

March 2024

Electricity – Guidance for Working Safely with Electricity in the University of Cambridge

Occupational Health & Safety Service
HSD001P (rev 6)



**UNIVERSITY OF
CAMBRIDGE**

Approval History

Revision	Reviewed by	Amendment history	Approved by	Date
6	Sub-committee for Physical Safety	Full review to remove ambiguity around extension cables. Removed table of proposed dates for PAT inspections, as they are now risk-based. Reference documents updated	Martin Vinnell	March 2024
1 - 5	Safety Office	None noted	Martin Vinnell	2012,2016,2020
First Addition	Published by the Safety Office		Martin Vinnell	2001

Scope

This guidance outlines basic measures to help everyone in the University control the risks from the use of electricity at work and is aimed at those using both Direct Current (DC) and Alternating Current (AC), at all voltages, including AC mains electricity. It does not cover other sources of energy that may be generated by equipment, e.g. radio waves or micro-waves etc.

Contents

1	Introduction.....	5
2	Risk Assessment.....	5
2.1	Identifying the hazards.....	6
2.2	Assessing the risk.....	6
2.3	Some factors affecting the risk of injury	7
2.4	Electrical injuries.....	7
3	Reducing the Risk of Injury	9
3.1	Control measures	9
3.2	Additional measures	9
3.3	Competence	9
3.4	Mitigation measures.....	10
4	Responsibilities and Legal Duties	10
4.1	Responsibilities of All Electrical Equipment Users.....	10
4.2	Department and Estate Division Responsibilities	11
5	Purchase of New Electrical Equipment	12
6	Second-hand Electrical Equipment.....	13
7	Teaching and Research Activities.....	13
8	Use, Design, Construction and Modification of Electrical Equipment NOT the responsibility of ED.....	14
9	Live Work and Testing	16
10	Reduced Voltage Equipment	17
11	High Voltages	17
12	References and Further Reading.....	17
	Appendix A The Electricity at Work Regulations 1989.....	18
	Appendix B First Aid for Electric Shock and Burns	20
	Appendix C General Guidance on Working Live.....	21
	Appendix D Electricity in a Potentially Explosive Atmosphere	23
	Appendix E Electrical Safety (List of User Visual checks)	24
	Appendix F Electrical Safety - Overnight Running.....	25
	Appendix G IP Code and Cable Ratings.....	26
	Appendix H High Voltage Precautions.....	27
	Appendix I Extensions and Leads.....	28
	Appendix J Electrical Safety Inspection Checklist.....	29
	Appendix K Definitions	31





1 Introduction

Electricity can kill. Each year about 1000 accidents at work involving electrical shock or burns are reported to the Health and Safety Executive (HSE) in the UK and of these around 30 are fatal (source HSE). Although most of these fatalities arise from contact with overhead or underground power cables, caution is required when dealing with any source of electrical energy. In addition, shocks from faulty equipment may lead to falls from ladders, scaffolds or other work platforms. Users of electrical equipment may not be the only ones at risk; poor electrical installations and faulty electrical equipment can lead to fires or explosion.

The Electricity at Work Regulations 1989 are a legal framework specific to electrical safety, which applies to all work activities with electricity, irrespective of voltage. The Regulations impose a range of duties on individuals, some of which are “absolute” and some of which are to be carried out “as far as reasonably practicable” meaning a carefully considered balance of the level of risk set against the cost of reducing the risk, which is only applicable if the costs are disproportionately large when set against the level of risk. Therefore, it is important not only to have knowledge of the Regulations but to understand the level of duty imposed by them. Refer to Appendix A for the scope and the level of duty imposed in the Regulations.

There are no voltage limitations in the Regulations, which extend from the smallest battery circuits to national grid transmission systems.

The HSE has published Guidance on the Electricity at Work Regulations 1989 as amended 2015 (<https://www.hse.gov.uk/pubns/priced/hsr25.pdf>) and a supplement Electricity at Work - Safe Working Practices (<https://www.hse.gov.uk/pubns/priced/hsg85.pdf>) which should be read in conjunction with the University guidance below.

The design, construction, operation and maintenance of electrical systems, (including purpose-built research equipment and rigs) must only be undertaken by appropriately competent persons and must fully comply with the requirements of all related legislation and standards to ensure that safe systems are established and maintained.

For the purposes of this document the terminology, definitions and abbreviations used are detailed in Appendix K.

2 Risk Assessment

The Regulations define ‘danger’ as the ‘risk of injury’ and the main aim of the Regulations is to prevent injury from any source of electrical energy. Therefore, it is important to identify the hazards associated with the source of electrical energy and to carry out a risk assessment to determine the ‘danger’ or ‘risk of injury’ associated with these hazards. Also see University’s Risk Assessment Handbook (<https://www.safety.admin.cam.ac.uk/system/files/hsd044m.pdf>).

Having determined the risk, then with the appropriate knowledge, evaluate the measures necessary to control that risk and implement them. This involves weighing the likelihood of injury and the severity of injury against the measures needed to avert the danger, considering the level of duty owed under the Regulations.

All risk assessments must be suitable and sufficient – risks must be managed responsibly. Anyone that is at risk from work on or with electrical equipment must be familiar with the risk assessment and abide by the control measures identified on the document.



2.1 Identifying the hazards

The main foreseeable hazards are:

1. **'Contact with' or 'arcing from' electrically live parts causing:**
 - a. **electric shock** and/or
 - b. **electrical burns** (direct, indirect, external and internal) and/or
 - c. **electrical explosions** from excessive current in cables or switchgear
2. **Electrical faults which cause overheating of electrical conductors and fires;**
25% of all fires are caused by an electrical fault, second only to arson as a cause of fire in the workplace
3. **Fire or explosion** where the use of electricity could be the source of ignition in a potentially flammable or explosive atmosphere e.g. from solvent storage, solvent use, solvent spillage, gas leak or dusty environment (a significant amount of fine airborne dust can explode ie: flour, sugar, starch, wood, some metals etc.)
4. **Physical injury** such as falling because of the shock or tripping over trailing cables.
Note: Damage to trailing cables from tripping or repeated 'treading-on' may cause potentially dangerous damage to occur, which may not be visible to the naked eye.

Remember that both normal UK single phase mains voltage of 230 volts 50 Hz AC and three phase 415-volt electricity supplies have the potential to kill.

**IF IN ANY DOUBT CONSULT A QUALIFIED
ELECTRICAL ENGINEER**

2.2 Assessing the risk

Having identified the hazards:

1. Decide who might be harmed and how
2. Evaluate the risks arising from the hazards and decide if existing controls and precautions are adequate or whether more are required
3. Record significant findings of the risk assessment
4. Review the risk assessment regularly.

