A Code of Practice for the Use of Electricity

in the Department of Physics

Scope

This code of practice is primarily for DC and mains frequency electricity. It does not cover RF or microwave, nor the X-radiation that may be generated by equipment such as accelerators. It covers all voltage ranges, from small battery powered devices up to items working at potentials in the kilovolt range with respect to earth. If you are using electricity in the regimes not covered here you should consult your safety representative, the Electrical Safety Specialist and/or the Safety Officer.

Contents

1 Hazards from electricity

You may well have experienced an electric shock from a mains device at some time in your life. The fact that you have survived does not mean that you are immune; it merely means that you were LUCKY.

Serious electrical accidents are reported to the Health and Safety Executive; of these approximately 10% are fatal.

1.1 Electric shock

Electric shock is generally painful, and is frequently accompanied by an involuntary contraction of muscles along the path of the current through the body. This can give rise to falls, fractures and muscle damage. If the fall is from a height, then this alone could cause fatal injury. The muscular contraction may render the shocked person unable to let go of the conductor that is delivering the shock. The muscular contraction may prevent breathing, which is particularly dangerous if the person is unable to let go. Electric current may cause the heart to go into ventricular fibrillation, and as a consequence compromise the pumping efficiency of the heart and cause an oxygen deficit in the brain.

Death following electric shock may therefore be caused by asphyxiation due to interruption of respiration, the consequences of falls, and direct interference with the functioning of the heart.

Quantifying the risk is difficult, as it is not possible to conduct experiments, but sufficient is known to indicate that the effects of electricity are both statistical (that is, one person's reaction may be different from another's) and also dependent on a number of other factors such as the path of the current, the conductivity of the surroundings, the time of exposure, the frequency of the supply, and even whether the casualty was taken by surprise. It is known that currents of only a few milliamps can cause fatal electric shock. The effects of electric shock are at their most acute at around the frequency of the mains supply – 50 Hz.

1.2 Electric burns

When a person has touched a live conductor there may be local, deep burns, reaching to bone. Conversely, there may be small, white areas, or there may be no visible damage at all.

N.B. Information regarding electrical apparatus outside the scope of this code: at high frequencies, it is not necessary to be in contact with the source in order to be burnt. For example at RF frequencies the heating effect is by absorption of the electromagnetic waves by a dielectric loss process in the body tissues. These burns can be deep in the body, and the casualty may be unaware that they are happening for some time. They are very slow to heal. It is roughly speaking equivalent to cooking part of your body in a microwave oven.

1.3 Arc burns

The breakdown voltage of air is of order 30 kV per centimetre, but an arc, once initiated, only requires 20 V per centimetre to maintain it. Thus a thin wire or tool can initiate an arc and be burnt away leaving a self-sustaining arc, if there is sufficient electrical energy to maintain it. A flashover on a three phase main may only last a fraction of a second, but could involve currents in excess of 1000 A and could deliver fatal burns.

An electric arc emits light which extends from the ultraviolet through to the infrared. While the visible and infrared radiation are intense, they do not cause problems when an arc is only seen once (arc welders do need to protect themselves, however). However, the ultraviolet light emitted from the arc is also intense, and can deliver severe burns to any part of the body that is exposed. Provided the casualty survives the initial wound (which he/she may not), they will generally recover, although they may be left with scarring or lose limbs. Any radiation entering the eye is likely to give rise to a very painful inflammation of the conjunctiva – "arc-eye". The eye generally recovers after a few days, although the possibility of permanent damage cannot be ruled out.

Vaporised metal, or metal spatter from an arc can become lodged in the skin or eyes of the casualty.

1.4 Explosion
Switchgear, electric motors and power cables are liable to explode if they are subjected to excessive currents, or if they suffer prolonged internal arcing faults.

Electricity is often the source of sparks which ignite atmospheres containing dangerous concentrations of flammable substances or dusts. Even a battery powered torch can be a source of ignition.

1.5 Fire
Fires can be started by overheating of cables due to overloading, leakage currents due to poor or inadequate insulation, overheating of flammable materials placed too close to electrical equipment, or the ignition of flammable materials by arcing and sparking. A particularly common problem is loose connections, which can lead to fire.

2 Some typical accidents that lead to these injuries – the <u>risks</u>

N.B. These are all preventable, but they have all happened.

- Tripping over trailing cables, causing falls. The person may fall into the equipment, or may suffer direct injury.

- Damage to cables lying on the floor, leading to conductors being exposed, or to other items, such as racking, becoming live.

- Overheating due to poor design or overloading, leading to fire.

- Accidentally touching exposed conductors when performing routine, or non-routine operations.

- Faults occurring in the apparatus, leading to items becoming live that are not normally live.

