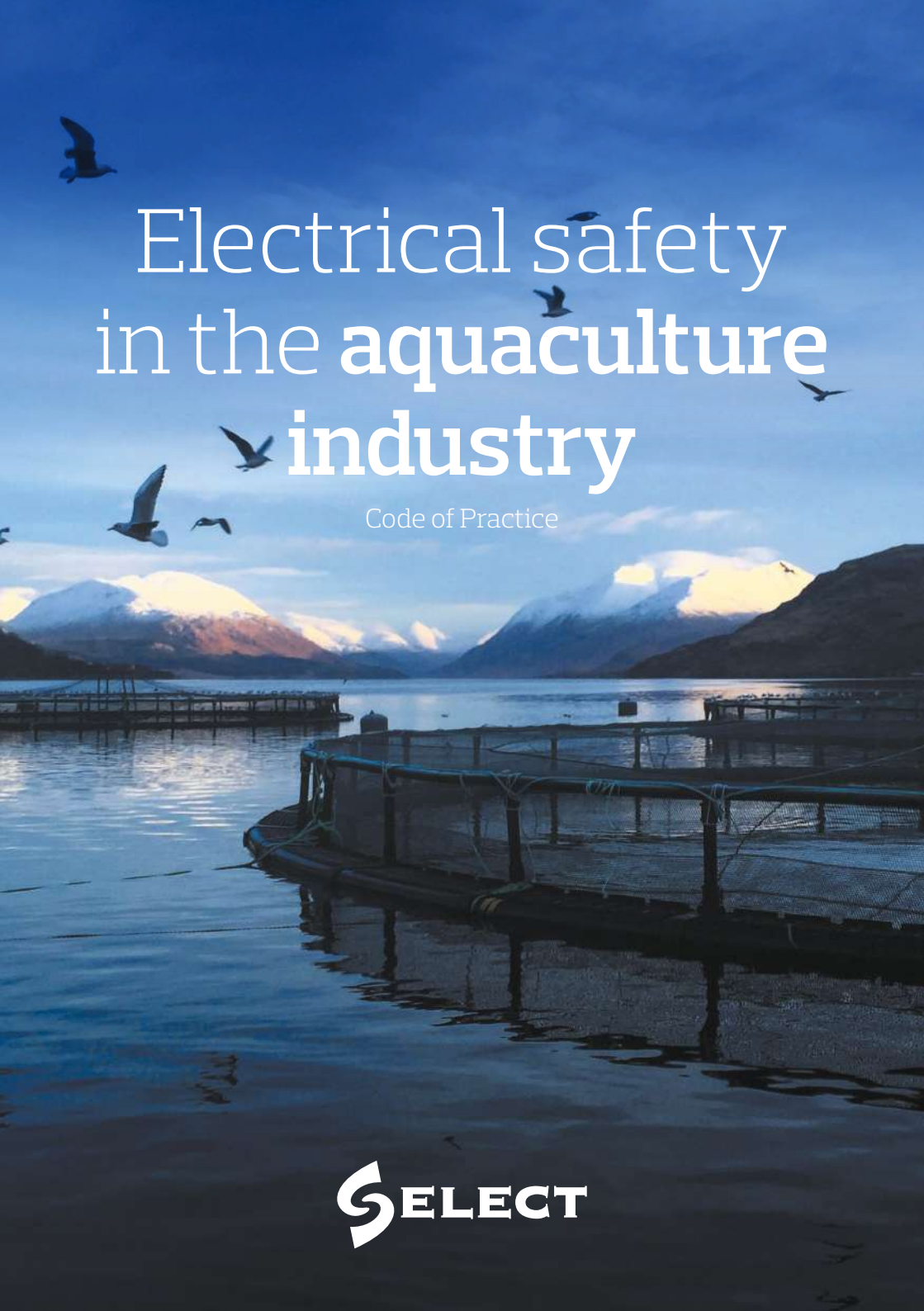

Electrical safety in the **aquaculture industry**

Code of Practice

SELECT

Contents

Foreword

This booklet was conceived and written by SELECT and produced in conjunction with the Aquaculture Safety Group (ASG) and the Electrical Contractors' Association (ECA).

The three organisations decided to privately publish the information, which was the result of extensive consultation and work by many parties, including the Health and Safety Executive (HSE).