Amongst other factors, it will be necessary to consider the implications of lone working as part of the risk assessment process.

For general risk assessment guidance see the University's Health and Safety Risk Assessment Handbook (April 2022).



2.3 Some factors affecting the risk of injury

Most injuries occur when the human body becomes either a route to earth or a route between two conductors for the flow of an electric current.

The HSE advise that the risk of injury from electricity is strongly linked to where and how it is used. The risks are greatest in harsh conditions and environments. Be aware of:

1. Wet surroundings – unsuitable equipment can easily become live and make its surroundings live, in addition wet skin is more conductive (see below)
2. Out of doors – equipment may not only become wet but may be at greater risk of damage
3. In cramped spaces, such as inside ducting, plant rooms or risers, which may have a lot of earthed metal, it could be very difficult to avoid a shock if an electrical fault developed
4. Some items of equipment can also involve greater risk than others i.e. portable equipment and extension leads which are particularly liable to damage and/or overloading/overheating
5. Experimental rigs are by definition ‘experimental’ and potentially liable to unforeseen consequences
6. Electrical injuries can be caused by a wide range of voltages, but the risk of injury is generally greater with higher voltage.

2.4 Electrical injuries

The severity of any electrical injury will depend on several factors including:

1. The amount of electricity flowing through the body, this is known as the ‘current’ and is measured in amps. The current is dependent on the:
 - a. Voltage (see Section 13 below)
 - b. Electrical conductivity of the skin. If the skin is wet its electrical conductivity rises by a factor of 100 with a consequent increase in the flow of electricity
2. The amount of energy in a shock, and consequently the damage done to the body, increases with the duration of time that the electricity flows through the body
3. The frequency of the electricity supply; the damaging effects of electric shock are at their most acute around the frequency of the UK mains AC supply (50 Hz)
4. The route the electricity takes:
 - a. If it flows from one arm across the chest to earth via the other arm it will almost certainly pass through the heart
 - b. If it passes from the arm to earth via the leg the effect on the heart will probably be less severe
 - c. If its flow to earth is impeded by an insulating material the effects may be mitigated i.e. if the person is wearing dry rubber ‘soled’ shoes or standing on a rubber mat.

Note: See Appendix B: First Aid for Electric Shock and Burns for more information.



2.4.1 Electric shock

A voltage as low as 50 volts applied between two parts of the human body causes a current to flow that can block electrical signals between the brain and the muscles, whilst currents of only a few milliamps can be fatal.

An electric shock can have several effects including:

- Stopping the heart beating properly, leading to oxygen deficiency in the brain
- Pain and loss of muscle control, through involuntary muscle spasms, which can be strong enough to damage the muscles, fracture bones or dislocate joints
- Preventing a person breathing, leading to oxygen deficiency in the brain
- Muscular spasms can prevent the person letting go of or escaping from the source of electricity. This is particularly dangerous if breathing has also stopped
- Causing the person to fall or be thrown into nearby machinery and structures and/or fall from height, which is potentially fatal.

2.4.2 Electrical burns

Electrical burns are different to thermal burns. When an electric current passes through the body it heats the tissue along the length of the current flow. This can result in deep internal burns that often require major surgery and may be permanently disabling. Burns are more common with higher voltages but may also occur with mains 230-volt supply if the current flows for more than a few fractions of a second. Electrical burns typically arise from direct contact with the conductor but can be the result of electrical arcing (which will also emit UV radiation, see 2.4.4 below).

2.4.3 Thermal burns

Overloaded, faulty, incorrectly maintained, or shorted electrical equipment can get very hot; whilst some electrical equipment gets hot in normal operation. Even low voltage batteries such as those in motor vehicles can get hot and may explode if they are shorted out. People can receive thermal burns if they touch or get too near hot surfaces, or they are near an electrical explosion. Other injuries may result if the person pulls quickly away from hot surfaces, particularly if they are working at height or if they accidentally come into contact with nearby machinery.

A single low voltage torch battery can generate a spark powerful enough to cause a fire or explosion in an explosive atmosphere (i.e. between the Lower and Upper Explosive Limits of a substance), which could occur in a solvent store or sump and where flammable dusts, vapour or gases are present. (Allowing alkaline batteries to get wet can result in a fire developing.)

Low voltage batteries such as those used in motor vehicles generate hydrogen during normal operation or overnight charging, which can explode if the battery is short circuited or disconnected incorrectly.

2.4.4 Arcing burns

Arcing causes a particular type of burn to the skin and eyes because of the UV radiation generated by the arc, like severe sunburn. Molten metal particles from the arc can penetrate, burn and lodge in the skin and eyes. These effects are additional to electrical burns and radiated heat damage caused by the arc. Arc resistant/arc flash personal protective equipment must be worn.

2.4.5 Electrical Explosion

Switch gear, electric motors and power cables can explode if they are subject to excessive currents, prolonged internal arcing or shorting. In addition to the explosive release of violent

electrical energy there may be metal and other projectiles ejected, as well as UV light and even molten or vaporised metal, which could all cause a range of injuries. In the classic accident of cutting through an underground high voltage cable with a digger the resultant explosion is as likely to cause injury, to the person and to bystanders, as the electrical current itself.

3 Reducing the Risk of Injury

3.1 Control measures

These can include:

- Ensuring all installations and equipment are to a suitable standard
- Primary and secondary insulation of all conductors i.e. wires, cables, etc.
- Guards, barriers, covers etc. to prevent any potential access to live parts
- Spatial separation of conductors from sources of earthing, including people
- Provision of a single emergency stop / isolation point for a whole rig or room
- Provision of safety cut-outs, such as fuses and Residual Current Devices (RCDs)
- Regular inspection and testing of all electrical equipment and installations
- Regular maintenance of equipment and installations
- Using reduced voltage or rechargeable equipment where reasonably practicable
- Using the appropriately rated equipment (i.e. spark-proof, waterproof)
- Provision of sufficient socket outlets to avoid overloading
- Alternative equipment in hazardous atmospheres (i.e. hydraulic or pneumatic)
- Training, including the assessment of competence where appropriate (see 3.4 below)
- Safe Working Practices including:
 - Safe operating procedures
 - Signage on equipment
 - Isolation
 - Locking off isolated equipment
 - Notices on isolated equipment
 - Permits to work
 - Following IET advice.

3.2 Additional measures

Persons assessed as specifically competent for particular tasks may also require:

- Insulated tools
- Personal Protective Equipment i.e.: rubber gloves / shoes / mats, goggles etc.

3.3 Competence

Competence would be judged by:

- Suitable and sufficient training (or close supervision by a competent person whilst undergoing training)
- Practical experience of working with electricity and the type of installation or equipment being used
- A thorough knowledge of the hazards involved in working with electricity
- Knowledge of the current safety standards and a clear understanding of the precautions required to avoid danger
- The ability to recognise whether it is safe to continue work, i.e. 'recognising at all times whether it is safe to continue to work and therefore knowing when to stop'.



