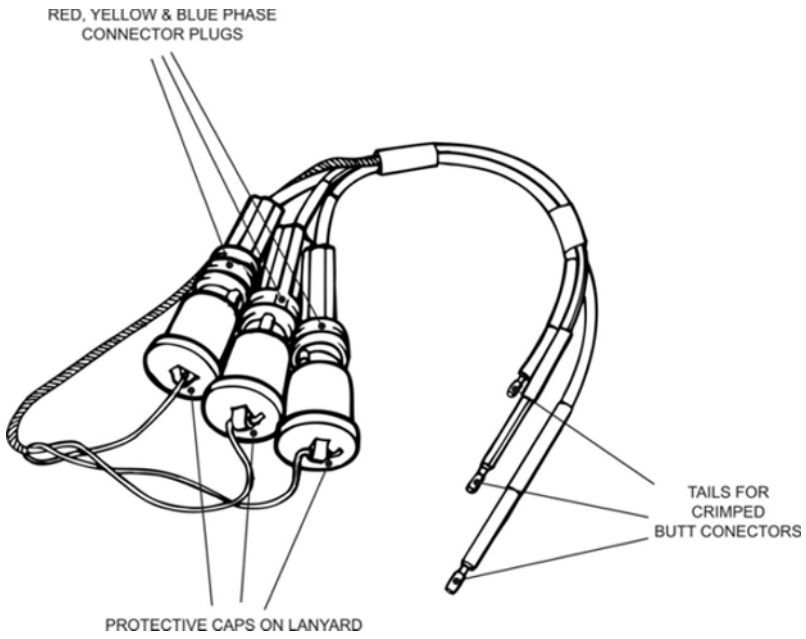


Fig 19-10. Cable Tails - T23 Frigates



1926. Electrical Supplies to Portable Pumps

WARNING - 440 VOLTS

POWER MUST BE ISOLATED AT THE SUPPLY SOCKET BEFORE THE ADAPTOR LEADS ARE CONNECTED/DISCONNECTED. CONNECTORS MUST BE KEPT DRY.

a. Switched sockets are provided at strategic positions throughout ships, for normal 440V 3 phase supplies to portable pumps (see Fig 19-11). The socket boxes are painted yellow and numbered in black. For connection to an emergency supply, a special switched adaptor cable (‘rats tail’) is provided in ERP lockers (see Fig 19-12).

b. Type 23 Frigates and later ships are fitted with electrical pump power sockets conforming to BS 4343. To enable pumps to be transferred between these ships and those fitted with the older design of socket (all pre T23 ships), one adaptor lead per pump is supplied. There are two types of adaptor leads:

(1) Type A, for pre T23 ships.

(2) Type B, for T23, LPH and later ships.

Fig 19-11. Switched Portable Pump Supply Socket

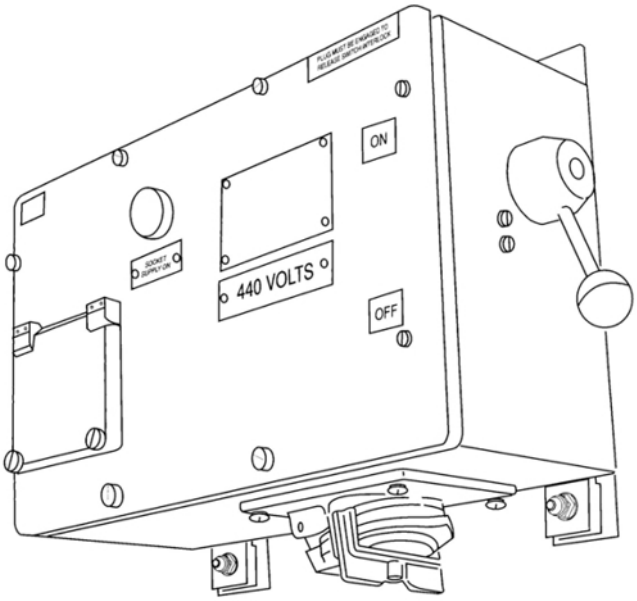
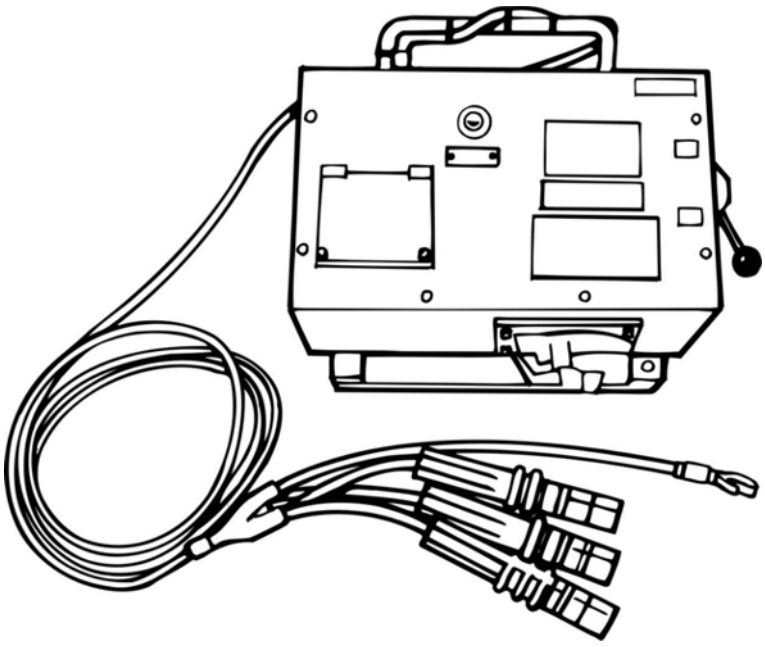


Fig 19-12. Switched Rat's Tail



1927. Battery Operated Lanterns

The allocation of battery operated lanterns (see Fig 19-13) is three to each FRPP, plus one each to sickbays, secondary medical positions and dental surgeries. Those allocated to these medical stations are to be clearly marked as such. They are to be held by the appropriate marine engineering section for issue when assuming DC State 1. Lantern maintenance is limited to replacement of the lamp or lens gasket, and recharging the two batteries using either the BC2 (2 way) or BC10 (10 way) charger. The charging system is self-regulating and the lantern may be left on the charger until required for use. Lamps indicate state of charge as follows:

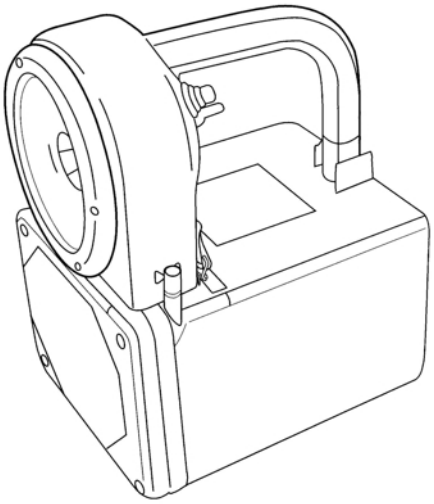
a. **Red Lamp.** Charging.

b. **Green or Green and Red.** Charged.

CAUTION

Lantern end casings or batteries must not be removed and battery seals are not to be removed during recharging.

Fig 19-13. Battery Operated Lantern



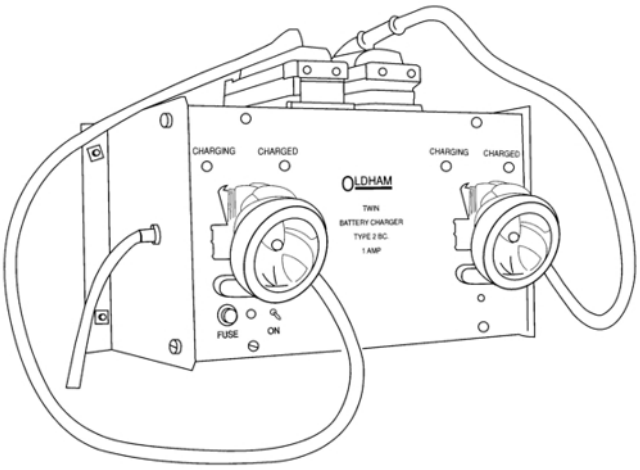
1928. Battery Operated Headlamps (Caplamps)

The allocation of headlamps is nine per FRPP. Also one each to the sickbay, SMP and dental space and three to each First Aid Party, to be stowed in the sickbay. Headlamp maintenance is limited to:

a. Recharging of the battery using the BC10 and BC2 chargers (see Fig 19-14). The charging indications are as for the lanterns in Para 1927. Headlamp batteries are sealed during manufacture and are not to be topped up. Battery seals are not to be displaced or removed.

b. Replacement of defective lamp filaments.

Fig 19-14. Headlamp Battery Charger



SECTION 2 - LOW VOLTAGE ELECTRICAL DAMAGE CONTROL PRACTICE

1929. Damage Control Officer (Electrical)(DCO(L))

a. At State 1, the DCO(L), in HQ1 is responsible for the integrity of the Main Electrical Supply System, including Converted Supplies. Where the ships main generators form part of the Propulsion System, the demarcation of ownership is to lie at either the Generator or the HV/LV Transformer, dependant on the ships equipment fit (the Prime Movers are owned by the Propulsion Manager/MEOOW1). In the case of a ship with Electrical Propulsion Motors (eg Type 23 or Type 45) the Propulsion Manager/ MEOOW1 is responsible for the operation of the Propulsion Motors and associated control equipment.

b. DCO(L)s specific responsibilities for Electrical Damage Control (Electrical DC) are listed in Para 0219. The Electrical DC Organisation should, where possible, be structured around the organisation detailed in Chapter 8. Later classes of ship may have to adapt to this around this guidance dependant on their manning state and advances in technology.