The result is believed to represent the best advice currently available and a source of reference for both aquaculture organisations and electrical contractors.

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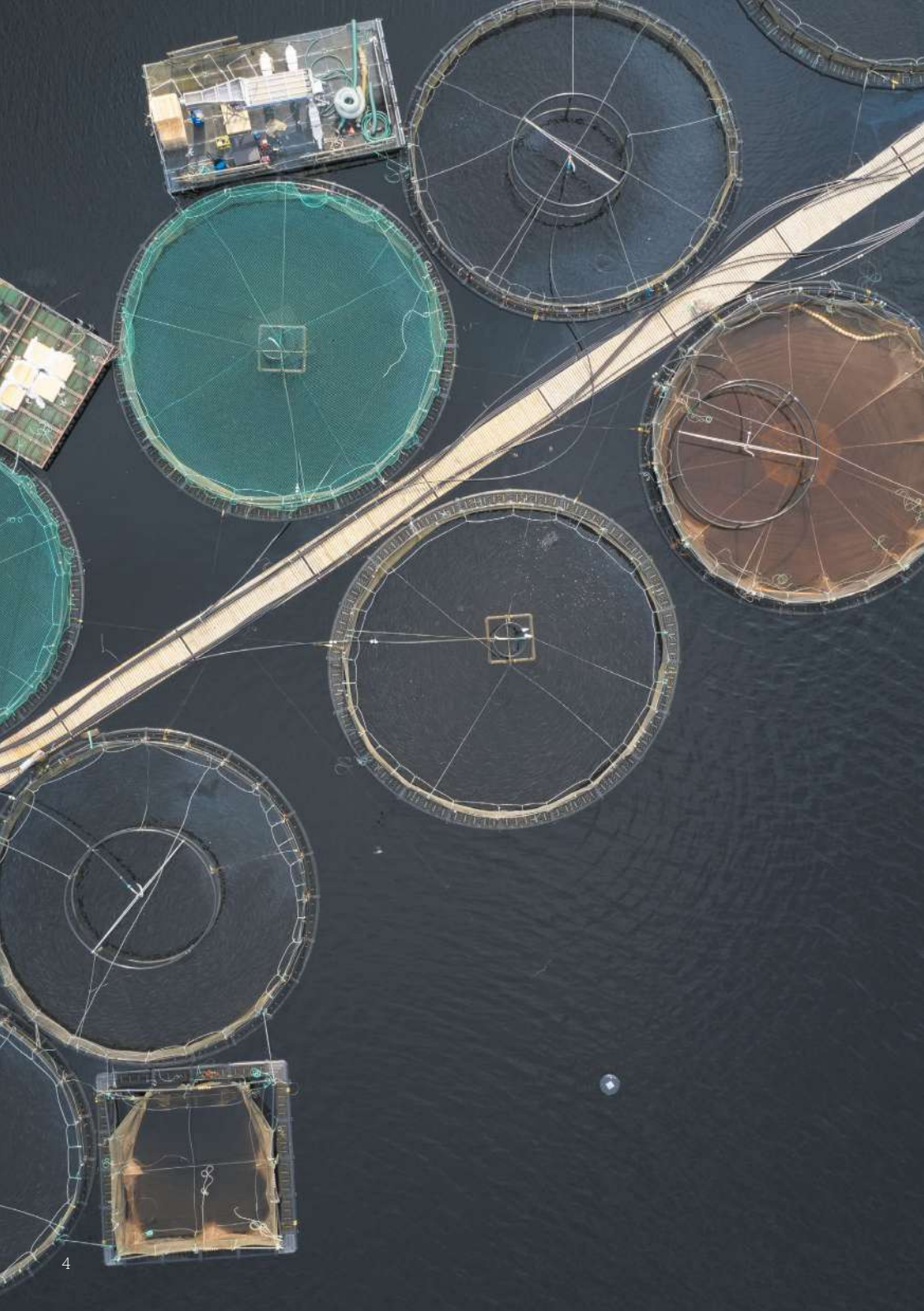

Electrical safety in the aquaculture industry

1.0 Scope

This Code of Practice (COP) provides industry guidance on how to comply with the law regarding electrical safety, i.e. the Electricity at Work Regulations 1989, hereafter referred to as 'the regulations'. The information and guidance in this COP should be considered by those responsible for the design, maintenance, selection of materials and methods of construction for electrical installations on and about aquaculture facilities and assets, including sea and inland water-located fish farms. Although it does not directly apply to land-based fish farms, it contains useful guidance. It supplements and does not replace any of the requirements of the current edition of BS 7671: 2018 Requirements for Electrical Installations, all relevant provisions of which require to be strictly observed. BS 7671 should be applied unless the specific circumstances are outside the scope of it. This may apply to some aspects of the fixed installation on board barges, where an appropriate boat/ship wiring standard should be followed, e.g. BS EN 60092-507.

