part three
electrical installations

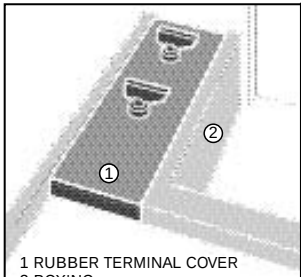
Cleat Hitch

Faulty electrics, or poorly installed electrical systems, can be a real hazard and could place you and others at risk. This part of the Standards aims to minimise the risks from short circuits and overheating cables, both of which are a common cause of boat fires. It also addresses the potential risks of hydrogen, a highly flammable gas that is a by-product of charging your batteries.

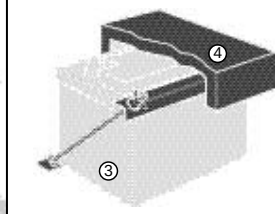
You can reduce these risks by making sure that batteries are stowed in a ventilated area, that batteries and cables can't move around, that your fuses and circuit-breakers are correctly rated for the circuits they protect and that wear and tear hasn't left your system vulnerable to failure.

Good electrical practices can also reduce the risk of personal injury caused by electric shocks.

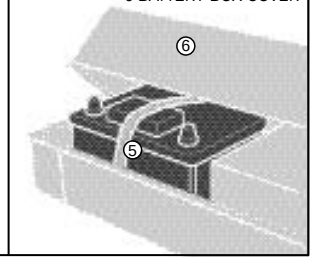
Three ways of securing and covering a battery



1 RUBBER TERMINAL COVER
2 BOXING



3 BATTERY CLAMP RESTRAINT
4 WOODEN COVER



5 STRAP RESTRAINT
6 BATTERY BOX COVER

batteries

To stop batteries from moving around, which could cause damage to their terminals and connections, or cause them to spill corrosive liquids over the boat, they must be securely fixed.

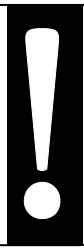
A source of ignition, like batteries, must be kept away from potential fuel sources to reduce the possibility of fire or explosion. So, batteries can be kept in the engine room, but they must never be under or next to a petrol or LPG tank, cylinder, stopcock, pipe or filter. It's a good idea to keep your boat's batteries at least half a metre (around 18ins) away from any petrol or LPG equipment.

If your batteries are kept in confined spaces in compartments it's essential that the build-up of flammable hydrogen gas is prevented. To achieve this, battery compartments must be properly ventilated.

To prevent sparks being created by metal objects or tools touching the top of batteries, which could act as an ignition source and start a fire or explosion, the positive and negative terminals of all batteries must have insulated covers in place. Some batteries don't have individually covered terminals, and traditional batteries have exposed connectors between the cells – in these cases you must cover the whole top surface of the battery. Covering batteries will also reduce the likelihood of electrical sparks caused by touching the terminals with a metallic object. [3.1]

electric cables

Cables can overheat if the cabling on your boat is not sufficient to carry the current. To minimise this risk the cables must be capable of carrying the current and be of the right construction and grade. New electrical installations must use



Upon entering the lock a slight impact with the lock wall caused the battery to slide and the battery terminals to make contact with the metal coaming of the hull. The hull became live. Via the engine bearers the electric current travelled along the metal braided fuel supply and return lines. Where these hoses touched, sparking occurred and the fuel hoses burnt through, allowing diesel spray to create a vicious fire. It took the fire brigade 20 minutes to extinguish the fire. [3.1]

From a report detailing a serious engine compartment fire on a hired narrowboat.

multi-stranded conductors, since solid conductors can easily break where there is high vibration or repeated flexing of a cable.

If solid conductor wiring is already fitted this is acceptable, as long as it's securely supported and shows no sign of wear and tear. It's a good idea to include a check on the condition of all of your boat's wiring during routine maintenance and inspection.

Fuel, water, heat, oils and other chemicals can all cause damage to your cables, reducing the effectiveness of the insulation and increasing the risk of cables overheating – which could cause them to short-circuit, spark and start a fire. Exposed 240V wiring can also give people on your boat an electric shock. To reduce these risks all cables must be properly insulated and/or sheathed with a resistant material.