1930. Electrical Repair Party Posts (FF/DD)

The Electrical Repair Party Posts on DD/FF operate from the Fwd and Aft switchboards, with the switchboard operator acting as the I/C Electrical Repair Party Post. Each party is to be made up of an I/C (who is to hold a Switchboard Operating Certificate) and at least 2 electrically competent ratings, identified with green brassards or surcoats. Only under exceptional circumstances should electrical team members be used in other DC organisations (eg firefighting) due to their limited numbers. Only the DCO(L) can issue 'Underground Maps' (authorising live electrical DC cable runs), except for LPH/LPD (see Para 1946) where subtly different procedures apply due to their larger size of electrical distribution system. The Electrical DC Teams have the following areas of responsibility:

a. Electrical State 1 Preparation.

b. Blanket Searching.

c. Electrical Damage Repairs.

d. Emergency Cable Running.

1931. The Role of the DCO(L) Assistant

The DCO(L)'s Assistant has a key position within the Electrical DC organisation. Their primary task is to permanently man the 'Green Line' acting directly on behalf of the DCO(L) and as such is 'in charge' of the Green Line, regardless of rank. Instructions passed to the Electrical Repair Party Posts and the Weapon Section Base should be acted upon as if given directly by the DCO(L). Following damage, the assistant is to control the flow of information from the Electrical Repair Party Posts to ensure vital information is not missed. Details should be written or marked in a legible format utilising the Electrical Incident Board and the Essential Supply Availability Board, so that the DCO(L) can easily assimilate the information. The assistant should regularly update the electrical incident boards with all losses, BDR (including fires and floods) and equipment failures. An ideal opportunity is during the Command Huddle where communications are minimised allowing a limited time to update each board. This information should then be passed to the I/C Electrical Repair Party Posts. The flash procedure is only to be used if the information affects the Command Aim either by the loss of a supply/equipment or its subsequent restoration.

1932. BDR Electrical Information and Stateboards

a. The DCO(L) is to have electrical information stateboard(s) detailing the Main LV Electrical Power System and the Emergency Supply System for use in the event of damage. These boards are to be of a standard design across each class of ship with only slight differences due to the current state of each ships enhancement/A&A fit. General guidance for typical information to be included on the stateboards comprises:

(1) A main electrical supply system line diagram from ships generators (or HV/LV transformers) to EDCEDP/EDR detailing all major components. A facility for annotating generator and emergency supply loading (KW or Amps) must be available.

(2) An emergency supply system line diagram ('Underground Map') overlaid onto a BDR plan of the ship. This is to include:

(a) Permanent risers.

(b) Through bulkhead connectors.

(c) EDCs/EDPs.

(d) Equipment capable of accepting emergency cables.

(e) Deck/bulkhead glands.

(f) Sequentially numbered Portable Pump sockets including normal supply details.

(g) All sources of emergency electrical supply eg Main and Emergency Switchboard Emergency Supply Units (ESUs) and Electrical Distribution Centres (EDCs) outlet socket connections (if fitted).

(h) Location of portable transformers, fuse panels and link boxes.

(i) Location of major items of electrical equipment.

(3) An electrical incident board used to list all the electrical defects requiring repair action including ETBOL. This board is to be used in support of the electrical 'tote board'.

(4) A common electrical tote board with a priority numbering system is to be used at all positions (1,2,3,4,5,6, etc). This will enable each defect authorised for repair, to be given a unique priority with the top 3 aligning with the Command Aim. If the priority subsequently changes, then the numbering system can be altered accordingly. Other information to be detailed is the nature of the defect and the related ETBOL.

(5) An essential supply availability diagram - 'ban the bomb' or its equivalent.

(6) A comprehensive list of EDC/EDP MCCBs including the fuse ratings and location of spare circuits.

(7) Details of main supply cable routes are to be held and include interconnector cables between switchboards and feeder cables to EDCs/EDPs.

(8) A list of all key WE weapon and sensor supplies that align with the Weapon Section Base Weapons and Sensors state boards.

(9) Details of Converted Supplies including Control and Communication Switchboards, Transformer Rectifier Units, Static Frequency Changers, Motor Generators, and Low Power batteries for ME and WE equipment.

(10) Copies of the Underground Map for all sections split into relevant electrical zones as required. The details of each electrical section should overlap its neighbour by at least one ship section to prevent inadvertent connection of 2 separate sources of supply.

(11) A list of pre-made emergency cables detailing its number, rating, length and location.

(12) A list of manpower available for Electrical DC including their dispersal station.

(13) A Blanket Search check off list to enable confirmation of completed routes.

(14) A list of State 1 preparations for each section.

(15) An area detailing the Command Aim, IBC's priorities and threat levels - Air, Surface, Sub-Surface, Mine and CBRNDC.

b. All documentation should be positively secured for action, yet portable in the event of HQ1 being evacuated. If this is not practical due to the sizes and number of boards, then a duplicate set must be held at HQ2 and information transferred to it from the Electrical Repair Party Posts.

1933. Damage Control State 1 Preparation

On closing down to Damage Control State 1 Condition Zulu the material state of important electrical equipment is to be checked and made ready. The following preparations are given as guidance and may differ between classes of ship:

a. All compartments are to be secured for action.

b. Major equipment Tagged Out and/or Out Of Action (including OPDEFs) is to be noted on the electrical stateboard.

c. Blanket search cards are to be annotated with the state of any MCCB already open on assuming State 1 and the current state of the distribution system.

d. Personnel are to be mustered and manning levels reported to DCO(L).

e. Electrical DC lockers are to be mustered and any deficiencies noted. For the contents of the lockers see BRd 2170(3) Chapter 2.

f. Personnel are to have available or carry:

(1) Torch/miners headlamp.

(2) Voltage Unitesters.

(3) DC Rubber Gloves (checked and serviceable).

(4) Electrical rates Rationalised Tool System (RATs) toolbox or similar equipment.

(5) Waterproof wax or permanent pens and blanket search route cards.

(6) All electrical safety rescue hooks located and available for use by personnel acting as a safety numbers for workers engaged in ‘live’ electrical work.

(7) Field Back Packs for DC(L) personnel to carry tools and equipment.

g. Portable pump sockets are to be checked for 440V 3 phase supplies.

h. The LV Electrical Distribution System (MEPS on a Type 23) is to be configured correctly for State 1 and emergency generators run up and proved on load. When an attack is imminent, all available generators should be running and on load to reduce supply losses.

i. Check for 440V output from the Switchboard Emergency Supply Units and EDC/ EDP Emergency Outlet Terminal Sockets.

j. All Battle Override switches (if fitted) are to be unlocked with the switch put to the override position (only unlocked for exercise purposes).

k. Ensure the following tools/General Purpose Testing and Measuring Equipment (GPTME) is available in each section:

(1) MIT 420.

(2) Clip on/Fluke Ammeter.

(3) Flukes.

(4) Unitesters.

(5) Cable repair equipment and consumables.

(6) RATS toolkits.

l. Check emergency/contingency lighting is operable.

m. All equipment is to be re-secured for action on completion of State 1 preparation.

n. Test all primary and back-up methods of communication.

1934. Blanket Searching

a. When a blanket search (automatic response to the order **"STAND TO"**), is initiated the search is to include inspections of the electrical distribution system and equipment in accordance with Blanket Search route cards. These cards must be comprehensive and include a set route to follow and indicate equipment to be checked. They must also provide an area for annotating defects to enable details to be passed to the I/C Electrical Repair Party Post without omission. If possible, serviceability checks are to be made as part of the blanket search. This will allow for prompt and accurate repair actions to be developed. The blanket searchers should be suitably trained to recognise fault conditions and be fully conversant with electrical safety. If an incident is discovered during the blanket search one person is to deal with the incident whilst the other contacts the relevant switchboard and then continues with the blanket search. The following is a general guide on items to be checked but is not an exhaustive list:

(1) **Electrical Distribution Centre (EDC)**

(a) Check the compartment or immediate vicinity for obvious signs of damage.

(b) Check that the busbar supply lamp is illuminated.

(c) Check that the Earth Percentage Meter indicates zero, if not make a note.

(d) Open the MCCB cubicle door and check for the following:

- Damage to EDC.
- Unusual smells or burning.
- Tripped breakers. Reset once, if further trip occurs note as defective.
- Check fuses for signs of rupture (red pop-out).

(e) Check the integrity and condition of the electrical cables going into and coming from the EDC.

(2) **PECP/SECP and Main Switchboards**

(a) Carry out full earth check, if not automatic within the MEPS.

(b) Carry out a discrepancy switch lamp test.

(c) Check the voltage, frequency and load of the running generators are within tolerance and stable.

(d) Check the condition of all switchboard Main Breakers and MCCBs supplying EDCs or equipment (eg compressors, fire pumps, Radar 996) where fitted.

(e) Check that a 440V output is still present from the Emergency Supply Units if in use.

(3) **Conversion Machinery**

(a) Check the condition of both static and rotating electrical conversion machinery if located within a CMR. Conversion machinery associated with individual equipments and in its vicinity should be checked by the end user eg Sea Wolf SFC.