2.0 Power Supplies

The main danger to be guarded against in selection of a suitable power supply is that of electric shock, which is particularly acute because of the wet surroundings aggravated by wind and water conditions and the damage/deterioration caused by salt contamination, rust and corrosion. Since electric shock in these conditions can result in further danger and injury due to the lack of stability of the structures, poor underfoot conditions and the handling of heavy and awkward plant and materials, the first consideration must be to limit the supply voltage so far as is practicable to ensure the integrity and efficiency of the methods adopted for the prevention of shock. Power supplies which may be available include:

2.1 Connection to a public electricity supply
2.2 Connection to a shore-based private supply
2.3 Local generation situated on a floating structure
2.4 Secondary batteries situated on a floating structure.

2.1 Connection to a public electricity supply

For direct connection to a floating fish farm installation, only a TN-S or TT earthing supply is suitable. If any other type of supply is available then its earth connection must be separate from that of the fish farm installation either by an isolating transformer or by the establishment of a local TT system, i.e. by ignoring the Distribution

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Network Operator's (DNO) earthing terminal and providing a consumer's earth electrode (the safety implications of which, particularly at the origin of the installation, must receive full and proper consideration).

2.2 Connection to a shore–based private supply

A shore-based privately generated supply will normally be a TN-S system and therefore suitable. In any other instance, however, one of the measures described in 2.1 should be applied.

2.3 Local generation

2.3.1 A local generator installed on a floating structure may be:

(a) a fixed diesel engine-powered unit, probably three-phase and sometimes of considerable size, or
(b) a small mobile unit rated at a few kW, and probably single phase.

Wind-driven extra low-voltage DC generators are also useful for powering radio communications equipment, which can then be independent of main power supplies.

2.3.2 The neutral earthing requirement for a fixed generating unit on a floating structure is the same as for a shore-based machine, i.e. TN-S connected, with the neutral connected to the frame of the alternator, engine etc., and also to any readily available and soundly bonded metalwork, e.g. the welded hull of the barge itself. The neutral must not be earthed anywhere else in the installation. Generators should be securely fixed to the structure they are mounted on with a permanent earth connection, where required in compliance with BS 7430.

2.3.3 The use of mobile generators should be restricted to situations where there is no reasonable alternative. Permanent power requirements should be supplied by fixed generators and provision for the operation of power tools should be incorporated into the permanent installation. A portable generator should only be used when exceptional requirements arise, e.g. on-site welding.

2.4 Batteries

2.4.1 Where batteries with open terminals and/or intercell connectors are used, they should be provided with loosely fitting insulating covers to prevent accidental short circuiting. The batteries themselves should be clamped or otherwise secured to prevent movement. Battery maintenance equipment, hydrometer, top-up bottles, etc. should be fixed in clips adjacent to the battery. Where distilled water is stored adjacent to batteries, it should be in well-stoppered and labelled plastic containers, secured against spillage. Electrolyte should not be available at offshore positions, but precautions should be taken against electrolyte drips after using a hydrometer.

2.4.2 When a battery forms part of a safety system, e.g. radio communications, consideration should be given to the fitting of a visual 'low charge' warning.

2.4.3 Batteries should be situated in well-ventilated positions away from any form of ignition. They should not be exposed to mechanical damage, water splashing or dripping, exposed to direct sunlight and/or excessive heat, e.g. engine exhaust systems. All connections should be permanently made by clamps and not by spring clips, with all terminals always covered by suitable rated and approved insulating material.

2.4.4 Unless there are functional reasons for earthing battery powered supplies, e.g. engine starting batteries, such supplies should be earth-free and protected by double pole fuses.

3.0 Voltages

3.1 In conditions as adverse as those existing on floating fish farms, the use of voltage as low as practicable is recommended, particularly the voltage from live conductors to earth.

