

# Safety in *electrical testing* at work

General guidance





## What is this guidance about?

This booklet provides basic guidance on safe electrical testing and is intended for anyone who runs or manages a workplace where electrical testing is carried out, and for those people doing the actual testing. It is complemented by information sheets which give more detailed information about specific types of testing.<sup>1-4</sup>

Electrical testing may be carried out for a number of reasons, for example:

- (a) quality assurance tests on electrical components;
- (b) diagnostic testing;
- (c) fault-finding on electrical plant;
- (d) routine safety checks.

The guidance contains recommendations to help you prevent or reduce electrical danger. Some of the main ways in which this can be done include:

- (a) following safe systems of work, for example:
  - (i) taking precautions to prevent people who are not doing the testing coming into contact with exposed live parts;
  - (ii) taking precautions to prevent the testers coming into accidental contact with exposed live parts;
  - (iii) protecting and insulating both the

equipment being worked on and the testing equipment.

- (b) using test equipment that is suitable for the job;
- (c) making sure that people doing the work are suitably trained and experienced so that they understand safe working practices and the equipment on which they will be working.

## What types of testing are covered?

This guidance covers electrical testing in situations (mostly low voltage, ie not exceeding 1000 V ac or 1500 V dc) where equipment like domestic appliances is being tested. Most of this equipment will be used on mains supply voltages of 230 V ac single phase and 400 V ac three phase. However, there could be internally derived voltages which are much higher and in some cases above the low voltage limits.

Some of the test voltages applied to equipment during testing may be above the low voltage limits. These voltages are not considered dangerous if the maximum output current available from the test instrument is reliably limited to no more 5 mA (traditionally 5 mA ac has been used, but since May 2001<sup>5</sup> new equipment should be limited to 3 mA ac).



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where equipment can be taken for testing? Is it necessary to set up a temporary test area around the equipment?

- (i) Are the testers able to supervise the working area sufficiently and at all times to prevent danger to others?
- (j) Where testing is part of an 'after sales service' how much must be done at customers' premises? If testing is being done in a customer's home, what special precautions are required to protect the tester and others?
- (k) To what extent should the testers be supervised or accompanied?
- (l) If the testers design, manufacture or use any special test equipment, does it meet BS EN 61010-1?<sup>6</sup>
- (m) How big is the unit under test and how much space is required around it to undertake the testing in a safe and unconfined manner?
- (n) Are all the other workshop employees competent to avoid danger if there is a need for them to approach the equipment? If not, how can you make sure that they do not do so?
- (o) Will the equipment be left unattended while live, for example while being 'soak tested'?
- (p) Does the workbench or separate area require a warning, eg a light, to show that testing is in progress?
- (q) Is there a need for additional emergency switching devices for use by other employees to reduce the degree of injury to testers? Can residual current devices (RCDs) be used to provide supplementary protection? (NB: This guidance and the complementary information sheets<sup>1-4</sup> refer to RCDs or 30 mA RCDs. See the section relating to residual current devices on page 9 for a fuller explanation.)
- (r) Is it possible to reduce the number of available paths to earth to reduce the likelihood of a phase-to-earth shock, eg by the use of barriers, screens and insulating mats?
- (s) Is it possible to use unreferenced supplies, eg isolating transformers/batteries to reduce the likelihood of a phase-to-earth shock?

## Managing electrical testing

You must provide a safe working environment and establish a safe system of work for your employees. The results of your risk assessment will help to identify the steps you need to take to do this. Employees must co-operate and take reasonable care for their own and other people's safety while they are at work. The following advice needs to be considered for all activities involving testing.

### **Personnel**

All personnel must:

- (a) understand that the risk of electric shock injury will still remain during the testing process, even with the use of earth-free test areas and/or isolating transformers and/or RCDs;
- (b) fully understand the scenarios in which these electric shock injury risks can arise in the particular workplace(s);
- (c) be given adequate first-aid training, including cardiac pulmonary resuscitation (CPR) skills.

### **Permanent test areas**

These areas must:

- (a) be under the control of a responsible person;
- (b) be in an area set apart by barriers to prevent entry;
- (c) have suitable warnings provided at the entrance;
- (d) be accessible during testing only to authorised staff or people working under their direct supervision;
- (e) have suitable warning lights indicating that testing is in progress and other warning lights to indicate when it is safe to enter the area (duplicate red and green lights are often used);
- (f) have emergency-stop push buttons or equally effective means to cut all test

supplies in the event of emergency. These emergency controls should be prominently identified. (NB: The emergency controls should not remove supplies to the general lighting in the area.)

- (g) display an electric shock poster, eg *Electric shock: First-aid procedures*,<sup>7</sup> at prominent locations, showing emergency arrangements, especially telephone numbers;
- (h) have good housekeeping arrangements, including adequate clear working space.