(b) Check the Control and Communication switchboard parameters and indications are correct, including a full earth check.

(4) **General Equipment Checks**

(a) Check Normal and Alternative supplies are available, where indicated.

(b) Check for signs of single phasing of motors, damage to equipment casings, electrical cables, shock mounts, pipe work and pump bellows as appropriate. Obvious indications of mechanical damage should also be noted.

(c) Reports on serviceability should be passed to DCO(L) at the earliest opportunity.

(d) Check indication lamps/instrumentation are within the required parameters.

b. Where EDCs are located in MMS, it may be more efficient to arrange for MMS crews to conduct blanket searches in those areas, passing electrical defects and 'blanket search complete' reports to DCO(L) via the MEOOW1. Similarly in ships where the large geographical separation of some EDCs and lean manning precludes a rapid blanket search, electrical blanket searches may be conducted by suitably trained FRPP or WE personnel, and reports passed to DCO(L) via the Weapon Section Base (WSB) or Switchboard 'Green Line'. In both cases, the responsibility for training of personnel lies with DCO(L), as does the provision of blanket search route cards.

1935. Incident Reporting

Following a comprehensive blanket search, compilation of the electrical defects is to be carried out by the I/C Electrical Repair Party Post, prior to information being passed to DCO(L). This will ease the task of prioritising defects enabling an accurate picture to be established prior to the Command Huddle. To aid the DCO(L), essential equipment supply losses that affect the Command Aim should be passed in full; eg **"M1-35 MCCB is tripped and will not reset - Normal supply to Goalkeeper".** Losses should be supported with serviceability checks and ETBOL's where possible. Verbal transmission on the 'Green Line' should be orderly and controlled by the DCO(L) Assistant. Whilst one switchboard I/C is passing information through to DCO(L), the other should annotate defects on his electrical stateboard for information.

1936. DCO(L) Management of Electrical Losses

a. The Command Aim and IBC's priorities drawn from the Command Aim is pivotal in allowing DCO(L) to formulate his priorities. The Command Aim and IBC's priorities should be passed to all Electrical Repair Party Posts on each occasion that it changes and written in a prominent position on the electrical stateboard for all to see. Reported losses should be marked up, on the Essential Supply Availability Diagram so picture compilation can be established. All electrical defects are to be annotated on the electrical incident board so that a long-term plan for rectification of lesser important defects can be established once priority defects have been dealt with. Information regarding losses which directly effect other key directors should be passed to them at the earliest opportunity, either verbally or using a method such as the 'post-it' routine. A list of the top 3 defects affecting the Command Aim, subsequent repair actions and ETBOLs should be compiled in readiness for the command huddle and subsequently passed to the Electrical Repair Party Posts. Repair actions issued should then be placed on the 'tote board' alongside the nominated Electrical Repair Party Post, its allocated priority and ETBOL. The 'tote board' is used to list all types of defects being dealt with and not just cable runs. Only when the repair or cable run is complete can the defect be removed from the 'tote board'. On completion of restoration of supplies or defect repair, the Command and the end user must be informed of its availability.

b. Losses affecting the Command Aim should be passed to the IBC; and if associated to weapons and sensors passed to the Weapon Section Base as a matter of urgency. Equipment losses reported to DCO(L) from the Weapon Section Base or via one of the other key directors in the SCC/HQ1 should be passed on to each Electrical Repair Party Post by the DCO(L) Assistant. Likewise, details of whole ship BDR incidents should be passed out to the Electrical' Repair Party Posts at a convenient point for annotation to their stateboard.

1937. Electrical Incident Board Marking

a. Should events dictate, anyone suitable, qualified and experienced might be called upon to take over the position of DCO(L), I/C Electrical Repair Party or the DCO(L) Assistant. It is therefore essential that incident boards be marked in a format using standard symbology. Incident boards are to be marked using coloured permanent marker pens; non-permanent marker pens or dry-wipe board markers are not to be used. Ink from permanent marker pens can effectively be removed using a standard pencil eraser or medical methylated spirit swabs. Standard markings for different classes of ship for the Essential Supply Availability Board are detailed at Fig 19-15.

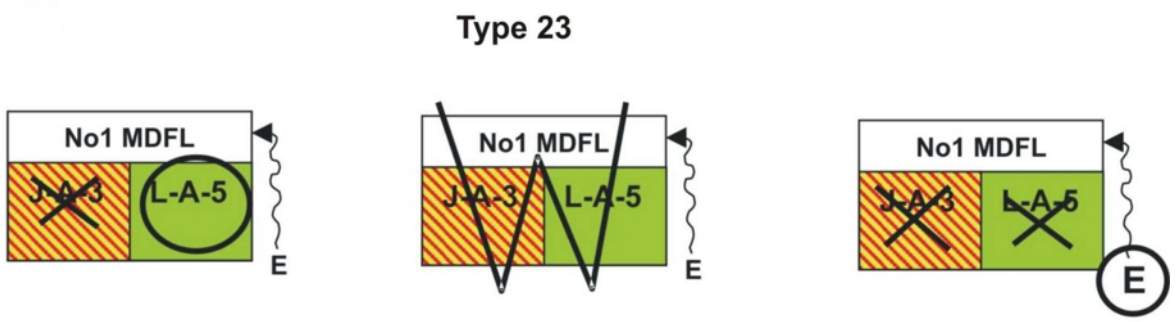
(1) Lost supplies should be marked with a 'X'.

(2) Equipment running in Alternative should have a 'ring' around the supply details to indicate that it is being supplied from its alternative supply.

(3) Wrecked equipment should be marked with a 'W'.

(4) Equipment running from Emergency Cables should be marked with an 'E' and circled to indicate that it is being supplied from emergency cables.

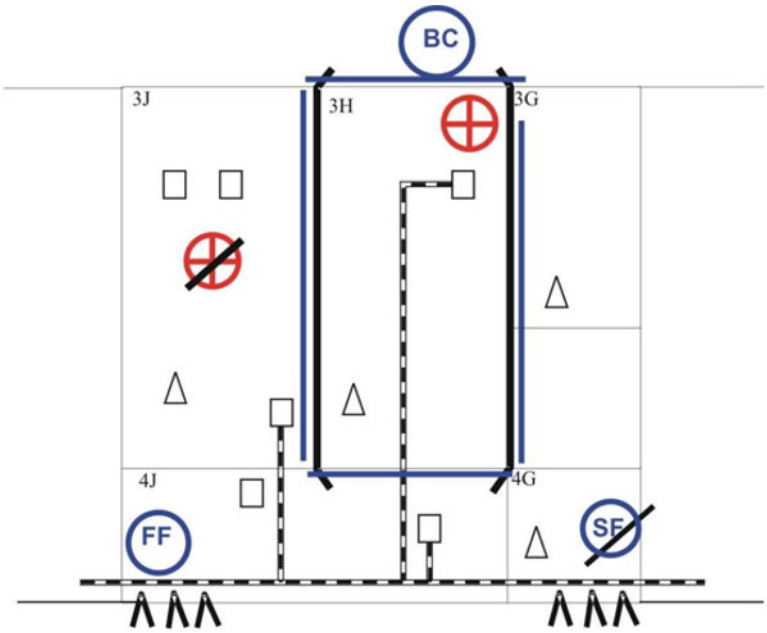
Fig 19-15. General Markings on the Essential Supply Availability Board



Note. *Due to the number of variants of the Essential Supply Availability Boards, marking of electrical losses should follow as far as possible the convention detailed above. If significant differences exist then a standard workable routine should be adopted at all positions.*

b. Whole ship damage incidents are to be marked on DCO(L)s and the I/C Electrical Repair Party Posts Emergency Supply Diagram ('Underground Map') to enable electrical incidents to be managed safely and to appreciate potential damage to electrical equipment and personnel. Incident markings are to follow the standard Annex 8B symbology. Due to the limited space available, the symbols should be reduced so that they do not obstruct the marking up of electrical incidents. Completed incidents are not to be erased from the stateboard but minimised and have a black line scored through as a reminder that electrical checks are required on electrical DC equipment. Once these checks have been carried out, the incident can then be removed from the board. Examples of damage control incidents marked on the 'Underground Map' are detailed at Fig 19-16.