3.2 In general, much of the equipment used on fish farms can be supplied at reduced low voltage (RLV) 110V 50Hz, either single-phase centre point earthed, or three-phase star point earthed, thus reducing the shock voltage to earth to 55V and 63.5V respectively. It is important to note that small single-phase generators are often dual voltage machines for either 220V/230V operation with the windings connected in series, or 110V/120V with paralleled windings. With this arrangement it may be one side and not the centre point of the 110V output which is earthed and so the shock voltage to earth will be 110V and not 55V as recommended.

3.3 Where RLV is not achievable due to voltage drop on a specific site, a suitable and sufficient risk assessment should be carried out to ensure that the chosen supply voltage allows electrical risk to be reduced as far as reasonably practicable.

3.4 Care is required, particularly for multi-voltage generators when, for example, 110V/120V, 220V/230V and 380V/400V may be available, to ensure that the selected output is in fact star connected with the neutral earthed.

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3.5 The equipment available/selected will decide the voltage requirements but most small power equipment, e.g. fish feeders up to say 0.5kW, should be supplied at 110V either single or three phase. Instrumentation also has an extra low voltage (ELV) and low power (LV) requirement and, although often designed for 220V/230V, supply could equally well be made suitable for 110V input. Larger equipment, e.g. hydraulic pumps, may not be practicable for 110V operation and may need a 400V supply, but the use of such voltage should be restricted to absolute necessities. In well-sheltered locations where deterioration is less likely, e.g. rest or mess rooms, it may be reasonable to have 230V supply to cookers and kettles, etc. but additional 30mA residual current device (RCD) protection should be provided.

Note: Both conductors of 110V circuits supplied from centre point earthed single phase systems or across phases of a three-phase supply require switching and overcurrent protection.

4.0 Protection against electric shock

4.1 Protection should be given by two independent and proven methods irrespective of the circuit voltage unless all the conditions for safety extra low voltage (SELV) supply have been satisfied.

The methods normally to be used will include:

(a) protective earthing, protective equipotential bonding and automatic disconnection of supply (ADS), and
(b) suitably rated RCDs of appropriate type.

These are not alternatives and both should be applied.

4.2 Protective equipotential bonding should not rely on fortuitous continuity of any of the floating structures and associated apparatus. To ensure the requisite low impedance of 'earth fault loops', reliance cannot be placed on hinged joints and coupling, connections between 'lay-in' or bolted decking, handrails, etc. Protective conductors should be continuous and in the form of a specific identifiable conductor, preferably forming part of the composite cabling of the installation.

4.3 To provide additional protection against electric shock, RCDs should be rated at no more than 30mA operating current. Instantaneously acting RCDs do not suitably provide selectivity and should

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therefore not be connected in series. Where time delay is necessary to ensure selectivity between RCDs in series, the supply side device should be of as low an operating value as is obtainable with a time delay, typically 100mA.

Note: Although standard reduced low voltage RCDs may operate correctly on 110V supplies, there may be difficulties with the test push operation due to leakage, either capacitive or inductive. RCDs installed should be suitable for use on the system supply voltage.

4.4 Selection of RCDs for fault and/or additional protection depends on the type of earthing system, the presence of DC components and frequencies (BS 7671 clause 531.3.5.1). The appropriate type(s) of RCDs should be selected.

5.0 Protection against environment

5.1 All equipment exposed to weather and wave conditions, e.g. fish feeders and controls mounted along walkways, should have a degree of protection of IPX6. Where equipment is within a structure giving shelter from waves and falling rain, but not spray or driving rain and is not subject to hose jets, e.g. in open-ended but roofed grading shelters, IPX4 may be suitable. In some locations, e.g. in an engine compartment or a mess room, then IPX3 may be sufficient. Each situation must, however, be individually assessed and an adequate degree of enclosure provided.

5.2 Equipment should be constructed of corrosion-resistant metal or alloy or be glass-reinforced polyester (GRP), nylon, polycarbonate or similar.

5.3 The degree of protection to be provided against mechanical damage should be assessed with due regard to the installation methods adopted. Cables run beneath walkways may not require additional protection, provided they are close to one side so that their fixings are not subject to damage. Cables run at handrail level or rising to equipment mounted on or above handrails require some form of support and protection, e.g. cable tray or trunking. Where damage may be caused by chafing or crushing, e.g. at walkway junctions, then flexible plastic suction hose to BS EN 3994, secured at its terminations and properly routed, should provide the necessary degree of protection.