### **Temporary test areas**

In some situations it may not be practicable or desirable to remove equipment to a permanent test area, eg because the equipment is too large for the test bay or is located at the customer's premises. If live testing needs to be carried out, a temporary test area should be set up around the equipment. When setting up a temporary test area, all the precautions listed above for permanent test areas should be taken, unless it is not practicable to do so, in which case an assessment needs to be made of what precautions are needed to reduce that risk to as low a level as possible.

Remember that simple 'Go/No go' plug-in testers will in general only provide a polarity check and an indication that an earth may be present, but not its effectiveness.

### **Earth-free areas:**

Make a test area as earth free as possible, in conjunction with the use of isolated supplies. To achieve this, take the following precautions:

- (a) use a test bench made of insulating material with shrouded legs and framework to prevent the possibility of contact with earth while testing;
- (b) remove all pipes, radiators, structural steelwork, metal conduits, earthed electrical appliances, metallic socket outlets etc from within reach of the test bench, or permanently shroud them with insulating material to prevent contact;



- (c) where soldering irons and task lighting are needed, they should be extra low voltage, supplied from an isolating transformer complying with BS 61558<sup>8</sup> to prevent the need for earthed metal at the test area;
- (d) if a television or radio aerial socket is needed at the test area, this should be of isolated construction complying with BS 415;<sup>9</sup>
- (e) insulating rubber matting complying with BS 921<sup>10</sup> should be provided on the floor, kept clean and dry, and regularly tested, and should be large enough for the test operative to remain on it whether standing or seated during testing (NB: Chair legs may damage the matting.);
- (f) if electrostatic discharge wrist straps are provided, these must incorporate a suitable resistance (say 1 Megohm or more). The use of a wrist strap which directly connects the wearer to earth is not permissible. For further advice see BS IEC 61340-5-1: 1998.<sup>11</sup>

### **Supplies to equipment under test**

Each item of equipment under test should be provided with its own test supply. These supplies should be from designated sockets or terminals





## Setting up safe test areas

It is important to make sure that anyone not involved with electrical testing work is kept free from risk. This can be done by confining testing work to a designated test area. In some workshops, it might be possible to set up a permanent workbench and test area, to which only the testers have access. Otherwise, unauthorised people should be prevented from approaching the equipment under test by physical barriers or other demarcation methods which form part of the test area boundary.

A test area can be:

- (a) a designated room built as a test area with special protection features and fitted with secure doors (possibly interlocked, depending upon the degree of risk) to prevent unauthorised access;
- (b) an area set aside in a workshop with some form of permanent barrier as a demarcation;
- (c) a work bench which might be designed as a test bench or be used for repairs and testing;
- (d) a designated work position within, or at the end of, a production line;
- (e) a temporary area set up around equipment

- using purpose-built barriers as demarcation;
- (f) an area around fixed equipment, such as switchgear, or control gear, where skilled people are carrying out repairs, fault-finding or testing during maintenance work.

In workshops where all employees have been adequately trained and instructed in safety practices and all unauthorised personnel are effectively excluded, local demarcation of the workbench or work area where testing is done may not be necessary. All employees need to be aware that those who are carrying out testing should not be distracted by the interference of others who are not involved with the test in progress.

## Protecting the people doing the testing

The measures that are used to protect the people doing the testing need to be effective to prevent them coming into accidental contact with dangerous exposed conductors. This might be either a single-hand contact with a source of energy which has one of its supply conductors

connected to earth, or another area of conducting surface.

Class I equipment is in this category because the mains at source are earth referenced; so is electronic equipment where a large metal surface (or chassis) is connected to the source. There is also a risk of injury from sources of supply which are not earth referenced and where accidental simultaneous contact with both poles of the supply is possible.

Methods of reducing the risk of a shock from simultaneous contact with conductors include:

- (a) testing at reduced, non-hazardous voltages and currents;
- (b) using interlocked test enclosures in which the unit under test is contained;
- (c) using temporary insulation;
- (d) replacing covers which need not be removed for the purposes of the test, for example once supply connections have been made;
- (e) creating an area which is as earth free as practicable;
- (f) using isolating transformers connected to the mains supply;
- (g) using 30 mA RCDs.

The following sections provide more detail about each of these protective measures.

### ***Safe voltages and currents***

It may be possible to test the equipment by energising it with non-hazardous voltages and current levels. This should always be considered as the first option before deciding to use dangerous voltages and current levels.