Fig 19-16. BDR Symbology Minimised on the 'Underground Map'



1938. Emergency Cable Run Diagrams

The DCO(L) is responsible for the issue of hand held cable run diagrams ('Underground Maps'). It is vital that these remain under the strict control of the DCO(L) due to the dangers prevalent from unauthorised cable runs (electric shock and/or inadvertent paralleling between switchboards). Initial information on individual cable runs may be passed verbally over the 'Green Line' to allow prompt action to re-supply equipment until the map is issued. The cable run diagram is then used to back up the verbal instruction and is authorisation to apply power. It should be noted that on larger ships the issue of the cable run diagrams is delegated to the I/C of the Electrical Repair Party Post. On all other ships fitted with an Emergency Cable capability the cable run diagram must be issued by DCO(L) from HQ1 and not delegated to the Electrical Repair Party Posts/Switchboards. The only exception to this directive is when an evacuation of HQ1 is in progress and DCO(L) is relocating to AHQ. Prior to evacuation, where possible, DCO(L) is to issue verbal authorisation via the 'Green Line' to the Electrical Repair Party Posts/Switchboards supervisors to conduct necessary cable runs without further authorisation. Once relocated DCO(L) is to conduct a verbal handover of responsibilities via the 'Green Line', ensuring that he is fully briefed of any actions taken in his absence. The following procedures and guidelines are to be followed when compiling cable run diagrams:

a. The equipment is to be confirmed serviceable prior to issue of a 'Underground Map'.

b. Normal and Alternative electrical supplies must have been lost prior to ordering an emergency cable run.

c. Cable run diagrams are to be used as the primary method of authorising the running and powering up of emergency cables. Failure to receive a cable run diagram due to whole ship incidents should not prevent power from being turned on provided the I/C of the Electrical Repair Party Post is content that the run has been completed safely. Verbal authorisation to apply power must be sought from DCO(L).

d. Cable runs are to be indicated on DCO(L)s and the I/C Electrical Repair Party Posts Emergency Supply System diagram by broken lines until the run is complete, after which the line is made continuous once power has been proved present at the equipment. Individual cables which are complete may be indicated with a tick until the whole run is completed. Lines are to be coloured green, using a permanent marker.

e. The cable run must identify from the service to the source of supply. Any connection to a point already energised with power must be clearly marked **'LIVE'**.

f. Cables marked on diagrams issued to cable running teams are to be indicated on the cable run diagram using green continuous lines (not broken), together with the following information:

(1) The time of issue.

(2) An ETBOL. Real time four digit term eg 1405 (pronounced one-four-oh-five).

(3) A unique priority.

(4) The equipment or service to be supplied.

(5) Priority MCCBs to be closed if re-supplying an EDC from an adjacent EDC.

(6) Any DC incident (eg fire or flood) which may impede the cable running activity or passage to a particular section.

g. Cable run diagrams are to be dispatched from HQ1 to Electrical Repair Party Posts in plastic envelopes for protection. Laminated cable run diagrams may be used as long as details are marked with permanent marker pens.

h. On completion of a cable run, the I/C Electrical Repair Party Post is to ensure the cable run diagram is returned to the DCO(L)(DD/FF). Verbal acknowledgement to DCO(L) is sufficient once the diagram has been returned to the I/C Electrical Repair Party Post.

i. Electrical sections or zones should be marked on the DCO(L)'s Emergency Supply Diagram and 'Underground Maps' to highlight points of demarcation preventing inadvertent paralleling of generators.

1939. Emergency Cable Running Procedures

Personnel are at an increased risk from electrocution (BR 2000(52)(1) Para 0318 refers) when live emergency cables are in use. Electrically competent personnel must properly supervise their use to ensure that all safety rules are followed. The person in charge of a cable run must be fully conversant with the procedures (that are carried out in accordance with the reference) and (wherever possible) be in possession of the cable run diagram prior to applying power. Prior to commencing the cable run, the electrical ratings undertaking the required cable run are to receive a comprehensive safety brief from the I/C of the Electrical Repair Party Post on the specifics of the run and any possible associated hazards. Emergency cables are not to be pre-run in anticipation of action damage. The following procedures are to be strictly adhered to when running cables:

a. Whenever possible, personnel should work in pairs.

b. Personnel **MUST** wear electrically insulated rubber gloves whether power is applied or not.

c. Emergency equipment previously exposed to fires or floods must be checked for earth faults and short circuits with GPTME prior to use.

d. Cable runs must be from the service equipment to the source of supply. If 2 teams are undertaking the run, then a 'leapfrogging' technique may be adopted but must be closely supervised by the I/C cable running team.

e. Emergency cable spill ends must be kept clear of the deck at all times. Where possible the whole cable should be kept clear of the deck to prevent water contamination and abrasive damage.

f. Care must be taken to ensure that the running of emergency cables does not breach watertight/gastight (WT/GT) integrity and the effectiveness of smoke boundaries are not compromised. If they have to breech WT/GT integrity the permission of the respective FRPP Officer must be sought.

g. Cables are to be run in such a manner as to allow them to be moved quickly in the event of further damage in the vicinity.

h. Emergency cables should not obstruct operating mechanisms such as rod gearing.

i. Cables can be hung from any structure solidly mounted to the ships hull with certain exceptions. The cables weight should be secured and supported using 'S' hooks (sky hooks) where possible. Examples of structures **NOT** to be used to support emergency cables are:

(1) Any pressurised small bore pipe work such as HP air, hydraulics and pneumatics.

(2) Existing electrical cables to prevent damage to their insulation.

(3) Non-robust installations that may fail due to excess weight.

(4) Doors or hatchways that may impede firefighting teams or personnel carrying out other duties.

j. Cables should not be coiled around fixtures and fittings to take up extra length. This could lead to induced currents, overheating and subsequent fire.

k. Prior to connecting cables to any HCOS, the switch should be set to the off position. Prior to switching to Emergency, the Normal and Alternative supplies are to be confirmed as isolated and the 3 phase emergency supply confirmed as present but not energised (eg emergency generator, switchboard ESU or EDC is serviceable).

l. 440V warning tallies must be secured adjacent to all **LIVE** connection points. For long cable runs, 440V warning tallies should be placed at regular intervals along the cable length.

m. The emergency cable run must be inspected by a competent rating before the electrical supply is energised ensuring all connections are sound, warning tallies are in place and it conforms to the instructions of the cable run diagram. Once power has been applied, 3 phase voltage must be confirmed as present at the nearest point to the service being supplied.

n. On completion of the emergency cable run and when power has been applied, the emergency supply is not to be interrupted without prior permission from DCO(L). Generator and ESU loadings are to be monitored and readings passed to HQ1 and FRPPs every 15 mins or when large load changes occur.

o. During a lull in the action, consideration should be given to securing the cables more permanently using cable ties, rope or other suitable material to allow the ‘sky hooks’ to be returned to the electrical DC lockers.

p. ESU loadings must be measured when power is first applied to the emergency cable run; this must be repeated, and recorded, every 15 mins whilst the cable is live.

1940. Equipment Isolation at Action and During State 3/2 Emergencies

At State 3 and State 2 the Tag Out system is the preferred method of isolation for equipment, as directed in BRd 167 Paras 1514-1521. At State 1, any equipment requiring repair due to action damage does not necessarily have to be ‘Tagged Out’ but all points of supply must be isolated prior to repair work commencing. Additionally, in the event of an emergency or incident whilst operating at State 3 or State 2 that requires prompt isolation of systems and/or equipment to safeguard personnel and machinery, a similar procedure can be adopted. When utilising this method at State 3 or State 2 (but only once the ship has been ordered to Emergency Stations) Action isolations may only be conducted with the IBC’s (MEO/EO) knowledge and permission. As soon as it is practicable to do so these isolations must be replaced by the full ‘Tag Out’ routine.

Safety to personnel is maintained using one of the methods detailed below. All members of the Electrical Repair Party Posts are to be fully conversant with these procedures:

a. If the equipment control panel starter is within eyesight of the person carrying out the repair then the starter is to be taken into local and switched to the off position. Repairs can then be carried out without the removal of the circuit fuses. It is recommended that this procedure is augmented by the use of 'Isolation tallies' iaw sub para f below.

b. If the equipment control panel starter is out of the line of sight, the starter is to be taken into local and switched off. A sentry may be placed on the equipment control panel starter to prevent inadvertent operation if personnel are available, although this is unlikely and does not represent the most efficient and best use of available manpower resources.

c. The fuses to the equipment are to be removed and held locally by the person carrying out the repair. Inadvertent replacement of the fuses is highly unlikely as this instruction would have to be ordered by DCO(L).

d. Where possible, if the equipment is supplied from a MCCB, the MCCB should be locked in the **OFF** position if fitted with a locking device.

e. If the MCCB cannot be locked the breaker can be switched to the off position and a sentry placed to prevent the MCCB being inadvertently operated. This method may be used if personnel are available, although this is unlikely and does not represent the most efficient and best use of available manpower resources.

f. Action/Emergency isolation tallies marked '**Isolated for Action/Emergency Repair - Do Not Remake MCCB'** may be used if they can securely be attached to MCCBs so that they do not fall off due to shock or ship movement. Similarly worded tallies can be attached to equipment starters to prevent inadvertent operation whilst repairs are underway.

g. If a repair is required to the electrical control panel starter then the isolation is not to be at the starter but further back up the supply such as a HCOS or MCCB. Once the isolation has been effected, all exposed conductors or damaged equipment must be checked using appropriate electrical test equipment to ensure all electrical supplies are isolated; whilst undertaking this task, personnel must wear DC rubber gloves and use insulated tools. Test equipment must be checked prior to and after use on a known electrical supply. Should the site be vacated at any time prior to the repair being completed then full precautions and tests on the electrical cables are to be repeated. A check for electrical power should include phase to phase and phase to earth checks. On assuming State 2 (if reverting from State 1) or falling out from 'Emergency Stations', if equipment is still isolated in accordance with the above instructions then a full 'Tag Out' routine must be carried out or as soon as practicable if remaining at Emergency Stations for a protracted period.

h. The term 'Action Tag Out' is **NOT** a recognised or authorised procedure and should not be used; similarly 'Action Tag Out' should not appear on any label or documentation associated with Equipment Isolation at Action/Emergency.