5.4 Protection against mechanical damage to equipment mounted along walkways, e.g. feeder controls and socket outlets, can be provided by off-set brackets so that the equipment does not project into the walkway.

5.5 Secure fixings are always a requirement for adequate protection, and care should be taken that the materials used are corrosion resistant or adequately protected after fabrication and, if necessary, after erection, by suitable plastics or paint coatings. It should be ensured that the IP rating of equipment enclosures is not adversely affected by the drilling of fixing or cable entry holes other than those provided by the manufacturer.

6.0 Cabling

6.1 For cables operating at low voltage, cross-linked polyethylene (XLPE) insulated, steel wire armoured (SWA), cables to BS 5467, PVC sheathed cables to BS 6004, or cables according to BS EN 50525 should be used. For the selection of suitable cables, the minimum temperatures for installation and handling, the presence of water and the exposure to sunlight (UV radiation) need to be considered.

Note: For cables to BS EN 50525, guidance on the use of such cables is given in BS EN 50565-1 and BS EN 50565-2. Where cables do not comply with a British or harmonised standard as per those listed in Table 4A3 of BS 7671: 2018 (as amended), this will require the use of such cables to be recorded as a departure on the appropriate certification provided to comply with Part 6 of BS 7671. Cables should be terminated by appropriately sized corrosion resistant mechanical cable glands to BS EN 62444: 2013. The armour/earth continuity tags provided by the gland manufactures should be used and tightly fitting PVC gland shrouds should entirely enclose the gland body and extend over the cable sheath, no more of which should be removed than is necessary to fit the gland.

6.2 SWA cable should not be used in situations where flexibility is required. Using this cable to supply the cages could cause more damage to the installation and equipment than is necessary, particularly where entering and leaving the barge and cage if not correctly supported and terminated. This cable is not of a flexible construction and is intended for non–flexible and fixed installations. Cabling suitable for the environment should be considered, e.g. marine grade.

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-26X1:0VDC-37
-26X1:0VDC-23
-26X1:0VDC-27
-25X1
-25X1:11.5
-25X1:11.7
-25X1:11.2
-25X1:11.12
-25X1:11.11

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6.3 The use of cable known as armoured flexible control cable, shielded flex or armoured flex (SY cable) should not be used for any external fixed wiring. If the boat/ship wiring standard (BS EN 60092-507) permits, this may be used inside the barge but must not be for external use.

6.4 For cables operating at 110V single or three-phase, and ELV, PVC insulated and sheathed multi-core flexible cables to BS EN 50525 should be used. They should be terminated in polymeric glands to BS EN 62444: 2013, correctly sized so the outer sheath of the cable is firmly gripped without crushing and ensuring the integrity of the enclosure, and with the correct thread size for the cable entry to the equipment, using compressible washers and/or jointing compound if necessary to ensure a watertight joint.

6.5 Submarine cable connection from a shore supply to a floating fish farm should take into account maximum tidal rise and fall – i.e.'spring tides' – prevailing water currents and the degree of movement permitted by the anchoring of the floating structure, and the nature of the landfall of the cable. The polyurethane sheathed and armoured cable as detailed in 6.1 should be used for either low voltage or reduced low voltage. The shore end should be laid in a trench for at least 5m above and 5m below spring tide high and low water marks. The nature of the shore will influence the details of such cable trenching. In sand, a depth of 1m may be practicable. Over a stony beach, less would suffice but the cable should be drawn through polyethylene or similar water piping to BS EN 3994 to give protection against mechanical damage.
A rock shore may be crossed by polyethylene piping through which the cable is drawn, secured by wrought iron saddles fixed by expansion bolt anchors to the rock, a route being chosen to give the smoothest contour. In certain situations, however, it may be possible to secure the cable to a jetty or slipway, provided a route can be found where damage is unlikely to be caused by boats, vehicles or other equipment. At the floating structure, several metres of cable should be formed into a loose spiral and secured by a suitable bracket or clamp below the water line so that the cable leaves the water vertically and is properly supported.