### ***Interlocked enclosures***

These can vary in size from a small bench-mounted box with an interlocked hinged lid to a large enclosure (large enough for people to enter) equipped with access gates which are secured by interlocks. It is important to ensure that the safety performance of the interlocking system is comparable with that of a switching

device used for isolation purposes. The use of a trapped key (key exchange) system interlocked with the access and the isolator can assist. In general, interlocking using the control system alone is not acceptable; the power supply should be isolated by the interlock system.

In certain circumstances there may be the potential for a stored charge to occur, eg from the use of capacitors. In these circumstances the supply to the equipment under test should be earthed, preferably automatically, before entry is made. If it is not possible to earth the equipment automatically, it should be manually earthed by the use of a suitably insulated earthing tool. Where automatic earthing is used, it is essential to use, in addition, a manual earthing device before making contact with any parts that have previously been made live.

Where large enclosures are used, you must make sure that people cannot be inside the enclosure while there is danger from the equipment being tested.



### ***Temporary insulation***

Where there is risk from simultaneous contact with hazardous conductors, do not assume that employees will be able to avoid accidental contact. Consider using temporary insulation which may be in the form of purpose-made screens or insulating sheets or shrouding (rigid or flexible). However, there may be a practical limit on the use of screens when testing compact electronic assemblies.

### ***Earth-free areas***

It is difficult to achieve a true earth-free area, since there is a need to ensure that floors and walls will not conduct current which can give rise to shock injury. Suitable insulating materials, including mats, are therefore needed to construct an earth-free area. These parts will then have to be tested at regular intervals to demonstrate that their insulation properties are being maintained.

An area which is as earth free as practicable can be more easily created, but a thorough risk assessment needs to be done to ensure that the testers will not make accidental contact with any earthed conductors. Items such as heating and water pipes and radiators should be enclosed, or the test area should be situated to prevent simultaneous contact by the tester with the item under test and the earthed item. Earth-free areas should have the minimum of exposure of conductive parts. A 30 mA RCD could be used as supplementary protection. Earth-free areas are often used in conjunction with isolating transformers.

Where it is not possible to make an area earth free because it is necessary for the test equipment and/or the equipment under test to be earthed, it is still possible to reduce the extent of the accessible earthed metalwork.

### ***Isolating transformers***

Isolating transformers connected in the test supply will prevent the risk of electric shock

if a person touches a single live conductor of the isolated supply while in contact with an earthed conductor.

It should be clearly understood, however, that an isolating transformer cannot prevent an electric shock if someone makes contact simultaneously with both conductors of the supply on the secondary side of the transformer, unless the output voltage is below 50 V ac (120 V dc) in dry conditions and 16 V ac (35 V dc) in wet conditions.<sup>13</sup>

The integrity of the isolation from earth should be tested regularly, or earth fault monitoring devices should be installed, to ensure that dangerous earth faults are detected.

### ***Residual current devices (RCDs)***

These are supplementary protection devices which do not prevent an electric shock, but are able to limit the duration of some shocks by being able to cause rapid disconnection of the electricity supply in the event of a relatively low current flowing to earth, such as may occur during an electric shock. They are, therefore, able to provide a much higher level of protection against the risk of a severe electric shock than could be provided from an unprotected source.

An RCD required to minimise the risk of personal injury should have a rated tripping current of no more than 30 mA and should not have an adjustable time delay. Although the 30 mA versions are often used, those with lower rated tripping currents (typically, 10 mA or below) are readily available and may be used to provide additional protection where nuisance tripping is not a problem.

Where personal safety depends in part upon the operation of an RCD, the RCD must be tested using the built-in test facility at appropriate intervals (eg portable RCDs before each use, fixed RCDs weekly). In addition, all RCDs



measurements that can be made by the oscilloscope. A technique has been developed to 'float' the oscilloscope (ie remove the connection to the supply protective conductor) which then allows the oscilloscope's enclosure to float above earth potential (which could be at high voltages for some types of measurement) with obvious possible shock risks. Operation of an oscilloscope with the protective conductor removed means that it is no longer protected against internal insulation breakdown. Another disadvantage with this situation is that it will then be necessary to attempt to create an earth-free area. Such use also defeats the equipment manufacturer's primary protection concept for Class I protection and should be discouraged.

Measurements on be made on a safe method that can be used to supply the oscilloscope which allow

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aware of all aspects of safety relating to testing. Specialist competent advice may be needed to ensure that the testing procedure is safe.

When setting up a testing area, it is important that people who are electrically unskilled or inexperienced are protected from electrical danger at all times. Appropriate precautions will also need to be taken to prevent injury of people who have electrical knowledge and skills. Remember that even a skilled person can make accidental contact with dangerous electrical conductors if they are not protected. Someone's personal electrical competence should not be relied on as their main protective measure.