The level of competence required will differ for different types of work i.e.:

1. A person required to inspect or connect a 13-amp plug requires a lower level of training and technical electrical knowledge than a person required to work on three phase 415 volt or high voltage systems. However, in both cases the level of competence must be proven, and appropriate records kept
2. A person in a department who will be required to carry out The Inspection and Testing of Electrical Equipment (formally known as PAT Testing) must hold a City and Guilds 2377 Certificate or equivalent qualification
3. A person working on the University's electrical distribution system would need to be trained and qualified as an approved electrician within an approved training scheme and be up to date with changes in Regulations and standards such as BS7671 (IET Requirements for Electrical Installations – 'Wiring Regulations' 18th Edition).
Note: Departments must consult with Estate Division before employing a person to work in this capacity.

3.4 Mitigation measures

Measures to mitigate the effect of an incident include:

- Ensuring PAT inspectors are trained and competent for the task (both in-house and external)
- Not allowing lone or out-of-hours working for certain tasks i.e. tasks identified by risk assessment as having an unacceptably increased risk because of lone or out-of-hours working
- Emergency planning
- Provision of emergency first aid (see Appendix B).

4 Responsibilities and Legal Duties

Everyone who uses or works with electricity at work has the responsibility to:

- Ensure that it is used in an appropriate and safe manner
- Ensure that risks associated with electricity at work have been assessed and are controlled.

4.1 Responsibilities of All Electrical Equipment Users

All users of electrical equipment have the following responsibilities:

1. Understanding the parameters of use of the electrical equipment used for their work
2. Ensuring that equipment is used according to manufacturer's instructions
3. Ensuring that risks do not arise from properly designed and constructed equipment being used outside the conditions for which it is intended
4. Whenever possible using reduced voltage equipment, including rechargeable units
Note: Almost a quarter of all reportable electrical accidents involve portable appliances.

5. Visually checking electrical equipment for signs that the equipment is in sound condition and reporting it if it is not. (See Appendix E)
6. Not to use or allow the use of faulty equipment
7. Not to attempt to repair faulty equipment or cables, unless fully competent to do so
8. Not to remove insulation, covers, earth connections or otherwise alter electrical equipment unless fully competent to do so
9. Ensuring that fuses, circuit breakers and residual current devices are used where appropriate, are in good condition and correctly rated
10. Ensuring that circuits are not overloaded, and extension leads are not daisy chained
11. Ensuring that where possible electrical equipment is switched off and isolated when not in use
12. Ensuring, as far as reasonably practicable, that all flammable material in the neighbourhood of live electrical equipment is removed to minimise the risk of a fire developing or spreading
13. Ensuring that when electrical equipment (other than fridges or freezers etc.) is left running overnight or for extended periods unattended out of hours, that:
 - a. The work has been authorised by a supervisor or other suitable person
 - b. The equipment is suitable
 - c. If possible, the equipment will 'fail to safety' should a fault develop
 - d. It is identified / labelled as running overnight and emergency shut down procedures are documented if appropriate (see Appendix F)
 - e. Additional precautions such as thermostatic cut outs or heat / smoke detectors are considered if appropriate.

4.2 Department and Estate Division Responsibilities

Heads of Department and Institutions are responsible for ensuring that all the electrical systems and equipment under their control are operated and maintained in a safe manner., They are also responsible for ensuring that all electrical systems and equipment are designed, operated, maintained, modified and extended in such a way that avoids danger and complies with the Electricity at Work Regulations 1989 (see Appendix A). It applies to all experimental rigs, research equipment, electrical/electronic workshops, portable electrical apparatus, light fittings, equipment fitted to the fixed electrical system such as workshop machinery and electrical kitchen equipment etc.

Heads of Department are thereby responsible for ensuring that adequate resources of people and equipment are available to ensure the safety of electrical systems under their control and that they have access to advice at an appropriate level. For small locations, departments or institutions this may be done using the services of ED or by using a contractor with the necessary expertise and experience.

ED are responsible for the design, construction, operation, repair, maintenance and modification of fixed electrical systems under Service Level Agreements with Departments.

This may include:

- a. Substations, switch rooms and all electrical services (other than those provided by the statutory authorities) including mains supplies, lighting conductors, general and special earthing, the lighting of roads, car parks and cycle and pedestrian route-ways
- b. The electrical distribution system including all subsidiary circuits up to and including socket outlets, fixed spurs and ceiling or wall mounted terminations. ED MUST liaise with departments, particularly with respect to timing, access, isolation of supplies and notification of intended works so that departments can prepare and co-operate in carrying out risk assessments.

Departments or Institutions (other than ED) must not carry out or cause to be carried out (e.g. by engaging contractors), any modifications or extensions of the systems defined previously as the responsibility of ED under their Service Level Agreement, without the prior knowledge and prior written approval of ED.

Note: Departments must ensure that areas where electrical switchgear is installed are kept clean, tidy, and un-obstructed. Dedicated switchgear areas must not be used for storage or other unapproved use.

When work is taking place on the electrical distribution system ED MUST, liaise with departments to ensure that in-house personnel and contractors are provided with a safe working area and are given sufficient information of any known hazards or risks to health and safety to enable them to work safely.

ED and Heads of Department must ensure that electrical systems and equipment for which they are responsible are properly maintained, inspected and tested e.g. portable electrical appliances must be 'PAT' tested periodically determined by risk assessment.

ED AND HEADS OF DEPARTMENT MUST ENSURE THAT RISK ASSESSMENTS ARE COMPLETED AND EFFECTIVE CONTROL MEASURES ARE PUT INTO PLACE BEFORE ANY ELECTRICAL WORK IS UNDERTAKEN

5 Purchase of New Electrical Equipment

When purchasing new electrical equipment, the following should be observed:

1. New equipment should be suitable for the environment in which it is to be used e.g.:
Specialised equipment for:
 - a. Use outdoors (check Ingress Protection rating; see Appendix G)
 - b. Use in potentially explosive atmospheres (see BS 60079 series standards)
 - c. Use in harsh environments (consult suppliers)
2. New equipment should be visually inspected before use, and placed on the Department's or Institution's PAT test register if one is available
3. New equipment if correctly CE or UKCA marked and made to standards associated with such markings does not normally require PAT testing before first use.
Depending on the type of equipment and how it will be used i.e. 'domestic' equipment

from a 'reputable brand' when used in a work environment may be suitable to use after pre-user-checks have been undertaken, however it should be subject to additional consideration. Some departments do insist on all electrical equipment being tested prior to use so please ensure you know your individual department's procedure

4. Only a competent person must fit plugs to electrical equipment and the correct fuse must be used
5. Whenever reasonably practicable purchase 'reduced voltage' equipment (up to 50 V AC), including rechargeable units
6. All equipment must be used in accordance with the manufacturer's instructions
7. Equipment purchased from outside the EU must always be verified to ensure it is electrically safe, by the importer or supplier. It should also be CE or UKCA marked.