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7.0 Isolation

7.1 Arrangement for isolation, switching off for mechanical maintenance, emergency switching and functional switching should satisfy the current edition of BS 7671: Requirements for Electrical Installations and must comply with relevant health and safety legislation. There may be an apparent advantage in using the minimum number of switches to reduce maintenance and possible breakdown. However, the distance involved on groups of cages can be very considerable and in the event of failure it is desirable to sectionalise the installation with a minimum of disconnecting of cables. There is also sometimes a lack of clear vision past obstructions at the cages, etc. so that the need for locking-off facilities is essential, particularly since switching may be carried out by mechanical as well as electrical personnel for their respective duties. In these circumstances, the use of individual padlocks and keys becomes essential.

8.0 Socket–outlets

8.1 Socket-outlets on floating structures should be confined to reduced low voltage (RLV) circuits, i.e. 110V single or three-phase with IP protection appropriate for the environment. Consideration should be given to mounting them quite high above the walkways, perhaps 2m, to minimise water penetration by waves and spray. The use of low voltage 230V socket-outlets should be restricted to enclosed rest or mess room-type accommodation and, even there, should be kept to the minimum and protected by 30mA RCDs. Engine/generator/pump enclosures, workshops, storage spaces, access walkways and workspaces, etc. should be equipped only with reduced low voltage outlets to IEC 60309. Sufficient outlets should be provided to obviate the need for excessive lengths of trailing cable.

9.0 Portable tools and appliances

9.1 Battery-powered handheld power tools are preferred. Where mains-powered tools are required, equipment should be operated at not more than 110V and should be ‘double insulated’ (Class II).

10.0 Lighting

10.1 If working or movement lighting is to be provided along access walkways, then luminaires of IPX6 construction should be used, securely fixed and at such a height that a ladder or other movable access equipment is not needed to carry out lamp replacement and cleaning of the luminaires. The voltage should be restricted to 110V, both for safety and to use lamps with more substantial filaments/LED better able to withstand the vibration and violent movement of the structures. If discharge lamps are used, then allowance has to be made for the delay in reaching full illumination after switching on, and the period which must elapse for cooling and re-striking after a momentary voltage reduction or interruption. To achieve more even illumination without risk of dazzle to personnel, it is recommended to use a larger number of smaller lumen output lamps rather than a few large units. This will also lessen the areas of darkness caused by lamp failure.

10.2 When the activation of an intruder (poacher, seal) alarm is followed by automatic illumination of the areas, the floodlights should cover the surrounding water rather than the fish cages themselves. To provide instant lighting, LED luminaires are preferred. However, if the normal fish farm supply is by a relatively large diesel generator which may not run continuously, then a small generator capable of automatic starting and rapid acceleration to full output will be required. Adequate lock-off isolation arrangements should be provided where work has to be carried out on such equipment which may otherwise become automatically energised.

10.3 Hand lamps provided for use as required during maintenance or repair work on plant or equipment should be operated from a 25V centre point earthed supply derived from a fixed transformer connected to the 110V system. Each hand lamp should be of all-insulated construction, provided with a substantial translucent guard completely enclosing the lamp/LED and be itself well protected. The hand lamp should be equipped with a substantial spring gripping device to secure it in a working position and the hand lamp should incorporate an efficient cord gripping device. The lamp holder should be of a different pattern, e.g. small bayonet cap (SBC), to those in use for other voltage on the installation and no switch should be provided on the hand lamp itself. The plug should not be interchangeable with those of different voltage systems. Alternatively, battery-powered products should be used.

10.4 Where lighting is not supplied from a land-based source, it is advisable to install luminaires at the generator position, powered from the engine starting battery via suitable overcurrent protection. This will enable pre-start checks of fuel, lubricant, coolant, lack of obstructions, etc. to be safely and more easily made.

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11.0 Battery-powered equipment

11.1 Where radio communication equipment is battery-powered with a wind or solar panel charger, such power supplies should not also be used for other purposes, e.g. seal scarers or intruder alarm systems which may require to operate when generator power is not available. Separate batteries and chargers should be provided for such apparatus.

11.2 Where there is a requirement to use a battery-based system to provide AC supplies – e.g. solar panels or wind turbines charging batteries to then power small AC equipment such as communications via an inverter, installed on a cage system which also has generator supplies present – the earth of the inverter supply must be connected to the earth of any other AC system in use on the same cage.

