Chapter 8
ELECTRICAL SYSTEMS

8. ELECTRICAL

As working boats and passengers ships have increased in both size and complexity, the need for their on-board electrical systems to deliver more power has grown. This power is supplied as alternating current (a.c.) at voltage levels of 110, 220 and even 440 V, while certain items of equipment may also require a direct current (d.c.) supply.

Electrical systems for yachts and other pleasure craft are mostly d.c. systems supplied by batteries that are regularly charged by a dynamo connected to the auxiliary engine. The growing demand for comfort in these vessels has led to the on-board installation of standard domestic appliances (stoves, refrigerators) and air conditioning. These appliances consume a lot of 220 V a.c. power that is generated by an alternator driven by a diesel engine.

There is no reason to treat the electrical system on a boat made from aluminium any differently from that of a craft made from steel. In both cases the hulls are metal and so subject to the same risks of corrosion in the event of the flow (or leak) of current across the hull.

A.c. or d.c. current must not be allowed to flow continuously through a steel or aluminium hull that is in permanent contact with sea water.

The effect of the flow of current is to polarise the hull (as the + or – pole) and so cause the dissolution of the most negatively electrical parts of the metal in contact with water (1).

If the hull is painted, then the paint will gradually peel and become blistered.

Electrical systems on board ships are governed by international standards issued by the IEC (2) or the CEN (3), as well as by the regulations of classification societies.

All of these standards and regulations are designed to ensure the safety of personnel and the continuity of the electrical supply on board (on which the safety of the vessel depends) which are absolute priorities. They in no way affect the resistance to corrosion of the metal parts of the ship that are in contact with water.

The sole aim of the recommendations that follow is to restate a number of elementary rules that, if carefully applied, will avoid the risks of corrosion to an aluminium hull. They do not contradict the standards or regulations, and most are either stated or implied in the recommendations.

(1) The anodic parts (+ pole) of the hull will dissolve, while on the cathodic areas H+ ions will be reduced to gaseous hydrogen with local alkalisation (excess of OH- ions) and attack the aluminium.

(2) International Electrotechnical Commission: Electrical installations in ships. International standard IEC 92-101.

(3) European Committee for Standardization: Small craft – Electrical systems – Extra-low-voltage d.c. installations. Standard NF EN ISO 10133. Small craft – Electrical systems – Alternating current installations. Standard EN ISO 13297.

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SYSTEMS

Current will never flow in the structures or hull of a ship provided its electrical system is installed properly in accordance with the usual codes of practice, standards and regulations governing shipbuilding and normal supervision (4), except of course in the event of an insulation fault which will be quickly identified and remedied provided regular maintenance is carried out and/or protective devices are set to the required level.

(4) In particular the monitoring of d.c. installations supplied by batteries during service and wintering.

1. GENERAL RULES

There are three rules which an electrical installation in a ship with an aluminium hull must obey:

1.1 Rule One: The hull is the earth (or ground)

The entire structure must be earthed to ensure the safety of persons (this is essential and mandatory when the supply voltage exceeds 55 V d.c. or a.c.) and the proper operation of the electrical and electronic systems. This earth is provided by the wet surface of the hull in contact with sea water ([5]), and is the reference potential of the system (the "earth").

Each of the earthing circuits:
- of the d.c. system, and
- of the a.c. system

must be connected to a single terminal sited in a junction box located in a dry place. The earthing circuits must be made using screened cable.

The connection to the hull is made by arc welding the aluminium conductor to a clean, unpainted area to ensure good electrical continuity. If the earthing system is made with copper cable, then the connection to the hull is made using a "bimetallic" aluminium/copper connector.

(5) Or fresh water in the case of craft used on rivers or lakes.

VICTORY LANE

1.2 Rule Two: The hull must be equipotentially bonded to all the metal structures of the electrical appliances

All the casings and enclosures of electrical units (motors, domestic appliances etc.) must be electrically connected to the hull.

There are two reasons for this:

- safety of personnel, when the power supply exceeds 55 V d.c. or a.c., and
- the operation of the electrical equipment.

In practice, equipotential bonds should be made as near as possible to the electrical items and be kept as short as possible, using cables or braids of appropriate section connected directly to the hull.

These connections must be positioned above any possible accumulation of water, as recommended by the standards and regulations.

Aluminium alloy superstructures on a steel hull

If by design, aluminium alloy superstructures on a steel ship are isolated from the hull, then electrical continuity must be ensured by conductors that are easy to inspect.