The precautions that are taken should be reviewed regularly, to make sure that they are being followed and are still appropriate for the work that is being done. As part of this safety review, employees should be given sufficient instruction and training on how the safe working procedures have been amended. This is especially important where there is a change in design of products being tested which is relevant to how the protection concepts are applied.

It is good practice to give one person the task of reviewing designs and implementing any

changes to safety procedures that are necessary following discussions with the test personnel. A safety review should be carried out when changes are made that may affect testing work, such as changes in production methods, supply arrangements, test methods and instruments, or when personnel changes are made.

Where testing is done by a contractor invited to a site, safe working arrangements must be discussed and agreed before the work starts, preferably at the contract discussion stage. This enables everyone concerned to know who is doing what and who is responsible for what, so that the work can be done safely and without risk to the contractor's employees, the site employees and others who might be affected. In particular, the person who is responsible for the safe isolation and state of the equipment should be identified and agreed.

## Legal requirements

The Electricity at Work Regulations 1989 are the principal legislation relating to electrical testing activities. Regulation 4(3) requires that 'work on or near to an electrical system shall be carried out in such a manner as not to give rise,

## References

- 1 *Safety in electrical testing: Servicing and repair of domestic appliances* Engineering Information Sheet EIS35 HSE Books 2002
- 2 *Safety in electrical testing: Servicing and repair of audio, TV and computer equipment* Engineering Information Sheet EIS36 HSE Books 2002
- 3 *Safety in electrical testing: Switchgear and control gear* Engineering Information Sheet EIS37 HSE Books 2002
- 4 *Safety in electrical testing: Products on production lines* Engineering Information Sheet EIS38 HSE Books 2002

*Electrical test equipment for use by electricians*  
GS38 1995 ISBN 0 7176 0845 X

*Electricity at work: Safe working practices*  
HSG85 ISBN 0 7176 0442 X

### **Other publications**

*A design guide for the electrical safety of instruments, instrument/control panels and control systems* (Ref 178) Engineering Equipment and Material Users' Association (EEMUA), 14-51 Belgrave Square, London SW1X 8PS Tel: 020 7496 8990 ISBN 0 85931 080 9

*DASA Quality criteria* (Section 2 'Competence' and 3.1 'Electrical Safety Tests') Domestic Appliance Service Association (DASA), 6-9 The Maltings, Stanstead Abbots, Herts SG12 8HG Tel: 01920 870173 (free)

*Electrical maintenance: Code of practice* The Institution of Electrical Engineers (IEE), Savoy Place, London WC2 R0BL Tel: 020 7240 1871 ISBN 0 8529 6769 1

### **British and international standards**

BS EN 61557-1:1997, IEC 6155-1:1997  
*Electrical safety in low voltage distribution systems up to 1000 V ac and 1500 V dc: Equipment for testing, measuring or monitoring of protective measures. General requirements* (full document is in nine parts)

BS 3535-2:1990 *Isolating transformers and safety isolating transformers. Specification for transformers for reduced system voltage.*

BS PD 6519 *Guide to the effects of current on human beings and livestock. Part 1: General aspects - Guidance on the effects of ac (frequencies between 15 and 100 Hz) and dc. Part 2: Special aspects relating to human beings - Guidance on the effects of alternating current*

*and frequencies above 100 Hz, with special waveforms, or in the form of short duration unidirectional single impulses. Part 3: Effects of current passing through the body of livestock.*

## **Addresses of trade and professional associations**

Radio, Electrical and Television Retailers' Association (RETRA),  
RETRA House, St. John's Terrace, 1 Amphill Street, Bedford MK42 9EY  
Tel: 01234 269110

Engineering Equipment and Material Users' Association (EEMUA),  
45 Beech Street, London EC2Y 8AD  
Tel: 020 7496 8990

British Electrotechnical and Allied Manufacturers' Association (BREAMA)  
Federation of the Electronics Industry (FEI)  
Russell Square House, 10/12 Russell Square, London WC1B 5EE  
Tel: 020 7331 2000

Domestic Appliance Service Association (DASA),  
69 The Maltings, Stanstead Abbots, Hertfordshire SG12 8HG  
Tel: 01920 870173

Association of Manufacturers of Domestic Electrical Appliances (AMDEA)  
Rapier House  
40-46 Lambs Conduit Street  
London WC1N 3NW  
Tel: 020 7405 0666

Institution of Electrical Engineers (IEE),  
Savoy Place, London WC2 R0BL  
Tel: 020 7240 1871

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British Standards are available from

BSI Customer Services, 389 Chiswick High Road, London W4 4AL

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Fax: 020 8996 7001

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This leaflet contains notes on good practice which are not compulsory but which you may find helpful in considering what you need to do.

This leaflet is available in priced packs of 5 from HSE Books, ISBN 0 7176 2296 7. Single free copies are also available from HSE Books.

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