To prevent damage caused by vibration, cables must be securely fixed at approximately 300mm (12ins) intervals, or run in a pipe or trunking which is adequately supported. Also, to reduce the chance of damage to the cables, they must be kept away from other heat sources such as exhaust outlets, cookers and stoves. [3.2]

main circuits

To minimise the risk of damage to cables, and to allow a visual inspection of the installation, main circuits must be installed above bilge water level. Bilge water level can usually be determined by the presence of a 'tidemark', the position of the bilge pump or its inlet, or the level at which the float switch is set.

All main circuits, other than starter circuits, must be protected by circuit breakers or fuses of the appropriate rating and of a suitable design. This means that the fuse or circuit breaker must have a rating which is lower than the current that would cause damage to the circuit. The safe operation of these

devices must not be compromised by the use of thicker fuse wire or by using tape to keep the contacts closed.

If your boat has a 240V supply it's strongly recommended that you fit a residual current device (RCD) to automatically disconnect the supply. This will prevent an earth leakage current flowing through a faulty appliance, and protects someone inadvertently touching a live circuit and getting an electric shock. [3.3]

cable installation

It's advisable to run the cables as high as possible to reduce the chance of heat or impact damage – at least 75mm (3ins) and ideally 125mm (5ins) away from any potential sources.

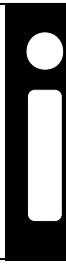
Cable conduits can be the 'clip together' uPVC type, galvanised steel or wood. But whatever the type, they must be firmly fixed at around 900mm (3ft) intervals. To minimise the chance of sparks coming off a damaged cable and igniting nearby fuels, cables must be kept at least 30mm (2ins) away from fuel and gas pipes – unless the pipe or the cable is in a suitable conduit or duct. [3.4]

cables & polystyrene insulation

It's a good idea to keep cables that are insulated or sheathed in PVC away from polystyrene thermal insulation – the two materials have been known to react and break down the cable covering. It's recommended that the electrical installation is periodically checked by a competent electrician – preferably every year – so that you can keep a record and spot the signs of a problem, before it becomes a potential hazard. [3.4]

battery master switch

In the event of an electrical fault it's important that all power to the electrical system can be cut off so that cables and circuits do not remain live. This will enable you to control any overheating which could start a fire, allow repairs to be safely made on any blown fuse or damaged cabling and reset the tripped circuit breaker. A battery master switch or switches, capable of disconnecting the system – including the starter circuits – must be fitted in a readily-accessible position, as close to the battery as possible.



You can help the examiner identify whether your 12 or 24 volt distribution cables are adequate to carry the current they are intended for, and that the fuses feeding each of the cables is suitable for the circuits. Why not label each fuse with the identity of the circuit it feeds? By turning the power off you can safely disconnect each fuse in turn, before switching the main power source back on and investigating which circuit is affected. This will also help you if you have to replace a fuse in the future. Always have a cover over the fuse mounting box. [3.3]

You must be able to get at the switch without having to move anything out of the way, or use tools or keys to reach it. If you can't see the battery master switch, you must mark its position very clearly so that emergency services or other crew members can easily locate it in the event of an emergency.

The switch must be capable of carrying the maximum current of the system, including when the engine is started. If there are separate circuits connected to separate batteries, each of them must have a battery master switch. A combined switch can be used, for example in a two battery system, where one battery is used for starting the boat's engine and the other is used for domestic services.

Electrical equipment, such as bilge pumps, security alarms, fire pumps and navigation equipment – some of which may have electronic memories – can by-pass the master battery switch, as long as they're protected separately by fuses or circuit breakers. This will enable them to carry on functioning safely but still disconnect in the event of a short circuit or overload fault. [3.5]

main starter & spark plug leads

If high current capacity cable strands break as a result of flexing or vibration and then come into contact with conductive material, significant sparking can occur, which in turn can start a fire. To reduce the risk of this happening, main and starter motor leads, which carry high currents, must have soldered or swaged connectors which will resist flexing and protect the cable strands at the terminals.