1941. Use of Rubber Gloves

a. Rubber gloves are to be carried by all members of the Electrical Repair Party at all times. They are to be manufactured to BS EN 60903 which have a maximum working voltage of 1000V AC and will be marked with the words 'Class 0' or a red colour code marking. The gloves are to be correctly stowed in the electrical DC lockers when not in use, ensuring that they are not compressed, folded, exposed to any source of heat or prolonged periods of sunlight or artificial lighting. Prior to use, each glove should be checked for perishing and be inflated to check for air leaks. Under no circumstances should voltages in excess of 1000V AC be touched wearing rubber gloves.

b. Rubber gloves should be worn at all times when running emergency cables. When investigating cable damage in trunks or channelling, they should be worn until all damaged cables have been electrically isolated, after which they can be removed for ease of cable repair. Damaged equipment should initially be investigated with rubber gloves worn until isolations have been confirmed, after which they can be removed.

c. Anti flash gloves may be relaxed for ease of repair following approval from DCO(L). They must be readily to hand for quick replacement on the order of **"Brace, Brace, Brace".** One or two additional sets of gloves should be carried to allow for torn gloves or to enable extra manpower such as a WE maintainer to assist with the run.

1942. Defect Repair

Components required to repair equipment are normally drawn from naval stores. If Naval stores do not carry the required component then DCO(L) and the Electrical Repair Party Post I/C's should look for non-essential equipment that they can remove the component from. Alternatively wrecked equipment with similar components can be used.

1943. Cable Repair Techniques

The ability to undertake a variety of cable repairs is essential to maintain the Operational Capability and fighting effectiveness of the ship, however cable repairs to High Voltage power cables are not to be undertaken (1000V AC or 1500V DC). It is therefore essential that all members of the Electrical Repair Party Post are capable of carrying out repairs safely and competently. Before instigating repair action, the DCO(L) should ascertain the full extent of the damage and determine the following points:

a. **Does the defect affect the Command Aim?** There is little point carrying out a repair if it is not in support of the Command Aim unless time, manpower and resources are available. Due consideration should be given to ensure that any repair required relates to the restoration of electrical supplies to equipment that is essential and the use of alternative equipment does not provide a safer solution.

b. **Is it safe to carry out the repair?** Can the cable be electrically isolated and the area made safe. Is the cable repair within the capability of the repair team because of the size and nature of the cable (eg generator main supply cables probably not).

c. **Are the correct tools and equipment available?** The preferred method of cable repair is with use of proper inline crimps and splices using an appropriate tool. Electrical repair teams should ensure that a variety of crimps and splices are held along with the correct tools and die sets including insulating self-amalgamating tape. Other methods of repair are available and detailed at Annex 19A. A basic cable repair kit made up by ships staff should consist of the following:

(1) An item of GPTME suitable for measuring voltage and resistance. The voltage range should be 24 to 1000V and 0 to 1MΩ.

(2) Insulated rubber gloves.

(3) A sharp knife.

(4) A small hacksaw.

(5) Pliers, side cutters (snips) and cable strippers.

(6) Self-amalgamating tape.

(7) Phase identification tape (red, yellow and blue).

(8) A selection of different sized terminal blocks with the appropriate screwdriver.

(9) A sufficient quantity of crimps and splices to make a repair connecting a minimum of 4 separate cores.

(10) A selection of different sized, separately bagged, groups of 4 bolts each fitted with 2 plate washers and nut.

(11) A selection of cable ties.

(12) Water-displacing silicone gel.

(13) A permanent marker.

(14) Pen and pencil.

(15) Cardboard identification tags for cable marking.

1944. Repair Methods

a. There are a number of recognised repair methods that can be used to repair cables and these methods are non-exhaustive. However, as with any action damage repair, ingenuity and lateral thinking is important. Specific details of the repairs listed below can be found at Annex 19A. A non-exhaustive list of common types of repair is:

(1) End to end junction of a single or multi-core cable.

(2) Joint using in-line crimps on a 3-core power cable.

(3) Joint using crimped cable tag ends and fasteners on a power 3-core cable.

(4) Joint using connector block (chocolate block or other type) on a 3-core power cable.

(5) Joint using a Paxolin connection block.

(6) Joint using locally manufactured connector.

(7) Joint using in-line crimps on multi core control cable.

(8) Joint using connector block (chocolate block) on multi core control cable.

(9) Joint for a co-axial cable (data core and screen).

b. The selection of the method is dependent upon the following:

(1) The type and size of cable.

(2) Equipment and tools available.

(3) The current that the cable is expected to carry.

(4) Accessibility.

(5) Location of the damaged cable with respect to the end termination point of the cable.

1945. General Instructions for Cable Repairs

a. Examples of electrical cable repair techniques and guidance on cable ratings and crimp/die selection are provided at Annex 19A and Annex 19B. The following instructions are general guidelines to follow when repairing common electrical power cables:

(1) Loosen the cable(s) from any surrounding support structure, cable channel and banding to give the repairer all round accessibility.

(2) Should the damage be adjacent to the cable termination point, consideration should be given to re-routing the affected cable and connecting the undamaged portion to the cable termination point.

(3) A knife or cable-stripping tool should be used to carefully remove the outer insulation either side of the damage to provide sufficient access to each side of the damaged area. Care must be taken to ensure the insulation on the inner cores is not damaged. This outer insulation, and any screening should be peeled back rather that cut off in order that it can be used to protect the joint on completion of the repair.

(4) With the individual cores fully visible the cable cores should be separated and the damage to each core assessed to determine what type of repairs are required.

(5) Not all cores may need to be repaired, so as a rule on 440V systems any core that is significantly damaged must be cut and properly connected. Cabling that has over 80% of its cross sectional area intact can sustain the full rated current for a limited time, typically less than one minute for motor starting currents.

(6) Should only minor damage to a particular core be detected, it is a management risk to repair the insulation whilst ensuring adequate support for the total cable and leave the minor damage outstanding.

(7) Care must be taken to readily identify each individual core. The majority of cables use either a colour or a numbering system. Removal of a generous amount of outer sheathing should expose the numbers. It is recommended that core identification be supported with a piece of phase tape or attachable tally with a unique number on it written with a permanent marker pen. If time allows, a written copy of the cable information should be made.

(8) Repairs to multi-cored cables should be staggered along the length of the damaged portion of cable. This allows for heat dissipation and provides a natural insulation barrier between phases.

(9) When using a connector block to join high amperage cable, the connector block is to be split so each connection can be insulated individually. This will reduce the likelihood of a short circuit in the event of any subsequent connection overheat or failure. The connector block should be of the correct current rating (or larger) for the task and cabling requirement.

(10) Work should be carried out on one core at a time to avoid inadvertent cross connecting.

(11) Whichever repair technique is used, the resistance of the contact joint must be minimal and every effort must be made to keep this resistance as low as possible. Less than 0.1Ω for a 100A current is the maximum acceptable. This is can generally be achieved by ensuring that:

(a) The cores are clean.

(b) The cross sectional area of the repair is at least the same as the original cable.

(c) The correct repair technique is used for the type and size of cables including tools and consumables.

(d) Where possible hydraulic or mechanical crimping sets should be the preferred repair option with the correct size die selected. Pliers or a hammer are not to be used to compress cable lugs on high power circuits.

(e) The joint is tight.

(12) Cables such as those used in audio circuits or machinery control systems with a relatively low voltage and current may be repaired by twisting the cores together and if time permits, enhanced with soft solder. However it should be remembered that this method affords no mechanical strength across the joint and hence the connection, is not guaranteed to be maintained particularly if subjected to stress. Cables for higher power applications particularly those that involve a high starting current such as large motors must utilise a method of repair that ensures tightness across the connected end of the repaired core to achieve as low a resistance as possible.

(13) Where possible, before applying power the integrity of the joint should be verified using GPTME. Standard electrical checks are to include the continuity of each core, the insulation resistance between cores and the insulation resistance between each core and earth. Minimum acceptable value is 1MΩ insulation and continuity of 0.1Ω. Poorly repaired cables will draw excessive amounts of current leading to excessive heat at the point of high resistance. There is a very strong chance that this will result in equipment failure due to circuit protection devices operating or at worst fire or meltdown of the cable. The following examples illustrate the problems that can be created if a high resistance joint is made:

(a) Example 1: Consider a 2 amp lighting circuit. A temporary repair is made with a poor quality joint having a resistance of 5Ω.

Power losses P = $I^2 \times R$
= $2^2 \times 5$
= **20 Watts**

The heat power dissipated through the repaired joint will be **20 Watts**.

(b) Example 2: Consider a HPSW pump motor with a Normal Full Load Current (NFLC) of 50 Amps and a poor quality joint with a resistance of 5Ω.

Power Losses P = $I^2 \times R$
= $50^2 \times 5$
= **12500 Watts**

The heat power dissipated through the repaired joint will be **12.5KW**, equivalent to of 6 x 2KW electric bar heaters or 4 x 3KW kettles.

(c) Example 3: To emphasise the effect of a good quality repair and the significant reduction of heat generated, consider an HPSW pump motor with a NFLC of 50 Amps with a repaired joint resistance of 0.1Ω.

Power Losses P = $I^2 \times R$
= $50^2 \times 0.1$
= **250 Watts**

The heat generated is significantly reduced by 1/50th at the repair joint.