Note: Where Departments or Institutions are themselves directly the importer (or the supplier) **they are responsible** for ensuring compliance with the electrical principles in the Electrical Equipment (Safety) Regulations 2016. These Regulations require electrical equipment to be safe and constructed in accordance with good engineering practice. All equipment must also comply with relevant and applicable European and British Standards.

This is not a trivial undertaking!

A competent and 'responsible' person is required to certify that the equipment is compliant must carry out the inspection and testing of such equipment.

6 Second-hand Electrical Equipment

Second-hand electrical equipment or electrical equipment which is hired or loaned out e.g. to another Department/University/Company also come under the scope of the Electrical Equipment (Safety) Regulations 2016. All electrical equipment must be safe, constructed with good engineering practice, and be inspected & tested by a competent person before it is used.

If you intend to sell or donate electrical equipment that you no longer use, you become the 'supplier' under the Provision and Use of Work Equipment Regulations 1998 (PUWER) and must fulfil all the requirements of this legislation. Further details can be found at <https://www.hse.gov.uk/work-equipment-machinery/puwer.htm>.

7 Teaching and Research Activities

The Electricity at Work Regulations must be considered in risk assessments carried out for teaching and research activities. Particular attention **MUST** be paid to the competent supervision of students and other persons who might be affected by the activities. The Regulations are specific in that no persons may be engaged in any work activity where

technical knowledge or experience is necessary to prevent electrical danger or injury, unless they possess such knowledge or experience or is under such a degree of supervision as may be appropriate having regards to the nature of the work.

**SUPERVISERS OF ACADEMIC RELATED AND RESEARCH WORK MUST BE
AWARE OF THE REQUIREMENTS OF THE ELECTRICITY AT WORK REGULATIONS
AND ENSURE / MONITOR THAT THEY ARE BEING COMPLIED WITH.**

8 Use, Design, Construction and Modification of Electrical Equipment which is NOT the responsibility of ED

Without detracting from the duty of the person in control of the danger, all departmental designs for apparatus which use electricity **MUST** be verified by the Electrical (Safety) Supervisor or a qualified electrician. If the department does not have access to these then ED **MUST** be consulted. Verification should ensure that all procedures set out in this guidance document and the Regulations have been observed. The Electrical (Safety) Supervisor **MUST** also verify the apparatus, rig or equipment is safe to use before it is operated. The designated 'Electrical (Safety) Supervisor' is an employee who should be appointed in writing by the Head of Department to advise the Department Safety Officer on all matters relating to electrical safety and be conversant with legislative and other requirements.

The following factors must be considered:

1. Before constructing electrical equipment, a risk assessment must be completed. Wherever practicable the control of danger must be addressed at the design stage. The risk assessment must include the following phases:
 - a. Construction
 - b. Testing
 - c. Commissioning
 - d. Operation
 - e. Maintenance
 - f. Storage, decommissioning and disposal

The IET Regulations provide basic design standards for all electrical installations, giving a good level of protection in most circumstances. However, the nature of laboratory work requires special consideration because of the increased level of user contact with equipment and the extensive use of water and other conducting liquids. For this reason, wherever reasonably practicable the sockets in a laboratory (room) should not be connected to different phases of the main building supply. Mixing electrical phases in a laboratory increases the magnitude of the phase-to-phase voltage differential between sockets and thereby increases potential severity of an electrical shock or burn (see British Occupational Hygiene Society Technical Guide No 10; Laboratory Design Issues, 1992)

2. In laboratories and workshops where electrical testing is routine there must be emergency stop buttons clearly marked and easily accessible to ensure that the electrical supply can be shut off quickly in an emergency

3. Residual Current Devices (RCDs) rated at no more than 30 mA limit the energy in a particular type of electric shock and can save life. RCDs must be used for:
 - a. Equipment for use with water or humid atmospheres
 - b. Equipment with leads that may trail over workshop floors
 - c. Equipment for use outdoors

It is best to use an RCD that is incorporated into the switchboard of your installation.

RCDs should be regularly tested in accordance with the manufacturer's instructions, typically by pressing a 'test' button to make sure that the RCD trips. Faulty or inoperative RCDs should be removed from use and replaced immediately.

Note: Type AC RCDs are affected by residual DC components and can become desensitized or 'blinded' and may not operate within the required time or, in some instances, may not operate at all

4. Electrical equipment must have a plug fitted by a competent person. The correct fuse must also be fitted. Before every use the user must visually inspect the equipment and if any damage is found the item must be removed from service and the damage reported.
5. Electrical equipment must be suitable for the environment in which it is intended to be operated. Special equipment is normally required for work in freezer and cold rooms, outdoors and in potential explosive atmospheres (see Appendix D).

Note that equipment removed from a cold room or freezer to a warmer environment must be left to equilibrate and any condensation 'on or in it' allowed to evaporate before it is re-used (at least overnight)
6. Equipment must be used as directed by the manufacturer's instructions. Changes to the mode of operation or modification to the equipment are only permitted if:
 - a. The user completes a risk assessment to assess any risk introduced by the change(s) and those risks are then adequately controlled
 - b. All changes and/or modifications are checked by a competent person
7. Live parts must be insulated or enclosed and suitable earth bonding provided to protect against shock from fault conditions
8. The use of multi-way adaptors, adaptor plugs, travel adaptors and non-UK plugs is NOT permitted. Personal items of electrical equipment should NOT be brought into departments except for laptops, laptop power supply's/cables and mobile phone chargers which can only be used if they have UK plugs on them. They will also need to be inspected and tested (formerly PAT Tested) by a competent person
9. Electrical energy supplied to a rig or equipment must be from a single easily isolatable source with an emergency stop button (e-stop). The e-stop must be clearly labelled and the means to turn off / isolate the supply must be always safely accessible under **all** reasonably foreseeable circumstances
10. It should be possible to isolate a rig or piece of equipment in such a way that it is verifiably electrically dead, either through removal of a plug or by locking off
11. Equipment should be earthed (class 1) unless it is double insulated (class 2) and marked as such with the appropriate symbol:



12. In every working environment good housekeeping is important – gangways must be kept clear for safe access and egress. Avoid trailing wires, however, if wires must trail across the floor they must be protected with cable traces. Access to switches, isolators and emergency shut down buttons must always be kept clear.