Spark plug leads must be supported so that they don't touch the engine block and cylinder head, as their insulation could become damaged by heat. This could cause them to spark and ignite nearby fuel. [3.6]

gas or petrol compartments

If you have electrical devices fitted in a compartment containing gas or petrol there's a danger of the flammable gases being ignited by hot components or electrical discharges and causing a fire or an explosion. To minimise the risk of this happening the electrical devices must be ignition-protected to meet BS EN 28846.

Boats built before 16 June 1998 are exempt from this requirement if it wouldn't be practical to comply, e.g. if the relevant component is not readily available. [3.7]

insulated two-wire systems

To provide efficient circuits and minimise the risk of fire or personal injury in the event of a short circuit or power overload, it's recommended that all electrical equipment – except engine circuits – is installed using a two-wire system, with one wire out from the positive and one back to the distribution box. For each circuit the positive must be connected to a fuse or circuit breaker, while the negative is taken to a common terminal connected to the battery negative and often earthed.

Some steel-hulled boats do have a one-wire system, using the hull to make the return circuit. But, as well as the risk of accidental short circuits, stray current can seriously damage the metal of the boat, and other boats in the water, contributing to hull corrosion.

Engine circuits are fitted with a low-resistance return conductor between the engine and usually the negative pole of the battery. This provides adequate protection to carry the starter current. The connections must be secure to prevent overheating and starter motor failure. [3.8]

suppression

To reduce interference to other vital systems, such as VHF radios, all electrical equipment, including the spark ignition and generating systems of engines, must be suppressed. [3.9]

Need more help or advice? Refer to Standards 3.1- 3.9 in the appendix page 8.

For more technical information refer to:

- BS EN ISO 10133 "Electrical Systems – Extra-low-voltage d.c. installations"
- BS EN ISO 13297 "Electrical Systems – Alternating current installations"
- British Marine Electronics Association BMEA "Code of Practice for Electrical & Electronic Installations in Small Craft". BMEA Tel: 01784 223600

part three checklist

3.1	battery securely installed	☐
	battery compartment adequately ventilated	☐
	battery covered with insulating and non-corrosive material	☐
	battery fitted away from petrol/lpg tank	☐
	battery fitted away from petrol/lpg cylinder	☐
	battery fitted away from petrol/lpg cock	☐
	battery fitted away from petrol/lpg pipe	☐
	battery fitted away from petrol/lpg filter	☐
3.2	electric cables of adequate current carrying capacity	☐
	electric cables of suitable construction	☐
	electric cables of suitable grade	☐
	electric cables insulated and/or sheathed	☐
	electric cables adequately supported in a suitable conduit	☐
3.3	main circuits installed above bilge water level	☐
	electric circuits protected with fuses/circuit breakers of appropriate rating	☐
	electric circuits protected with fuses/circuit breakers of appropriate design	☐
3.4	*electric cables installed as high as possible*	☐
	electric cables run clear of all sources of heat	☐
	electric cables run adjacent to fuel pipes in a suitable covering	☐
	electric cables run adjacent to gas pipes in a suitable covering	☐
	*PVC cables run clear of polystyrene insulation**	☐
3.5	master switch installed	☐
	master switch capable of disconnecting the system	☐
	master switch readily accessible	☐
	master switch as close to the battery as possible	☐
	master switch capable of carrying maximum current	☐
	bilge pump/security alarm/fire pump/navigation equipment circuits, which bypass the master switch, separately protected by fuses or circuit breakers	☐
	master switch position clearly marked	☐

3.6	main leads fitted with soldered or pressure crimped connectors	☐
	starter motor leads fitted with soldered or pressure crimped connectors	☐
	spark plug leads supported clear of engine block/cylinder head	☐
3.7	electrical device fitted in petrol compartment, ignition protected*	☐
	electrical device fitted in gas compartment, ignition protected*	☐
3.8	*electrical equipment two wire insulated*	☐
	engine circuits have a low resistance return conductor between battery and engine	☐
3.9	spark ignition and generating systems effectively suppressed against radio/TV interference	☐
	electrical equipment effectively suppressed against radio/TV interference	☐

Check List items in bold are Mandatory
Check List items in italic are Advisory

*EXEMPTION AVAILABLE