(14) After each separate core is repaired, it must be individually insulated using self-amalgamating tape. The insulation should cover the repair totally, extending over the inner insulation. As well as being a good insulator, this tape will provide a degree of water protection. A layer of electrical phase tape should be placed over the self-amalgamating tape. This provides additional strength and prevents the self-amalgamating tape on the individual cores sticking to each other. It must be emphasised that phase tape is not an insulating tape but an identification tape even though it may have insulating properties. The outer sheathing that was originally stripped back should be utilised and pulled over the repaired inner cores to offer extra protection. If no outer sheathing is available then a substitute insulating material should be used. A further layer of self-amalgamating tape should be bound over the entire length of the outer insulation extending beyond the limits of the original damage to ensure that fluid is not able to penetrate inside the cable and into the individual cores. The joint should now be given some mechanical strength by providing suitable support across the repaired section of cable; eg an insulated length of metal bar, wooden splint or length of broom handle.

(15) On cable repairs supplying 115V and above a voltage warning tally should be placed adjacent to the repair since the integrity of a cable has been breached and a temporary repair made.

(16) On restoration of electrical power, care must be taken to ensure this is done in a controlled manner and equipment users must be involved at all stages since the equipment may have been out of action for some time. On initial energising of the equipment, the repair should be monitored for possible signs of overheating or short circuit at the joint. The person monitoring the repair should have with them a CO_2 extinguisher and a suitable means of communication to the isolating point. Once some confidence in the repair has been gained the sentry can be stood down with periodic rounds being carried out on the repair.

b. Following damage to cables it is more than likely that the repair will involve inserting a new section of cable between two points. This will result in 2 repairs per cable being required placing an even greater emphasis on the quality of repair stated above. A suitable cable will have to be obtained from locally held stores or by removing a section of supply cable from unimportant or wrecked equipment. To assist with cable selection a detailed table is given at Annex 19B. **It must be stressed that repairs carried out in the action scenario should only be considered temporary until a full repair can be carried out at a repair facility.**

c. For further information regarding cable selection, jointing and repair, refer to the following publications:

(1) BR 2000(51)(4A) - Workshop Technology Electrical Practices.

(2) Def Stan 02-512 Part 8 - Guide to Cables, Electrical and Associated Items.

(3) BR 4603(1) - Electrical Installation Manual Volume 1 Installation Practices.

1946. Electrical Repair Party Posts (QEC/LPH/LPD)

The Electrical Repair Parties operate from each FRPP and consists of a Senior Rate I/C and at least 2 electrically competent ratings, identified with green brassards or surcoats. Each party is under the overall control of the DCO(L) but may on occasions be employed on mechanical damage repair activities dependant on the Command Aim. Enough personnel must be retained to enable Blanket Search activity to continue immediately after **"Stand To"**. Care should be taken to ensure that the Electrical BDR Team personnel are not employed on tasks from which they cannot be easily recalled in the event of an electrical incident taking priority. The I/C Electrical Repair Party has the authority to issue 'Underground Maps' on behalf of the DCO(L) due to the distance and number of decks, doors and hatches between each section and HQ1/SCC. Maps must be issued on the instruction and priority of the DCO(L).

SECTION 3 - DAMAGE CONTROL AND FIREFIGHTING IN A HIGH VOLTAGE (HV) ENVIRONMENT

1947. Introduction

a. The following guidance for damage control and firefighting within HV compartments has been derived from best Naval practice and commercial experience. Guidance within this section must be modified and endorsed by local standing orders to reflect the specific design of any HV system.

b. The policy and procedures to be adopted in a State 1 environment are detailed in the class specific BRd 2170 Vol 7 and if appropriate Departmental Standing Orders.

1948. Definitions

a. **High Voltage Environment.** A HV environment is said to exist if voltages present within the compartment or equipment exceed 1000 volts AC (1KV) or 1500 volts DC (1.5KV) under normal working conditions. Where a compartment contains no HV equipment but is transited by HV cables the compartment is to be considered as a HV compartment in the event of a fire within. Kill Cards for such compartments are to have HV cable runs annotated in **RED**.

b. **The Authorising Engineer.** The Authorising Engineer (AE) is to comply with the regulations in BRd 3000 and BR 2000(52)(1).

c. **HV Live.** This term is used to inform personnel that the ship is either generating HV, is capable of generating HV or is connected to an external HV Shore Supply.

d. **HV Disconnect/HV Disconnected.** This term is used as a request to, or order from, the Command for competent ME personnel to disconnect a particular equipment or compartment from the HV power system but not secure individual breakers (eg HV Disconnect the FAMR). HV breakers feeding the relevant equipment/compartment will be opened (but not racked out).

e. **HV Isolation.** This term is used to inform personnel that an equipment or compartment has been disconnected and separated from the source of electrical energy in a secure fashion (eg HV Breaker Open and Racked Out).

f. **HV Safe.** This term is used to inform personnel that a particular compartment/ area is safe to enter with all forms of HV power source disconnected, and the appropriate HV decay periods have elapsed. This term must only be used in conjunction with the clearly identified compartment/area.

g. **HV Dead.** This term is used to inform personnel that the ship is no longer capable of generating HV and all sources of HV supply are to be disconnected and isolated with circuit main earths applied.

Note. *There is a clear requirement to utilise the terms* ***HV ISOLATION*** *and* ***HV DISCONNECT/DISCONNECTED*** *within the SCC/MCR to ensure that operators are in no doubt over the state of HV systems. However, the only terms which should be used over the main broadcast are* ***HV SAFE*** *and* ***HV LIVE.***

1949. HV Hazards

Damage control and firefighting within a **LIVE** HV environment can expose personnel to a number of additional hazards including:

a. Massive electric shock from **LIVE** equipment.

b. Blast effects resulting from an internal arc caused by either battle damage, damage control and firefighting activity in the vicinity or the development of an initial electrical fault.

c. Exposure to dangerous arc products.

d. Increased exposure to the fire hazard due to the restrictions placed on firefighting.

e. Increased fire propagation resulting from the initial delay in using more effective firefighting equipment until such time that HV equipment is made safe.

1950. HV Fires

WARNING

IT IS IMPORTANT TO NOTE THAT WATER (EVEN IN THE FORM OF SPRAY OR AFFF FOAM) AND DIRECT INJECTION OF CO_2 ARE TOTALLY UNSUITABLE FOR FIGHTING FIRES ON LIVE HV EQUIPMENT.

a. Electrical fires are so called because they are usually caused by some fault to a live electrical circuit, which has generated sufficient heat to ignite insulation, paint or some other combustible material close to it. The fault is often caused by:

(1) A breakdown in insulation resistance of an electrical component or cabling.

(2) Water ingress.

(3) Action damage.

(4) A breakdown of clearance distances eg introduction of conducting foreign bodies.

b. The heat generated by an unprotected HV electrical fault can in extreme cases be sufficient to instantaneously vaporise the conductors in the fault region resulting in rapid expanding flame front that will seek an escape route from the cabinet and into the compartment. The extent of the flame front or blast effect will depend on the design of the equipment and only last momentarily whilst the residual fire will depend on the amount of combustible material in the vicinity of the equipment.

c. Due to the high fault energy inherent within the high voltage system, HV fires will not be extinguished until electrical power is first **DISCONNECTED** and this is more than likely to occur either through the correct operation of the safety protection devices fitted (eg circuit breaker trip) or due to the high energy discharged through the fault region resulting in an open circuit.

1951. Ingress Protection Codes and Categories of Enclosure

a. Ingress Protection (IP) codes are a commercial standard laid down in British Standards whereas Categories of Enclosure are a military requirement described in Defence Standards (see Table 19-1).

b. With the introduction of HV equipment their existence and importance has been brought into focus regarding RN firefighting policy. The specification defines the environmental protection performance of the enclosure. The first figure of the code identifies the degree of protection against the ingress of solid objects. The second figure indicates the resistance offered by the enclosure to water penetration.

c. Therefore an IP65 rating means that the unit is protected against access with a wire (1 mm), is dust tight and withstand jetting water from all directions.

d. HV compartments will contain IP rating tallies on all electrical equipment, however, it must be noted that that the IP ratings for equipment can and do degrade over time, particularly if maintenance or defect rectification has been undertaken incorrectly.

e. **Categories of Enclosure.** Although the IP Code is used in the specification of Naval equipment it supplements, but not replaces, the enclosure category. The general categories are as follows:

(1) *Category 1.* Normal drip proof.

(2) *Category 2.* Totally enclosed and spray proof.

(3) *Category 3.* Watertight to 0.1 bar.

(4) *Category 4.* Watertight at 0.4 bar.

(5) *Category 5.* Watertight to pressures above 0.4 Bar.

f. The majority of electro technical equipment will fall into Category 1. However, equipment intended for installation in machinery spaces with fixed firefighting spray systems must be enclosed at least to Category 2.

g. IP ratings are mainly dependent on the type of ventilation required for the equipment and the quality of the cable glands. Additionally poor maintenance, such as not replacing doors and panels correctly, or not changing damaged seals, will degrade ingress protection, but not change the equipment rating.