9 Live Work and Testing

The Regulations define live working as “any work on or so near any live conductor (other than one suitably covered with insulating material so as to prevent danger) that danger may arise” i.e.: working on, with or near live exposed or directly accessible electrical conductors that contain or are carrying electrical energy which could cause injury.

It is the University’s general policy that work on ‘live electrical systems’ should not be carried out unless specifically authorised under very exceptional circumstances

The University and the HSE acknowledge that one of these exceptional circumstances is limited testing and diagnostic work where it is not possible to do the work on a dead circuit.

In these and other rare exceptional cases Regulation 14 of the Electricity at Work Regulations 1989 requires the person in control of the danger to:

1. Determine in each case that it is un-reasonable in all circumstances to work on conductors which are dead
2. Then determine in each case that it is reasonable in all circumstances to work on or near conductors which are live
3. Carry out a specific and detailed risk assessment to:
 - a. identify the risks
 - b. assess the risks
 - c. identify methods of effectively controlling the risks
 - d. implement the control measures

Note: If the work or testing can be carried out using a reduced voltage supply, the risk of injury will be reduced accordingly.

**A SPECIFIC WRITTEN RISK ASSESSMENT MUST BE COMPLETED BEFORE ANY
LIVE WORK IS UNDERTAKEN**

MOST IMPORTANTLY
**ONLY PERSONS SPECIFICALLY COMPETENT TO DO SO ARE PERMITTED TO
WORK LIVE**

For further guidance on risk assessment see the HSE publication: [Safety in Electrical Testing at Work INDG354](#). Further general guidance on live working is given in Appendix C.

10 Reduced Voltage Equipment

One of the best ways to reduce the risk of injury from electricity is to reduce the voltage. For portable equipment this can be achieved simply by using a step-down transformer to reduce the voltage to 110 V. These transformers are normally of a design known as 'centre tap to earth'. In practice this means that any voltage involved in an electric shock will only be 55 V, while the full 110 V is available to the equipment.

All power tools used on building sites, for maintenance operations or for work near water should be either reduced voltage or battery-operated rechargeable units.

Lighting installations can be operated at even lower voltages which are therefore even safer.

11 High Voltages

Normal electrical safety precautions are inadequate to prevent injury to persons operating equipment in the vicinity of high voltages. High voltages are generally considered to be those more than 1000 V (1 kV), but the term may be used to refer to voltages more than 600 V.

Operation and maintenance of the University high voltage supply distribution network is the responsibility of ED and is covered by strict rules of operation.

Experimental work involving high voltages requires specific safety procedures and a higher degree of competence (See Appendix H).

12 References and Further Reading

1. Memorandum of Guidance on the Electricity at Work Regulations 1989
2. Guidance on Regulations HSR25 – ISBN 0717616029
3. The Electrical Equipment (Safety) Regulations 2016
4. The Institution of Engineering and Technology (IET) Code of Practice for In-Service Inspection and Testing of Electrical Equipment 5th Edition 2020
5. DK First Aid manual 11th edition:
<https://www.yumpu.com/en/document/view/66520551/download-free-pdf-first-aid-manual-11th-edition-by-dk>
6. Code of Practice for the Use of Electricity in the Department of Physics, University of Cambridge: <https://www.phy.cam.ac.uk/>
7. HSE website: www.hse.gov.uk/electricity
8. Health and Safety Office website: www.safety.admin.cam.ac.uk/
9. Electrical Safety First website: <https://www.electricalsafetyfirst.org.uk/>

Appendix A The Electricity at Work Regulations 1989

Absolute Duty:

If the requirement in the Regulation is ‘absolute’, for example the requirement is NOT qualified by the words “so far as reasonably practicable”, the requirement must be met **regardless of cost** or any other consideration.

Reasonably Practicable:

Someone who is required to do something “so far as reasonably practicable” must assess, on the one hand the magnitude of the risks of a particular work activity or environment and, on the other hand the costs in terms of physical difficulty, time, trouble and expense which would be involved in taking steps to eliminate or minimise those risks. If, for example, the risks to health and safety of a particular work process are very low, and the cost or technical difficulties of taking certain steps to prevent those risks are very high, it might not be reasonably practicable to take those steps. The greater the degree of risk, the less weight can be given to the cost of the measures needed to prevent risk.

In the context of these Regulations, **where the risk is very often that of death**, for example from electrocution and where the nature of the precautions which can be taken are often very simple and cheap, e.g. electrical insulation, RCDs, emergency stop buttons, earthing, covers etc, **the level of duty to prevent that danger approaches that of an absolute duty**.

This comparison does NOT include the financial standing of the duty holder. Furthermore, where someone is prosecuted for failing to comply with a duty “so far as reasonably practicable”, it would be for the accused to show the court that it was not reasonably practicable for them to do more than they had in fact done to comply with the duty.

A Summary of the Regulations Most Relevant to University Activities:

Regulation		Standard of duty
Regulation 3	Employer, employee and the self-employed duty to comply with the Regulations	Absolute
Regulation 4	All electrical systems shall be constructed to prevent danger. All work activities are to be carried out as not give rise to danger.	Reasonably practicable
Regulation 5	No electrical equipment is to be used where its strength and capability may be exceeded as to give rise to danger.	Absolute
Regulation 6	Electrical equipment sited in adverse or hazardous environments must be suitable for those conditions.	Reasonably practicable
Regulation 7	Permanent safeguarding of live conductors is required	Reasonably practicable

Regulation		Standard of duty
Regulation 8	Equipment must be earthed, or other suitable precautions must be taken e.g. the use of RCD's, double insulated equipment, and reduced voltage equipment	Absolute
Regulation 9	Nothing is to be placed in an earthed circuit conductor which might without suitable precautions give rise to danger by breaking electrical continuity.	Absolute
Regulation 10	All joints and connections must be mechanically and electronically suitable for use.	Absolute
Regulation 11	Suitable protective devices should be installed in each system to ensure all points of the system and users of the system are safe guarded from the effects of fault conditions.	Absolute
Regulation 12	Where necessary to prevent danger, suitable means shall be available for cutting off the electrical supply to any electrical equipment.	Absolute
Regulation 13	Adequate precautions must be taken to prevent electrical equipment which has been made dead in order to prevent danger, from becoming live whilst work is carried out.	Absolute
Regulation 14	No work can be carried out on live equipment unless this can be properly justified. This must be based on risk assessment. If such work is to be carried out, suitable precautions must be taken to prevent injury.	Absolute
Regulation 15	Adequate working space, adequate means of access and adequate lighting shall be provided at all electrical equipment on which or near which work is being done in circumstances that may give rise to danger.	Absolute
Regulation 16	No person shall engage in work that requires technical knowledge or experience to prevent danger or injury unless he/she has that knowledge or experience or is under appropriate supervision.	Absolute

Note: Technical details on the practical application of the Regulations are found in the supporting guidance issued by the HSE (HSR 25; Third Edition 2015)

Appendix B First Aid for Electric Shock and Burns

Thankfully most electric shocks are minor however when a person is electrocuted the passage of electrical current through the body may stun them causing their breathing to stop. The electric current may cause burns where it enters, passes through and exits the body to go to 'earth'. In some causes the current also causes muscular spasms and may prevent a casualty from breaking contact with it.

