

Safe Isolation of low voltage installations

by Jon Elliott

The HSE and other major stakeholders in the electrical installation industry have, for some time been concerned about the number of serious electric shock and burn accidents which have been occurring to experienced electricians and others carrying out electrical work. Many of these incidents can be attributed to a failure to perform safe electrical isolation procedures prior to work on or near conductors or equipment intended to dead.

This article seeks to summarise the statutory and non-statutory requirements for isolation; to raise awareness of the many and various devices now produced to enable virtually all switching devices to be safely isolated and to describe the requirements for voltage indicating devices and the need to confirm their continued suitability for use. The basic procedure for safe isolation is described, followed by an overview of the health implications and legal consequences that may arise as a result of not carrying out safe isolation where required.

Mostly this article seeks to point out that there is no excuse for not being able to safely isolate an installation, circuit or item of equipment.

Statutory requirements

The most important statutory requirement concerning work carried out on or near electrical installations is the Electricity at Work Regulations (EWR) 1989. Those regulations within EWR of particular relevance to safe isolation are numbers 12 (Means for cutting off the supply and for isolation) and 13 (Precautions for work on equipment made dead). Regulation 12 (1) (b) states that where necessary to prevent danger, suitable

means shall be available for the isolation of any electrical equipment, where isolation means the disconnection and separation of the electrical equipment from every source in such a way that the disconnection and separation is secure (para (2) refers).

The Memorandum of Guidance on the Electricity at Work Regulations 1989 (HS(R) 25) published by the Health and Safety Executive advises with reference to Regulation 12 (1) (b) above that isolation is the process of ensuring that the supply to all or a particular part of an installation remains switched off and that inadvertent reconnection is prevented.

The issue of preventing inadvertent reconnection is covered in Regulation 13 (of EWR 1989) which requires that *“Adequate precautions shall be taken to prevent electrical equipment, which has been made dead in order to prevent danger while work is being carried out on or near that equipment, from becoming electrically charged during that work if danger may thereby arise”*.

The coverage of Regulation 13 in HS(R) 25 highlights the need to lock off any switching device being used to provide isolation, or where isolation has been achieved by a fuse, by their removal and retention in a safe place during the isolation period.

Non-statutory Requirements

Within BS 7671:2008, the following are of particular relevance in terms of safe isolation:

- Regulation 132.15.1 contains the following fundamental principle:

Effective means, suitably placed for ready operation, shall be provided so that all

voltage may be cut off from every installation, from every part thereof and from all equipment, as may be necessary to prevent or remove danger.

- Regulation group 537.2 contains the requirements relating to isolation
- Regulation group 537.3 contains the requirements for switching off for mechanical maintenance.

Table 53.2 summarises the suitability of particular protective, isolation and switching devices to be used as an isolator, an emergency switch, or a functional switch and is reproduced overleaf.

Electrical installation work trainees and apprentices that have attended college for

appropriate initial training should have been taught how to carry out safe isolation, including securing the device in the "OFF" position. However, adoption of incorrect isolation procedures 'in the field' still appears to be far too frequent. Clearly, the commonly occurring practices of simply switching circuit-breakers off, and placing insulation tape over them, when a circuit needs to be isolated, or merely removing a fuse and leaving it on top of the distribution board are not acceptable and do not give compliance with Regulation 13 as stated above. Moreover, to leave a circuit which is intended to be safely isolated unsecured is totally unnecessary and potentially dangerous.

It should be noted at this

point that it is not necessary to lock off a means of isolation which remains, at all times, under the control of the person who is dependent upon the continued isolation of the circuit or item of equipment in question, although doing so may still be wise where this is possible.

HSE and SELECT (the Electrical Contractors Association of Scotland) have produced a guide on safe isolation procedures. This may be accessed and downloaded at the following internet address:

<http://www.select.org.uk/downloads/publications/Select%20-%20Safe%20Isolation%20Procedures.pdf>

The HSE / SELECT guide was used as the basis of a similar,

later guide produced by the Electrical Safety Council in association with a number of organisations having an interest in electrical safety, including the IET. This guide may be accessed at the following internet address:

http://www.esc.org.uk/pdfs/business-and-community/electrical-industry/BPG2_08.pdf

Locking devices

Employers should ensure that appropriate locking devices are made available to their employees (as defined in the Health and Safety at Work etc Act 1974) and to ensure that they are used when it is necessary to isolate circuits or items of equipment fed from live distribution boards.