The propulsion system

Shipbuilders often install engine bearers, transmission shaft supports etc. on metal/rubber buffers or elastomer baseplates in order to absorb vibration (6).

Only the holding-down bolts will ensure electrical continuity between the engine and the hull (unless they are insulated by plastic sleeves), but this contact is not always perfect given the clearance between bolt and thread and the presence of substances such as oil, diesel etc.

While this arrangement is sufficient for protecting the aluminium from possible risks of bimetallic corrosion and reducing the intrusion of noise and vibration, the propulsion system must be equipotentially bonded to the hull for at least two reasons:

- fire safety: if the starter motor of the internal combustion engine is not "bipolar", then if it short-circuits the metal fittings on diesel or petrol supply pipes will act as a conductor for the short-circuit current and the resulting heat may be enough to ignite the fuel.
- the normal operation of the cathodic protection (7).

The metal casing of the engine must therefore be connected to the earthing system or aluminium support by means of a flexible cable.

1.3 Rule Three: The hull must never be used as an active conductor

In other words, the hull must not be used as a current return in the way that the body of a car is used.

This means that:

- in d.c. systems there must be two screened supply cables, one per pole,
- in a.c. systems there must be one screened conductor per phase and one for neutral (if distributed).

Given the aggressive nature (due to the presence of salt) of the marine environment and its inherent moisture, it is important to select equipment suitable for use in severe conditions. Particular care should be taken with connections which should have a level of IP protection that complies with the relevant standards and regulations.

Preference should also be given to engines whose electrical loads, such as starter motors and ignition, are bipolar (with return cable).

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(6) This arrangement can also be used to prevent possible bimetallic corrosion of the supports: floor plates, aluminium shapes in contact with baseplates made of cast iron, steel, in the presence of water.

(7) Cf. Chapter 11.

2. DIRECT CURRENT INSTALLATION

This is the sole source of power on board most pleasure craft.

2.1 Batteries

Batteries are best accommodated in a dry, well ventilated place, usually a battery box lined on the inside with an acid-proof insulating material.

This precaution is essential both to avoid stray currents in the event of an electrolyte leak and to prevent the surrounding metal from being attacked by battery acid.

It is always advisable to disconnect both battery terminals when pleasure craft are wintered or during prolonged periods of inactivity.

2.2 Earthing

If one of the battery terminals has to be earthed then it should be the (–) pole (negative).

2.3 Insulation testing

Regular testing of the insulation of d.c. systems is highly advisable, and a simple setup (figure 115) will enable this check to be performed (8).

INSULATION TESTING

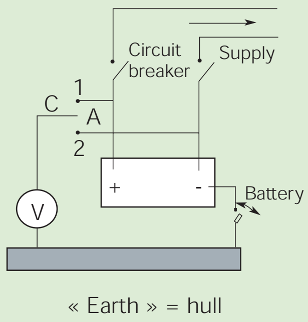

Figure 115

In normal operation the earthing strip is closed, switch C is off and the circuit breaker is closed. Routine testing is carried out as follows:

- open earthing strip,
- circuit breaker closed,
- switch to position 2 – an insulation fault in the negative circuit will cause the voltmeter to deflect,
- switch to position 1 – an insulation fault in the positive circuit will cause the voltmeter to deflect.

(8) It is although possible to use the conventional setup with indicator lamps instead of a voltmeter.

3. ALTERNATING CURRENT INSTALLATION

A.c. systems are used when high electrical power is required.

3.1 Neutral

If the neutral is not distributed and must be connected to earth (the hull), this should be done across a high impedance to limit the intensity of any fault currents.

3.2 Insulation testing

This should be done by a suitable instrument that continuously monitors the insulation of the d.c. system, in particular by calibrated circuit breakers (e.g. 35 mA).

3.3 Quayside supply

Ships often ‘plug in’ to the onshore mains supply when in port. The two systems, i.e. the shore supply and the ship-board system, must be separate. If they are not, then the aluminium hull and the submerged steel parts of the dock such as sheet piles, concrete reinforcement etc. will form the two poles of a galvanic cell and the aluminium will corrode.

This is because the aluminium hull becomes the anode protecting the submerged steel parts and will therefore be corroded.

This risk is easily eliminated by placing an isolating transformer at the head of the ship’s power distribution system.

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