Table 19-1. Ingress Protection Codes

PROTECTION AGAINST ACCESS TO HAZARDOUS PARTS FIRST NUMERAL	
Number	**Description**
0	Non - Protected
1	Protected against access with back of hand (50 mm)
2	Protected against access with jointed finger (12 mm)
3	Protected against access with a tool (2.5 mm)
4, 5, 6	Protected against access with a wire (1 mm)
PROTECTION AGAINST INGRESS OF SOLID FOREIGN OBJECTS FIRST NUMERAL	
Number	**Description**
0	Non - Protected
1	Objects equal or greater than 50 mm
2	Objects equal or greater than 12.5 mm
3	Objects equal or greater than 2.5 mm
4	Objects equal or greater than 1 mm
5	Dust Protected
6	Dust Tight

INGRESS PROTECTION CODE - SECOND NUMERAL		
IP Code	**Protection Against Ingress of Solids**	**Meaning For Protection From Ingress of Liquids**
0	No protection	No protection provided.
1	Protected against vertically falling drops of water. Limited ingress permitted.	Vertically dripping.
2	Protection against vertically falling drops of water with enclosure tilted 15° from the vertical. Limited ingress permitted.	Dripping up to 15° from the vertical (equivalent to CO_2 and Dry Powder Fire Extinguishers).
3	Protected against sprays to 60° from the vertical. Limited ingress permitted.	Limited spraying.
4	Protected against water splashed from all directions. Limited ingress permitted.	Splashing from all directions.
5	Protected against low pressure jets of water from all directions. Limited ingress permitted.	Hosing jets from all directions.

INGRESS PROTECTION CODE - SECOND NUMERAL (Cont'd)		
IP Code	**Protection Against Ingress of Solids**	**Meaning For Protection From Ingress of Liquids**
6	Protected against strong jets of water.	Strong hosing jets from all directions (equivalent to a Centre Fed Hose Reel (CFHR)).
7	Protected against the effects of immersion between 15 cm and 1 m.	Temporary immersion (equivalent to a Size 2 Hose and F/F Nozzle).
8	Protected against longer periods of immersion under pressure.	Immersion.

COMBINED CATEGORY AND IP RATINGS				
Enclosure Category	**Description**	**Minimum Acceptable IP Rating**	**IP Protection Against Solids**	**IP Protection Against Liquids**
1	Normal Drip Proof	IP32	>2.5 mm	Dripping
2	Totally Enclosed and Spray Proof	IP54	Dust Protected	Splashing
3, 4, 5	Watertight	IP68	Dust Tight	Continuous immersion up to 1 m

1952. Real Time Risk Assessment

WARNING

WHILST PROVIDING GUIDELINES FOR DAMAGE CONTROL AND FIREFIGHTING, EACH INCIDENT MUST BE EVALUATED IN REAL TIME AND THE APPROPRIATE ACTIONS TAKEN, BALANCING THE DANGER TO THE SHIP POSED BY THE FIRE AGAINST THE RISK TO PERSONNEL FROM LIVE HV EQUIPMENT.

a. It is important to emphasise that the initial response to incidents (fire and floods) within compartments containing correctly functioning LIVE HV equipment must be rapid, instinctive and safely undertaken within the guidelines detailed in this Section.

b. It is a general principle that where the HV equipment has sustained damage or is malfunctioning, power must be **DISCONNECTED** before committing personnel into the compartment.

c. At increased levels of operational intensity it must also be borne in mind that damage control and firefighting activities may compromise the integrity of the power and propulsion plant, degrading fighting capability and subsequently jeopardising the mission aim. Hence, operational posture and the tactical environment will undoubtedly impact on the decision whether to HV **DISCONNECT** or contain an incident without disconnecting to maintain the fighting capability for as long as practicable under battle conditions.

d. At increased levels of operational intensity, if an incident or the response to an incident is likely to result in water or FF media impinging on live HV equipment a dynamic risk assessment must be undertaken by the Authorising Engineer to inform command and justify the increased risk to personnel against the broader mission aim.

Note. *Where fire has ignited on the low voltage elements of high voltage equipment (control circuitry in addition to LV windings of link transformers), it may cause damage to the control; monitoring and/or safety devices fitted and could subsequently lead to a HV fault.*

1953. Fires Within a Live HV Compartment

a. Where all HV equipment within the compartment has ingress protection (IP) of IP56 or greater (generally RN Main Machinery Spaces) and the integrity of the HV equipment is not endangered by the fire, then manual firefighting is permitted using dry powder, CO_2 extinguishers, AFFF SPE and CFHRs. Where any HV equipment within the compartment has an IP rating of less than IP56 (generally HV and LV switchboards and RFA Main Machinery Spaces), then manual firefighting is limited to CO_2 and dry powder extinguishers. Manual injection ports for CO_2 extinguishers must **NOT BE** used on HV equipment until it has been **DISCONNECTED** and reported as HV **SAFE** over main broadcast.

b. CFHRs may be deployed and used in compartments with live HV equipment where the ingress protection of all the HV equipment is IP56 or above, although HV equipment should not be intentionally sprayed. Power should be **DISCONNECTED** and reported as HV **SAFE** over main broadcast as soon as operationally practicable. In compartments where the ingress protection of the HV equipment is less than IP56, then CFHRs should remain stowed and isolated until the affected space is **DISCONNECTED** and reported as HV **SAFE** over the main broadcast.

c. Lay flat hoses must neither be deployed nor charged within any HV compartment where the ingress protection rating of the HV equipment is less than IP 57 (submersible) until such time that it has been confirmed that all HV equipment in the affected space has been **DISCONNECTED** and reported as HV **SAFE** over the main broadcast. Normal RN firefighting procedures are then to be followed.

Note. *Manual firefighting using AFFF SPEs and CFHR is permitted in compartments with an IP rating of less than IP56 ONLY when concessions are formally documented following agreement by the Naval Authority, Material Duty Holder and Operating Authority Duty Holder. Where concessions are held, SOPs should be amended accordingly.*

1954. Fixed Firefighting Systems

The following operating restrictions are applicable to current fixed fire suppression systems:

a. Fixed 2 shot CO_2 drench systems are to be operated as follows:

(1) The first shot may be used without disconnecting power although where the fire has been initiated by a HV fault, then power should be **DISCONNECTED** as soon as practicable.

(2) The second shot should only be used after HV **DISCONNECTION**.

b. Fixed water/AFFF spray systems may only be operated over live HV equipment in extreme cases where the risk to the ship outweighs personnel safety. This normally, but not necessarily, refers to State 1 scenarios where an especially aggressive response to the fire is warranted. In such situations all personnel should be evacuated from the compartment and the operation shall only be authorised personally by the Authorising Engineer.

c. Fixed water/AFFF spray systems normally operated for compartment cooling should only be used when it has been confirmed that power to all HV equipment within the compartment has been **DISCONNECTED**. It is noted that in extremis where the ingress protection of all HV equipment within the compartment is IP56 or greater and operational constraints prevent the rapid disconnection of power then high level spray systems may be operated as soon as the compartment has been evacuated of all personnel. Fixed low level water/AFFF spray systems, normally fitted for bilge protection may be used without **DISCONNECTION** of HV supplies when the equipment within the compartment is IP56 or greater.

Note. *Equipment with an IP rating of 56 or less has no protection against the effects of immersion.*

1955. Portable Firefighting Equipment

The following operating restrictions are applicable to current portable firefighting equipment:

a. The CO_2 SPE may be used in the vicinity of live HV equipment up to 12 kV where the ingress protection is greater than IP22; however, CO_2 may not be allowed to directly impinge on live HV conductors due to the risk of ice forming on critical components degrading clearance distances. For this reason it is important that CO_2 is **NEVER** injected into **LIVE** HV equipment even though the fitted ports contain a deflector nozzle to mitigate the risk of direct discharge onto live conductors. CO_2 is an inert gas and will not support combustion or life at concentrations above 35%. It is heavier than air and displaces oxygen by forming a temporary blanket providing limited post fire protection, but no cooling effect. Carbon Dioxide will cause limited obscuration in use, however, its effectiveness can be significantly degraded by even weak ventilation, due to the reduction of CO_2 concentration levels.

b. Manual CO_2 injection ports fitted to HV equipment should only be used to extinguish any residual fire once the power has been **DISCONNECTED** to the defective equipment. However, CO_2 may be manually injected into the low voltage side of any HV equipment before disconnecting power where it is clearly marked safe to do so.

Note. *All panels containing CO_2 injection ports must be clearly marked with the maximum operating voltage of the cubicle.*

c. Dry powder may be used in the vicinity of live HV voltage equipment up to 12 kV, where the ingress protection rating is greater than IP22. Dry powder is a quick and effective smothering agent but has limited post fire protection and no cooling effect; it will also cause rapid obscuration and is significantly degraded by strong ventilation. The residual powder has been proved to be conductive but will absorb moisture and should be removed from electrical equipment as soon as reasonably practicable.

d. AFFF fire extinguishers should only be used in the vicinity of live HV voltage equipment if all the high voltage equipment within that compartment is protected by an ingress rating of IP56 or higher.

1956. Electrical Disconnection and Isolation

In all fire and flood situations in an HV compartment, permission for HV **DISCONNECTION** must be swiftly sought from the Command and, where necessary, achieved and maintained by the most appropriate means that ensures that the system cannot be inadvertently re-energised. All HV equipment in the affected space must have **HV ISOLATIONS** effected prior to firefighting teams conducting a full re-entry. The Officer in charge of firefighting and damage control (DCO at Sea and the OOD in Harbour) is to make a pipe on General Broadcast informing all personnel as soon as the compartment has been made **HV SAFE**. The following pipes are to be made:

a. **Smoke Alarm**

"SMOKE ALARM, SMOKE ALARM, SMOKE ALARM, SMOKE ALARM IN (Compartment Name, Location Marking and Fire Zone). THIS IS A HV COMPARTMENT. ATTACK PARTY (AND ME(ET)OW) TO INVESTIGATE".

b. **Fire**

"FIRE, FIRE, FIRE, FIRE IN (Compartment Name, Location Marking and Fire Zone). THIS IS A HV COMPARTMENT. ATTACK PARTY MUSTER AT THE SCENE. SUPPORT PARTY MUSTER AT (FRPP1, FRPP2, FWD FRPP, AFT FRPP). CONTAINMENT PARTY MUSTER IN HQ1/EMR. DROP ALL SMOKE CURTAINS AND CLOSE FIRE DOORS IN THE VICINITY OF THE FIRE".

c. Once HV is Confirmed **DISCONNECTED** and the decay time has elapsed:

(1) Pass and repeat HV **SAFE** to I/C Main Group.