What you can do

1. Assess the situation - **DO NOT PUT YOURSELF AT RISK**
2. Is the casualty's life threatened? If so, send for help – phone for an ambulance 999 explaining exactly where you are and what has happened, then call for a University First Aider (procedures vary across departments)
3. Do not touch the casualty if you suspect that they are still in contact with the electric current. They will be 'live' and you risk electrocution
4. If it is safe to do so isolate the electrical supply e.g. switch off and remove the plug if possible
5. If this cannot be done **do not** use anything metallic to break contact. Stand on some dry insulating material such as a telephone directory and use a wooden object such as a broom handle – **IF SAFE TO DO SO**
6. Push the casualty away from the electrical source or push the source away from the casualty (with the wooden broom handle) - **IF SAFE TO DO SO**

REMEMBER, IF WATER IS PRESENT ON THE FLOOR OR ON THE EQUIPMENT IT WILL CONDUCT ELECTRICITY AND GREATLY INCREASES THE RISK OF ELECTRIC SHOCK.

7. If the casualty is unconscious, after the area has been made safe and help sent for
 - a. Open the airway and check for breathing
 - b. If the casualty is breathing put them into the recovery position regularly checking their circulation
 - c. If the patient is not breathing commence CPR if you know how to do this
 - d. A casualty who has been unconscious must go to hospital in an ambulance
8. If the casualty is conscious, talk to them asking what happened. Sit the casualty down and reassure them – they may require treatment for shock. Look for burns (they may be red, white or black) and if possible, immerse the burn in cold water. A casualty with burns **must go to hospital**.
9. An accident report form must be completed, and the Departments Safety Officer notified.

Appendix C General Guidance on Working Live

THE FOLLOWING INFORMATION ON LIVE WORKING IS FOR **GUIDANCE ONLY** AND DOES NOT CONSTITUTE A SAFE WORKING PRACTICE FOR GENERAL USE.

ANY PERSON DOING LIVE WORKING IN THE UNIVERSITY **MUST BE FULLY COMPETENT AND AUTHORISED** TO CARRY OUT SUCH WORK.

Live working is working with equipment that is energised or contains stored energy, where there is any possibility of danger, that is, a risk of injury.

Dangerous voltages include those above ~ 50 V AC or 100 V DC in dry non-conductive conditions.

In general, it is very unlikely that a student would be given permission to work live, except after rigorous risk assessment and **ONLY** under very close and **CONSTANT** supervision of a competent person.

1. Establish that live working is fully justified
2. If it is, do a risk assessment and develop a safe system of work with suitable and sufficient control measures, which will incorporate at the very least the following:
 - a. A plan of the work, including detailed information about the electrical system
 - b. The establishment of adequate clear working space, head room and lighting; with no tripping hazards or obstructions¹

Note: The HSE guidance publication 'Safety in Electrical Testing at Work' INDG 354, recommends the creation of an earth free work zone in conjunction with the use of isolated supplies. The creation of an earth free work zone requires a high degree of competence and should not be attempted without the appropriate competence.

3. Checking for pre-existing earth faults on Class 1 equipment before and after testing it
4. Access to the work area should be restricted and prohibited to all those not directly involved with the work
5. The provision of emergency-stop buttons clearly marked and easily accessible to ensure that the electrical supply can be shut off quickly in an emergency
6. A warning sign should be erected to indicate that live working is being undertaken
7. The live equipment should not be left unattended unless secure arrangements can be made (e.g. locking the door whilst retaining all keys and erecting a warning sign)

¹ 1 metre clear working space is recommended for live parts at 415 V, (or 1.5 metre if there are parts live on both sides of the work, although this situation should be avoided wherever possible i.e. by screening).



8. Prevent anyone touching parts at dangerously different potentials at the same time either directly or through the use of tools – install temporary barriers, insulating screens, etc
9. Ensure adequate training and competence of those doing the work – they should recognise their own limitations
10. Only properly insulated tools to British Standard should be used (see HSE Guidance Note GS38)
11. Protective equipment and clothing should be provided and used where it would reduce the risk of contact with live parts or earth i.e. rubber mats
12. Horizontal surfaces and projections inside control cabinets should not be used for temporary storage of tools and other equipment
13. There should be a second competent person present who is aware of what you are doing, can safely make the equipment dead and render first aid or summon assistance
14. Have a rehearsed emergency plan.

WORKING LIVE ON YOUR OWN, OR OUT OF HOURS, IS FORBIDDEN

Appendix D Electricity in a Potentially Explosive Atmosphere

1 Areas which may have explosive atmospheres

The use of electricity can generate hot surfaces and sparks which can ignite an explosive atmosphere. An explosive atmosphere could be present in a variety of places including some laboratories, cold rooms, freezers, near fuel tanks, gas storage facilities or in many places where vapour, mists, aerosols or dusts exist.

The areas where it is possible that an explosive atmosphere may exist must be treated as a high-risk area. The Dangerous Substances and Explosive Atmosphere Regulations 2002 (DSEAR) require that such areas be risk assessed before any new work is carried out in them and that measures be taken to control the risk.

2 Equipment and Explosive Atmosphere

Electrical and non-electrical equipment and installations in potentially explosive atmospheres must be specially designed and constructed so that the risks of ignition are eliminated or reduced (ATEX rated equipment). Techniques include sealing electrical equipment so that the explosive atmosphere cannot encounter electrical components, reducing the power of the electrical equipment and de-energising electrical equipment where a fault or explosive atmosphere is detected. (See British Standard series BS 60079 -:2014).

3 Static Electricity

Care should be taken to prevent static discharges to potentially explosive atmospheres. Measures such as earth bonding and the selection of antistatic clothing and footwear can help to reduce the risk of static discharges.