Most switchgear manufacturers now produce

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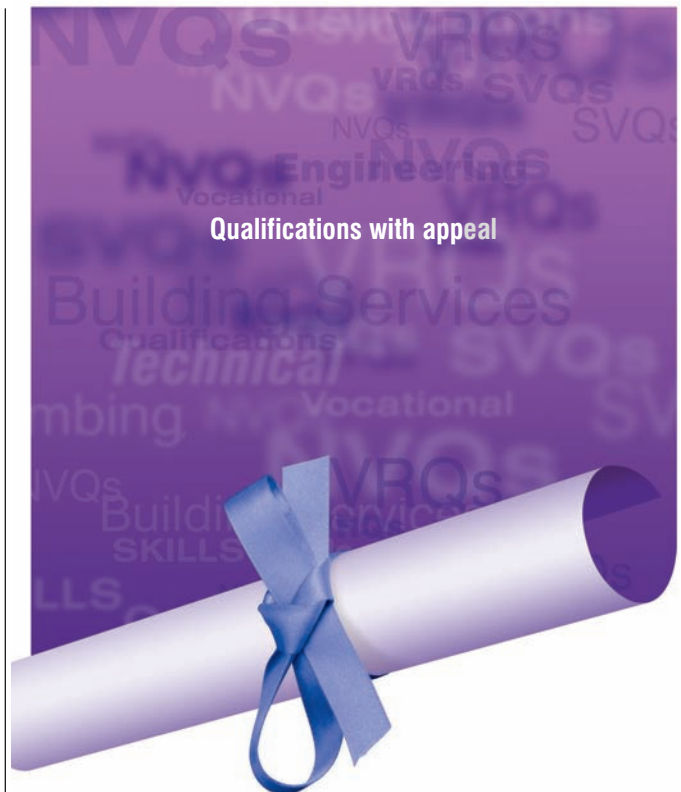
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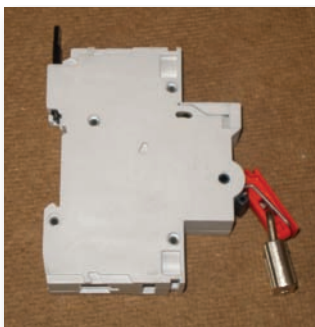


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Examples of readily available lock-out devices for use with circuit-breakers



Examples of lock-out devices which may be obtained from switchgear manufacturers free of charge

Devices	Standard	Isolation ⁽⁵⁾	Emergency switching ⁽²⁾	Functional switching
Switching device	BS 3676: Pt 1 1989	Yes ⁽⁴⁾	Yes	Yes
	BS EN60669-1	No	Yes	Yes
	BS EN60669-2-1	No	No	Yes
	BS EN60669-2-2	No	Yes	Yes
	BS EN60669-2-3	No	Yes	Yes
	BS EN60669-2-4	Yes	Yes	Yes
	BS EN60947-3	Yes ⁽¹⁾	Yes	Yes
BS EN 60947-5-1	No	Yes	Yes	Yes
Contactor	BS EN 60947-4-1	Yes ⁽¹⁾	Yes	Yes
	BS EN 61095	No	No	Yes
Circuit-breaker	BS EN 60898	Yes	Yes	Yes
	BS EN 60947-2	Yes ⁽¹⁾	Yes	Yes
	BS EN 61009-1	Yes	Yes	Yes
RCD	BS EN 60947-2	Yes ⁽¹⁾	Yes	Yes
	BS EN 61008-1	Yes	Yes	Yes
	BS EN 61009-1	Yes	Yes	Yes
Isolation Switch	BS EN 60669-2-4	Yes	Yes	Yes
	BS EN 60947-3	Yes	Yes	Yes
Plug and socket-outlet (≤32 A)	BS EN 60309	Yes	No	Yes
	IEC 60884	Yes	No	Yes
	IEC 60906	Yes	Yes	Yes
Plug and socket-outlet (>32 A)	BS EN 60309	Yes	No	No
Device for the connection of luminaire	BS IEC 61995-1	Yes ⁽³⁾	No	No
Control and protective switching device for equipment (CPS)	BS EN 60947-6-1	Yes	Yes	Yes
	BS EN 60947-6-2	Yes ⁽¹⁾	Yes	Yes
Fuse	BS88	Yes	No	No
Device with semiconductors	BS EN 60669-2-1	No	No	Yes
Luminaire Supporting Coupler	BS 6972	Yes ⁽³⁾	No	No
Plug and unswitched socket-outlet	BS 1363-1	Yes ⁽³⁾	No	Yes
	BS 1363-2	Yes ⁽³⁾	No	Yes
Plug and switched socket-outlet	BS 1363-1	Yes ⁽³⁾	No	Yes
	BS 1363-2	Yes ⁽³⁾	No	Yes
Plug and socket-outlet	BS 5733	Yes ⁽³⁾	No	Yes
	BS 1363-4	Yes ⁽³⁾	Yes	Yes
Switched fused connection unit	BS 1363-4	Yes ⁽³⁾	Yes	Yes
Unswitched fused connection unit	BS 1363-4	Yes ⁽³⁾	No	No
		(removal of fuse link)		
Fuse	BS1362	Yes	No	No
Cooker Control Unit switch	BS4177	Yes	Yes	Yes

Yes - Function provided No - Function not provided

(1) Function provided if the device is suitable and marked with the symbol for isolation (see BS EN 60617 identity number S00288). 