(2) Make the following pipe x 2.

"THIS IS THE DCO/OOD, THE (Compartment Name and Location Marking) IS NOW HV SAFE. ALL FIREFIGHTING EQUIPMENT MAY NOW BE USED IN THE (Compartment Name and Location Marking)".

1957. Decay Times

HV decay times must be indicated on individual equipment and recorded on compartment Kill Cards. Local standing orders and standard operating procedures must be amended to reflect the additional hazard represented by decay times in excess of 20 seconds to decay to below 440V.

1958. Firefighting Procedures

The adopted firefighting procedures will depend on the design of the installed HV system as well as the operational state of the vessel and nature of the incident. Clear guidance must be provided in local standing orders and the ships firefighting teams (HFEP (Harbour)/ SSEP (State 3)/FRPPs and Mobile Repair Parties (State 1)) must all be familiar with the procedures, layout and hazards within all HV compartments. The following generalised guidance is provided:

a. **Small Fires within a HV Compartment.** Small fires should be attacked, without waiting for electrical disconnections, using the most appropriate first aid firefighting equipment designated as safe for use within the compartment. Once power to the HV equipment has been **DISCONNECTED**, standard RN firefighting procedures may be applied, noting that the excessive use of water may cause significant damage to the HV equipment, putting it beyond operational use. If the fire is not easily contained then the early evacuation of personnel from the compartment should be considered and fixed suppression systems deployed in accordance with the local operating procedures.

b. **Small Fires on Low Voltage Equipment within a HV Compartment.** Standard RN firefighting procedures apply and a CO_2 extinguisher should be used either with a discharge horn or a bayonet connection for electrical cabinets; all electrical power to the affected equipment should be isolated as soon as reasonably practicable. If the affected low voltage circuits/equipment is integral to HV parent equipment, this equipment is to be HV **DISCONNECTED** as soon as practicable.

c. **Major Fires within a HV Compartment.** The compartment should be evacuated of all personnel and fixed fire suppression system deployed in accordance with the local operating procedures. Unless it is operationally essential all HV equipment should be **DISCONNECTED** as soon as reasonably practicable.

d. **HV Fires.** HV power must be **DISCONNECTED** as soon as practicable and where fitted the fixed fire suppression systems deployed in accordance with local operating procedures. Where there is no fixed suppression system, a controlled re-entry should be made once all HV equipment, low voltage equipment and other mechanical hazards within the effected compartment have been **ISOLATED** in accordance with accepted RN practice.

e. **Fire Danger within a HV Compartment**. Where immediate action is required or HV power cannot be **DISCONNECTED**, a localised fire danger may be made safe where the risk of not taking action outweighs the risk of exposure to high voltage. This will depend on the location and ingress protection of the installed HV equipment. However, HV power should be **DISCONNECTED** as soon as operationally practicable as a precautionary measure and before applying any form of foam blanket where the ingress protection of the HV equipment within the compartment is less than IP56.

f. **Fire Alarm within a HV Compartment**. Members of the Attack Party should carry out investigating a fire alarm inside a closed HV compartment once all other means of evaluating the compartment state have been exhausted (eg CCTV/viewing port).

g. **HV Compartment Re-Entry.** Having **ISOLATED** the compartment, the method of re-entry and recovery will depend on the individual circumstances of the incident and operational state of the vessel; noting that the excessive use of water could cause significant damage to the HV equipment within the compartment and prevent the full recovery of that equipment. Where a fixed gaseous suppression system has been deployed or significant smoke and toxic gases have accumulated then a waterwall seal or closed door must be maintained at the containment boundary.

(1) Main machinery space re-entry is to be carried out in accordance with current firefighting procedures as detailed in Annex 21F and the ships specific CBRNDC Orders, once it has been confirmed that all HV equipment has been effectively **ISOLATED**. However, where a fixed fire suppression system has been deployed quickly and there has been minimal rise in the overall compartment temperature, consideration should be given to limiting the extent of water damage within the compartment with the careful choice of entry point and local risk assessment made on the amount of compartment cooling required.

(2) Dedicated high voltage compartments with fixed fire suppression systems and dedicated ventilation/purging arrangements (eg Gas Turbine Alternator) should be recovered using the re-entry principles outlined in Annex 21M, once all HV equipment has been effectively **ISOLATED** and the compartment temperature (monitored using the TMS) is below 60°C (see Annex 21A for re-entry notes).

h. **Boundary Monitoring/Cooling.** Boundary Monitoring may be carried out within **LIVE** HV compartments **ONLY** under the supervision of a Competent Person. However, should it become necessary to use water for cooling then power should be **DISCONNECTED** as soon as operationally practicable and plastic sheeting used to cover the HV equipment, noting the principles laid down in Annex 21D.

1959. Damage Repair Procedures

The appropriate HV safety procedures must be followed before undertaking damage repair on/or adjacent to HV equipment until such time that the operational tempo or Command aim require a more direct approach. Once HV power has been **DISCONNECTED**, standard Damage Control procedures should be followed. The following generalised guidance is provided for recovery under action or emergency conditions, noting that incidents can rapidly deteriorate with little warning:

a. **Pumping and Flooding.** Small floods remote from HV equipment may be contained without disrupting power to the Command and fixed pumping equipment deployed at the earliest opportunity. Major flooding is likely to cause significant damage to HV equipment and where it is non-submersible and in immediate danger from floodwater, power must be **DISCONNECTED** not only to safeguard the equipment and personnel, but also wider system integrity.

Only portable electrical submersible pumps and fixed eductors should be used to remove floodwater in HV compartments; **portable routine eductors should not be used.**

b. **System Repair**. The repair of minor fluid leaks remote to HV equipment may be carried out following standard procedures without disrupting power to Command. Where appropriate, consideration should be given to covering HV electrical equipment with plastic sheeting to minimise risk to equipment and personnel. Major leaks from fluid systems that represent a serious risk and a danger of spray contamination of HV equipment are to be dealt with immediately. In such cases, HV equipment must be **DISCONNECTED** as soon as practicable until the fluid system has been isolated or repaired.

c. **Shoring.** Shoring must be carried out in live HV environments **ONLY** under the supervision of a HV Competent Person, and the risk of man-handled timber and steel shores adjacent to live HV equipment must be assessed against the Command's priorities and where possible power should be **DISCONNECTED**. If operationally essential, HV equipment may be re-energised post shoring at the discretion of the Authorised Engineer.

d. Extreme caution must be exercised in re-energising HV equipment and systems previously affected by action damage. Integrity testing and inspections should be undertaken in accordance with BR 2000(52)(2). Deviations from this procedure requires the authority of the Authorising Engineer as determined by operating regulations.

1960. Manning of Firefighting and Damage Control Parties (HFEP/SSEP/State 1)

All firefighting and damage control teams entering compartments containing live HV equipment are to comprise of sufficient HV Competent Persons to ensure the safety of both personnel and equipment. Therefore, provision must be made to ensure that there are sufficient personnel within the DC organisation with adequate electrical training. The following specific training and qualification standards for onboard personnel should apply:

a. The I/C of both the Attack Party and the Support Party of firefighting parties must be HV Competent.

b. All personnel within the Damage Control organisation must be HV aware.

c. All personnel proceeding into HV compartments to undertake firefighting, containment or damage control activities must be accompanied by at least 1 HV Competent person.

d. The OOD or DCO in charge of firefighting and DC in a HV compartment must be HV Competent, and they must be advised on the implications of HV hazards within that compartment by a HV Competent ME Officer or ME Senior Rating.

1961. Training

Onboard firefighting and damage control training must be conducted in such a manner within HV spaces to ensure that personnel are competent and familiar with the local procedures and HV hazards.

a. For strictly controlled training serials (ie during OST) lay flat hoses may be charged, isolated and then pressure relieved at the nozzle prior to deploying into compartments containing HV equipment of IP rating 54 or greater under strict supervision.

b. Appropriately qualified safety numbers or trained staff, locally endorsed by the Authorising Engineer, must be present to closely monitor any damage control and firefighting training within compartments containing HV equipment.

c. Mechanical smoke generators may be used within HV compartments under the direct supervision of appropriately qualified training staff, locally endorsed by the Authorising Engineer.

1962. High Voltage Authorised Person's Logbook and Diary

A High Voltage Authorised Person's Logbook and Diary (RNS 3284) is issued to all personnel attending the appropriate training module at HMS SULTAN. The purpose of the logbook is to allow Authorised personnel to maintain their own record of HV switching operations and practical work. This will also assist the Authorising Engineers in monitoring and auditing their platforms procedures. Any HV qualified engineers currently in date within the Surface Flotilla who wish to receive a logbook are to contact HMS SULTAN by e-mail: SULTAN-ctec@nrta.mod.uk for a copy.