Appendix E Electrical Safety (List of User Visual checks)

1. Check that the equipment has been inspected and tested by a competent person.
2. Users of electrical equipment should visually check for signs that the equipment is in sound condition every time they use it. For example:
 - a. Is there damage (apart from very light scuffing) to the cable sheath?
 - b. Is the plug or socket damaged, for example the casing is cracking or any of the pins of the plug are bent? Or missing?
 - c. Is there any inadequate or non-standard joint(s), including taped joint(s) in the cable?
 - d. Is the outer sheath of the cable effectively secured where it enters the plug or the equipment? Obvious evidence would be if the coloured insulation of the internal cable cores were showing. A gentle / light tug at the cable when the equipment is unplugged will test if the cable is secure
 - e. Is there any damage to the external casing of the equipment or are there any loose parts or screws?
 - f. Are there any panels or covers missing i.e. can any live parts be accessed by any reasonably foreseeable route
 - g. Is there evidence of overheating (burn marks or discolouration)?
 - h. Is the plug marked with fuse rating, and is correct fuse fitted? – but only if this can be checked without opening the plug i.e. on modern moulded plugs with a flip out fuse holder, otherwise consult a competent person to check

Note: These checks also apply to extension leads and associated plugs and sockets

3. Checks should be undertaken by the user when the equipment is taken into use and during use. Any faults should be reported; the equipment taken out of use immediately and labelled as faulty. The plug should be removed to prevent further use. The equipment should not be used until repaired and tested by a competent person
4. Ensure that cables are not squashed under furniture, trapped in floor boxes etc
5. Do not run cables through door or window openings where they could be damaged.

Appendix F Electrical Safety - Overnight Running

Suggested “Overnight Running Permit”, for use adjacent to equipment when running equipment unattended / overnight:

Overnight or Unattended Running of Electrical Equipment	
Department:	Room:
Name:	Contact Details:
Details of Experiment / Equipment:	
Emergency Procedures:	
Authorised by:	Date from: to:

Fill out the permit with:

1. Your department
2. The room the equipment is authorised to be used in
3. Your name
4. Your contact details
5. Appropriate details of the experiment or equipment e.g.:
“Non-hazardous plant cell cultures on a rotary shaker at 60 rpm (room temperature)”
6. Appropriate emergency procedures e.g.:
“If power fails no action required” OR “If power fails contact”
“If shaker overheats switch off and isolate” etc..... etc.....
7. The permit should be authorised; as appropriate, this could be done by a supervisor or the researcher themselves, depending upon experience and Departmental policy.
8. Complete the date from which the permit will run from and to.
9. Affix permit close to equipment so that it is clear to what it relates.

Appendix G IP Code and Cable Ratings

IP Code Ratings (BS EN 60529) (First two elements only)

Element	Numeral or letter	Meaning in relation to equipment	Meaning in relation to persons
Code letters	IP		
		Protection against ingress of solid objects	Protection against access to hazardous parts with
First numeral	0	No protection	No protection
	1	> 50 mm diameter	Back of hand
	2	> 12.5 mm diameter	Finger
	3	> 2.5 mm diameter	Tool
	4	> 1.0 mm diameter	Wire
	5	Dust protected	Wire
	6	Dust tight	Wire
		Protection against ingress of water with harmful effects	
Second numeral	0	No protection	
	1	Vertical dripping	
	2	Dripping, tilted at 15°	
	3	Spraying	
	4	Splashing	
	5	Jetting	
	6	Powerful jetting	
	7	Temporary immersion	
	8	Continuous immersion	

Example: IP65 is protected against ingress of a 1 mm wire, dust and jetting water.

Flexible Electric Cables should comply with BS EN 50525-1 and BS EN 50525-2 Parts 11, 12, 21 and 71

Cable size	Current Rating (maximum current)	Typical Uses
0.5 mm ²	3 A	Light-duty e.g. table lamps, radios, etc.
0.75 mm ²	6 A	Electronic equipment (check rating)
1 mm ²	10 A	Electronic equipment (check rating)
1.5 mm ²	15 A	All extension leads, heavier electrical equipment i.e. (welders, heaters, kettles)

Appendix H High Voltage Precautions

Precautions to be taken when undertaking experiments involving high voltage include:

1. **All work must be authorised** by a supervisor or competent person according to Departmental policy
2. No internal adjustments or modifications are to be made whilst the equipment is live, i.e. **NO live working**
3. Measurements must be taken with permanently connected instruments
4. All parts of the equipment which are at high voltage must to be made inaccessible to human contact when the equipment is live by the provision of appropriate insulation, protective barriers or other means
5. Sufficient electrode spacing must be provided to prevent arcing / flashovers
6. The voltage source must be capable of rapid isolation by the person in charge of the experiment in case of an emergency
7. No lone working, equipment is only to be operated when there is at least one other person in close proximity, in order that assistance can be given should the operator receive an injury from the equipment
8. Operators and assistants should be familiar with and practiced at appropriate emergency first aid procedures
9. Capacitor banks should be discharged after the equipment has been switched off and bleed resistors incorporated into the design so that any remaining capacitor energy is dissipated
10. Before adjusting the de-energised equipment, measurements must be taken to ensure that there are no dangerous voltages present, having first carried out the capacitor discharge routine, as appropriate
11. To prevent inadvertent contact, the apparatus must be guarded by insulating screens or barriers placed at an adequate distance from any exposed live part and warning notices must be displayed. Adequate distances are considered to be:

Up to 50 kV	3 metres
50 kV - 100 kV	4 metres
150 kV - 250 kV	5 metres

Appendix I Extensions and Leads

Many portable items of electrical equipment used in the work environment such as desk top lamps and fans are often supplied with a relative short length of cable. Ensuring the laboratory, office or workshop has sufficient socket outlets at convenient points will minimise the need for extension leads and adapters, but occasionally their use will be unavoidable.

The use of extension leads can present their own risks

- tripping and falling
- cable damage due to wear, particularly where leads are walked over or stored badly
- when fitted to equipment they can become tangled
- overloading which increases the risk of fire.

When the use of an extension lead is unavoidable:

- It is **ESSENTIAL** that no extension lead should be overloaded and should only be used with low wattage equipment like IT equipment. Heaters and kettles are examples of high wattage equipment and these items must **NEVER** be plugged into extension leads
- It is recommended that no extension lead be more than 5 metres in length
- The daisy chaining of extension leads is **NOT** permitted (plugging an extension lead into another extension lead)
- The use of extension reels is **NOT** permitted unless being used for temporary construction purposes or temporary events and in these instances, the lead must be fully unwound to prevent overheating
- Only use extension leads fitted with suitably insulated connectors and plugs
- The extension lead should be positioned carefully to prevent the risk of damage to the cable. If possible, fix in position with cable ties
- If the cable must cross a pathway, the risk of tripping and damage can be minimised by covering it with a rubber protector strip, (better still take it over the pathway – fixed/supported above 2m if possible)
- Check that the extension lead plug contains the correctly rated fuse for the equipment used
- Regularly check that leads, plugs and sockets are undamaged. A visual inspection will usually be sufficient.