(2) See Regulation 537.4.2.5

(3) Device is suitable for on-load isolation, i.e. disconnection whilst carrying load current.

(4) Function provided if the device is suitable and marked with 

(5) In an installation forming part of a TT or IT system, isolation requires disconnection of all the live conductors. See Regulation 537.2.2.1.

Table 53.2: Guidance on the selection of protective, isolation and switching devices

locking devices that allow a range of moulded case circuit breakers (MCCBs), circuit-breakers (formerly known as MCBs) and RCBOs to be padlocked in the OFF position.

A number of manufacturers will now provide lock-out kits designed for use with their

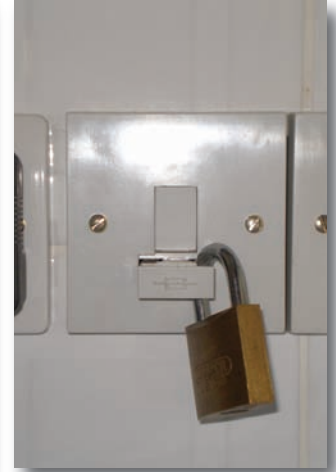


Universal lock-out device shown separately and securing a consumer unit main switch in the OFF position





Examples of lock-out devices permitting more than one person to apply a lock for reasons of safety



Fused connection unit isolated by means of a small padlock

products free of charge upon request.

There are also a number of manufacturers of safety equipment that produce a range of universal circuit-breaker locking kits and other products allowing the secure isolation of virtually any type of switching device or even domestic and industrial type plugs and socket-outlets.

In situations where a number of persons are reliant upon a single isolation device remaining in the OFF position, a number of devices which permit the use of multiple locks are also available as can be seen above.

In many cases fused

connection units (commonly, but incorrectly referred to as fused spurs) can have the fuse carrier secured in the OPEN position as shown using a padlock thus providing an effective means of isolating equipment being supplied by the connection unit.

Whenever an electrical installation, circuit or item of equipment is secured in the OFF position by use of a lock, the key to the lock should be taken away and kept under the control of the person relying upon the safe isolation remaining effective. Similarly where a fuse has been removed to effect isolation, the fuse and any spare fuses in close proximity to the distribution board or consumer unit should be retained under the control of the person relying upon the isolation remaining effective.

Voltage indicating devices and proving units

In order to carry out the safe isolation of an installation or part thereof it will be necessary to use a voltage indicating device. HSE state clearly in guidance note GS 38 - *Electrical test equipment for use by electricians* that contact type voltage detectors and test lamps specifically designed to identify whether or not a voltage is present

should be used for this purpose. The use of multi-range instruments is not recommended as it is possible to select an inappropriate range setting; the leads may not be sufficiently robust; and the probes may have excessive bare metal exposed; all of which may possibly put the user in danger. Reliance on non-contact type voltage indicators is also not recommended for use as the sole means of confirming that a circuit or piece of equipment has been made dead.

A wide range of contact type voltage indicating device are available as can be seen from the images included in this article.

The general condition of a voltage indicator should be checked prior to each use and especially if the instrument has not been used for some time. Particular attention should be paid to the outer casing, leads, and probes. Only the minimum amount of probe should be exposed to allow the instrument to be used correctly. If a voltage indicator shows significant damage or deterioration, the voltage indicating device, or where appropriate, the component parts in question, such as tips and lamps, should be replaced before further use.

The functionality of a voltage indicating device must be confirmed prior to each use. This can be achieved by checking on a known supply or perhaps more conveniently by using a proving unit such as the one shown.

Basic Safe isolation procedure

The following steps are the minimum that would be expected in terms of confirming safe isolation of a circuit or item of equipment.

- Locate / positively identify correct isolation point or device
- Check condition of voltage indicating device
- Confirm that voltage indication device is functioning correctly
- Switch off installation / circuit to be isolated
- Verify with voltage indicating device that no voltage is present
- Re-confirm that voltage indicating device functions correctly on known supply / proving unit
- Lock-off or otherwise secure device used to isolate installation / circuit
- Post warning notice(s)

Any warning notice posted should convey in simple terms that the installation, circuit or item of equipment has been



Use of proving unit to verify functionality of voltage indicator

deliberately disconnected from the supply. It should inform the reader that care must be taken to ensure the safety of persons who are reliant upon the continued effectiveness of the isolation and should state that the installation, circuit or equipment should not be reenergised until it has been confirmed that it is safe to do so.