12.0 Navigational lighting

12.1 The appropriate authority should be consulted and agreement reached on the need or otherwise for the provision of navigational lighting on floating fish farms.

13.0 Maintenance

13.1 It is recommended that a preventive maintenance programme is created and followed, either site or company specific, and in accordance with Regulation 4 of the Electricity at Works Regulations 1989, BS 7671 and manufacturers' requirements. This should take into consideration an assessment of electrical risk arising from the particular installation against the risk to personnel carrying out preventative maintenance work. A distinction may be appropriate between the maintenance requirements for fixed wiring on the barges and the wiring out to, and on, the cages.

13.2 Regular inspection of equipment, including the electrical installation, is an essential part of any preventive maintenance programme. This regular inspection may be carried out as required without dismantling, or with partial dismantling as required, and supplemented by appropriate testing.

13.3 Where testing requires dismantling, consideration should be given to the increased risk associated with dismantling and reassembling and to ensure that these actions are justified in a harsh environment. The need for dismantling should be risk assessed for each site and recorded.

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VFO/MR
A/B
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EXIT

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13.4 Where there is a risk assessed management system in place for inspection and preventative maintenance of the installation, e.g. where there are competent permanent on-site maintenance staff, periodic inspection and testing can be replaced by an adequate regime of continuous monitoring and maintenance of the installation and its constituent equipment. However, appropriate records should be maintained on site to show that an inspection and preventative maintenance plan is in place and is being adhered to.

13.5 Where a site-specific risk assessment to determine the maintenance plan has not been carried out – although this guide recommends that it is – then periodic inspection and testing should be completed with a maximum period of three years for the barge installation and one year for the cage installation. For cage installations, refer to 13.3 above and consider the need for a site-specific risk assessment carefully.

14.0 References

14.1 The Electricity at Work Regulations 1989

14.2 Guidance on Regulations **www.hse.gov.uk**

14.3 HSE – Electricity webpages **www.hse.gov.uk/electricity**

14.4 BS 7671: 2018: Requirements for Electrical Installations. IET Wiring Regulations

14.5 BS EN 60092-507: 2015: Electrical installations in ships – small vessels

14.6 BS 7430: 2011: Code of practice for protective earthing of electrical installations

14.7 BS EN 3994: 2014: Plastics hoses. Helical-thermoplastic-reinforced thermoplastics hoses for suction and discharge of aqueous materials. Specification

14.8 BS 6004: 2012+A1:2020: Electric cables. PVC insulated and PVC sheathed cables for voltages up to and including 300/500V, for electric power and lighting

14.9 BS EN 50363-0: 2011: Insulating, sheathing, and covering materials for low-voltage energy cables – general introduction

14.10 BS EN 62444: 2013: Cable glands for electrical installations

14.11 BS EN 50525: 2011 Electric cables. Low voltage energy cables of rated voltages up to and including 450/750V part 2-11 Cables for general applications. Flexible cables with thermoplastic PVC insulation

14.12 BS EN 50525: 2011 Electric cables. Low voltage energy cables of rated voltages up to and including 450/750V part 2-21 Cables for general applications. Flexible cables with crosslinked elastomeric insulation

14.13 BS EN IEC 60309-5: 2019: Plugs, socket-outlets, and couplers for industrial purposes – Dimensional compatibility and interchangeability requirements for plugs, socket-outlets, ship connectors and ship inlets for low-voltage shore connection systems (LVSC)

14.14 BS EN 50565-1 Electric cables – Guide to use for cables with a rated voltage not exceeding 450/750V – Part 1: General guidance

14.15 BS EN 50565-2 Electric Cables – Guide to use for cables with a rated voltage not exceeding 450/750V – Part 2: Specific guidance related to EN 50525 cable types

14.16 BS 5467:2016 Electric cables. Thermosetting insulated, armoured cables of 600/1000V and 1900/3300V for fixed installations

14.17 INDS28: Health and safety on floating fish farms

Founded in 1900, SELECT is Scotland's largest construction trade association.

It has nearly 1,250 member businesses who collectively have an annual turnover of around £1billion and employ over 15,000 people and 3,500 apprentices.

SELECT also delivers training courses to more than 3,500 electricians each year and is committed to regulation of the industry for a safer Scotland.

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