Appendix J Electrical Safety Inspection Checklist

 UNIVERSITY OF CAMBRIDGE		Electrical Safety Inspection Checklist	
Location of Inspection:			
	Item	Yes	No
1	Is there free access to isolation switches for the equipment?		
2	Is it obvious which isolation switch belongs to which piece of equipment?		
3	Can the equipment be isolated, and that isolation made secure (e.g. by padlock)?		
4	Are all joints or connections mechanically and electrically suited to purpose?		
5	Are the leads in good condition?		
6	Are there any exposed conductors at potentially dangerous voltages (>50V ac, 120 V dc) in the equipment?		
7	Are the covers all in place?		
8	Are the doors to electrical cabinets closed?		
9	Are all leads placed safely (e.g. not trailing across the floor, or underneath boxes, etc., where they are liable to damage)?		
10	Are all pieces of electrical equipment 'in-date' as regards PAT testing?		
If electrical work is being carried out with the normal covers removed or opened:			
11	If live, would there be voltages or stored energy present that could be dangerous?		
If yes, then:			
12	Has the equipment been isolated securely and proved to be dead?		
13	If the answer to 12 is NO, then is there adequate justification for the equipment to remain live? (Convenience is not an adequate justification). Terminate the work immediately if the answer to this question is NO.		
14	Is the person working on the equipment suitably experienced to do so, and if not, under close supervision from someone who has such experience?		



15	If the work is being done live, is it being done with adequate precaution to prevent injury – e.g. using the correct tools, in a cordoned off labelled area or closed room.		
Comments, observations or recommendations arising from the above:			
Inspection carried out by:		Date:	

Appendix K Definitions

Arcing: is the electrical breakdown of air (or any gas) resulting in a current flowing through normally non-conductive air (or gas) between to separate conductors. This produces a high temperature discharge and intense UV light (arc light), both of which can cause burns. Air becomes a conductor at its 'breakdown voltage' of approximately 30 kV per centimetre, however once the arc has been initiated it can be maintained at a much lower voltage

Amp: the amp or ampere is the international standard (SI) unit of electrical current and is used in specification of fuses and cables etc. (see Watt below)

Charged: means that an item has acquired a charge, either because it is live (see below) or because it has become charged by other means, such as static or induction charging or has retained or regained a charge due to capacitance effects, even though it may be disconnected from the rest of the system

Conductors: defined in the Regulations as any conductor of electrical energy (electricity). The definition is not limited to conductors intended to carry current, if a material can conduct electricity in the physical state it is in, then it is a conductor, i.e.: solid glass is a good insulator whilst molten glass is a conductor

Current: this is the flow or movement of electrons (electric charge) which can either be:

- Direct Current (DC) involving the flow of electrons along a conductor or
- Alternating Current (AC) where energy flows along a conductor by the alternating oscillation of electrons at a prescribed frequency, rather than their direct flow

Danger: is the 'risk of injury'

Dead: for a circuit to be dead means it is neither live nor charged

Double insulation: uses two independent layers of insulation over live conductors, each layer alone being adequate to insulate the electrical equipment safely. This removes the need for an earth and such equipment will not have an earth wire i.e. portable power tools

Earth: earthing or grounding is the connection of an object, such as a metal casing to a plate buried in the earth/ground via a conductor. This enables current to flow freely to earth if the object inadvertently comes into contact with a live conductor

Electrical equipment: includes everything used, intended to be used or installed for use, to generate, provide, transmit, convert, conduct, distribute, control, store, measure or used electrical energy

Electrical explosion: a violent and catastrophic rupture of any electrical equipment because of excessive current releasing violent electromagnetic forces and heat, or from prolonged internal arcing faults

Electrical system: is a system in which all the electrical equipment is or may be electrically connected to a common source of electrical energy

Fuse: is a device designed to automatically cut off the supply of electricity in a given time if the current exceeds a given value i.e. 1, 2, 3, 5, 10, or 13 amps etc.



Grounding: see Earth above

Ingress protection code (IP): is a code assigned to the type of protection against danger offered by a particular piece of equipment i.e. IP65 rated equipment resists dust and a jet of water

Insulator: a substance that either does not conduct electricity or conducts it very poorly and can therefore be used to 'insulate' a conductor (see conductor above)

Isolation: involves cutting off the electrical supply from all, or a discrete section of, an installation by separating it from every source of electrical energy. This is more than simply 'switching off' a supply, since it requires that measures have been taken to ensure that it cannot be accidentally re-energised i.e. 'locked off' to physically prevent re-energisation

Live: an item or conductor is live when it is at a voltage as result of being connected to a source of electricity, i.e. as in normal use (also see above)

Mains voltage: The standard UK mains voltage is 'supplied between 220 V and 240 V' AC at 50 cycles per second often simply referred to nowadays as 230 V AC 50 Hz. Note that equipment from 'abroad' may be rated to different voltages and/or frequencies

Person in control of electrical danger: is a duty holder and this person must be competent by formal training and experience, with sufficient knowledge to avoid electrical danger

Reduced Voltage Equipment: Equipment operating at voltages at or below 50 V AC

Residual current device (RCD): An electro-mechanical device to automatically isolate the electrical supply when there is a difference between the current flowing into a device and the current flowing from the device. RCDs can be designed to operate at low currents and fast times (usually 30 milli-Amps and 30 milli-seconds)

Static electricity: is produced by the build-up of electrons on weak electrical conductors or insulators, which may be gases, liquids or solids. It can be caused by friction or charge transfer by induction. Discharges of static electricity can cause electric shock or act as a source of ignition. The build-up of a static charge can be prevented by the appropriate use of an earth cable, allowing the electrons to flow to earth before they can build up

Short circuit: this occurs when a direct connection is made by a conductor between the power supply and earth, or between two conductors, causing a potentially dangerous rapid increase in current

Three phase 415 V supplies: have at least three conductors carrying separate AC voltage waveforms that are equally offset (120°) in time

Voltage: Voltage is the [difference of electrical potential](#) between two points of an [electronic circuit](#), expressed in [volts](#) (V). It measures the capacity (not the technical meaning) of an [electric field](#) to cause an [electric current](#) in an [electrical conductor](#)

Watt: the SI unit of power, often marked on electrical equipment. It can be used to calculate the amperage required (Amps = Watts divided by Volts). Everyday 230 V examples include:

- Light bulbs of say 25 to 100 Watts i.e. 0.1 to 0.4 Amps
- Computer processors of say 300 to 400 Watts i.e. 1.3 to 1.7 Amps (~ 2 A)
- Electric kettles of say 1850 to 2400 Watts i.e. ~ 8 to 10 Amps



Safety Office
Greenwich House
Maddingley Road
Cambridge
CB3 0TX

Tel: 01223 333301
Fax: 01223 330256
safety@admin.cam.ac.uk
www.safety.admin.cam.ac.uk/
HSD001P (rev 6)
© University of Cambridge