The health implications

The health implications which may be experienced as a result of a failure to correctly isolate before working on or near conductors or equipment intended to be dead are

- Physiological shock – in the short term this might be manifested as nausea and disorientation and in the longer term, a loss of confidence
- Involuntary muscular action resulting in injury – in such cases, injury may occur directly as a result of a muscular reaction sufficiently violent to tear muscle, break bones or dislocate joints, or indirectly as a result for example of falling from a ladder or from impact with objects in close proximity to the person receiving the shock
- Burns and tissue damage – depending upon the amount of energy expended at the points of contact (an electric shock characteristically leaves both an entry and an exit wound), burns may range from relatively superficial levels of tissue damage causing discomfort but no long term damage, through to deep seated burns causing a medical condition known as *compartment syndrome* the effects of which can be necrosis (tissue death). This may necessitate amputation of fingers or limbs to prevent the onset of complications such as gangrene.

Any current will travel along the path to earth offering the least resistance. In the case of human tissue, nerves and blood vessels offer the least resistance whilst bones offer the highest resistance. As a result, damage to the circulatory and nervous system occur frequently

- Renal (kidney) damage, which may range from being minor to long term and severely debilitating
- Atrial fibrillation - an irregularity in the rhythm of the heartbeat somewhat less severe than ventricular fibrillation. In most cases, a condition that can be reversed with typically few or no long term complications
- Myocardial infarction - heart attack caused by the presence of a blood clot within the coronary artery
- Ventricular fibrillation – the most common cause of death from electrocution, which generally occurs immediately

In the case of an alternating current and assuming a hand contact, the average person will be aware of a current passing through their body at around 0.5 mA. Such a current level will not have a detrimental effect. A person generally loses the ability to break contact with the live part at around 10 mA and beyond this level, ventricular fibrillation (an erratic heart beat characterised by an inability to circulate sufficiently oxygenated blood around the body) may occur and may result in death. Currents above 2 A will result in the heart stopping.

The likelihood of ventricular fibrillation occurring is dependent upon a number of factors:

- Skin resistance – sweat dramatically lowers

resistance of skin whilst hardness (typical of manual labour activities), dryness and presence of dirt typically raise skin resistance

- The path of the current through the body – by way of example, the risk factor is 2 ½ times higher for a hand to foot contact than for a hand to hand contact. It is worth mentioning at this point that hand to hand contact electric shocks are thought to account for approximately 60% of fatalities
- The magnitude and type of current – human tissue is most sensitive to currents at frequencies between 40 Hz and 150 Hz
- The duration of the current – the more prolonged the contact time, the greater the damage caused by the shock
- The magnitude of the voltage – in general, the higher the voltage the higher the risk of shock
- When, during the heart's cycle, the shock occurs

The legal consequences

Employers or employees who commit an offence as a result of a failure to comply with the requirements of the Electricity at Work Regulations 1989 can be prosecuted under the Health and Safety at Work etc. Act 1974.

On 16th January 2009 the Health and Safety (Offences) Act 2008 came into force. This Act has the effect of increasing penalties and providing courts with greater sentencing powers for those who break health and safety legislation.

To summarise, the Health and Safety (Offences) Act 2008 introduces a new schedule 3A to the Health and Safety at Work etc. Act 1974 and to the Health and Safety at Work (Northern Ireland) Order 1978.

This new schedule:

- Raises the maximum fine which may be imposed in the lower courts to £20,000 for most health and safety offences
- Allows certain offences, which were previously only pursuable in the lower courts, to be triable in either the lower or higher courts
- Makes the imposition of a prison sentence an option for more health and safety offences in both the lower and higher courts

Prosecutions are likely to be made against employers and employees considered to have breached health and safety legislation.

References (and useful sources for further reading)

- BS 7671: 2008 - IET
- DD IEC/TS 60479-1: 2005 – Effects of current on human beings and livestock. Part 1 General characteristics
- Electrical injuries and lightning strikes – www.patient.co.uk
- Electrical test equipment for use by electricians (GS 38) – HSE
- Electricity at Work Regulations (EWR) 1989 – The Stationery Office Ltd
- Health and Safety (Offences) Act 2008 – The Stationery Office Ltd
- Memorandum of Guidance on the Electricity at Work Regulations 1989 (HSR 25) – HSE

Acknowledgements

Images of Martindale voltage indicator, Martindale proving unit and Drummond test lamp were reproduced with the kind permission of Martindale Electric Company Ltd. Thanks are also extended to Schneider Electric Limited and Hager Engineering Ltd for providing samples of lock-out devices and circuit-breakers for use in some of the images contained in this article. ■