- Failure to maintain, or poor maintenance of apparatus

- Loose connections in plugs

- People coming to an injured person's assistance, being unable to make the system dead, or believing that they have made the system dead due to confusion with the switches, etc. This leads either to a second casualty, or the worsening of the condition of the injured person due to the delay.

- Faults occurring between phases of three phase main, leading to flashover (where the electrical energy is conducted through the air in the form of an arc).

- A plug and socket become wet, and either cause electric shock, or catch fire due to internal arcing.

- Turning on an electric light in a room where there is an accumulation of flammable gas causes explosion due to the spark at the switch.

- Leaving a cardboard box close to an electric light bulb; it catches fire.

- A conductor, e.g. a spanner, is laid across the terminals of a lead-acid car battery, causing a current to flow sufficient to melt the conductor violently, and to cause the battery to explode, showering sulphuric acid in all directions.

- The leads from a battery charger being disconnected from the battery terminals while the power is still switched on, causing a spark that ignites the hydrogen that has been given off during charging.

3 The Basic Legal Requirements

The requirements in this code of practice are based on British Law, and constitute a set of basic rules for reducing the likelihood of electrical accidents. The text of the Electricity at Work regulations, 1989, and accompanying guidance, is available at http://www.hse.gov.uk/pubns/priced/hsr25.pdf.

Where the words SHALL or MUST are used, the requirement is absolute. Where the phrase ‘so far as is reasonably practicable’ is used, it requires a balance to be struck between the cost of the preventive measures and the risk that it being eliminated or reduced. If the risk is small, and the cost of prevention is large, then you need not adopt the preventive measures. The greater the degree of risk, the less weight can be given to the cost of measures needed to prevent that risk. In the context of electricity, where the risk is very often of death, and the means to prevent it are often cheap (e.g. by insulation), then the level of duty to prevent danger approaches an absolute duty.

If you wish to use measures other than those proposed in this code of practice, then the level of safety that they achieve must be no less than that achieved by the measures in this code.

As with any other work activity, you must do a risk assessment before you begin work in which the risks are anything other than trivial, in which you must assess the hazards, decide what the risks are and who they affect, and devise and implement a safe, and legal, system of work. This must be communicated to all those who it affects.

4 Controlling the Risk in the Design and Construction of Systems

4.1 The fixed wiring

The fixed wiring in any building is to be designed, installed and maintained to IEE standards, by competent electricians. Research staff and others must not make any connections or disconnections directly into this system. Faults must be reported promptly to the Maintenance Staff.

When reorganising laboratory layout, it is essential to check that the sockets are still accessible, or that other arrangements are made to ensure that the electrical supply to apparatus in the room can be cut off speedily.

In a room where electrical testing is routine – such as an electronic workshop, emergency (red) buttons should be installed on the benches which cut off power in the event of an emergency.

Bake-out tape for vacuum apparatus, equipment for use with water, equipment with leads that may trail over metal workshop floors, or equipment for use out of doors, must all be used in conjunction with an RCD (residual current device).

4.2 New equipment

When equipment is brought into the department, a plug should be fitted by a competent person if the equipment does not already have one, and the correct fuse must be fitted. The equipment must be inspected visually for damage or faults, and it is strongly recommended that it is also electrically tested. It must be given an identity number, entered into the database, and given a date for recall.

Equipment must be purchased to suit the environment in which it will be operated. For example, special equipment is normally required for work outdoors and work in potentially explosive atmospheres.

Equipment must be used as directed by the manufacturer's instructions. Changes to the mode of operation, or modifications to the equipment, are only permitted if the user performs a risk assessment to assess and control any risk introduced by such a change.

Equipment brought from home must also be tested – and this includes the kettle you brought down from the attic to make yourself that nice cup of coffee in the long hours waiting for your equipment to cool down, and the radio with the mains adaptor so that you can listen to your favourite station!

The plugs on equipment brought into the department must be of a normal British type. In particular Schuko plugs must not be used, with the sole exception that Research groups may make special provision for visitors to the department by providing suitable adaptors.

4.3 Apparatus designed, constructed or modified in-house

Apparatus must be constructed to good engineering standards. Before constructing equipment, a risk assessment should be done to explore the possible modes of failure of the equipment, and whether they present danger. The danger should be controlled at the design stage wherever practicable. The risk assessment should include the following phases of life of the system: construction, testing, commissioning, operation and maintenance. A functional diagram and a circuit diagram should be drawn up, and records kept of any modifications made. There are some core British Standards that may be used in construction, and advice may be obtained from the Department Electrical Specialist or one of the people nominated to verify the safety of apparatus built in-house.

Live parts must be insulated and enclosed, and suitable earth bonding provided to protect against shock from fault conditions. Any exception to this must be discussed with the Electronics Section. Enclosure must be to the correct IP rating. The mains earth wire must be connected to the metal case by a screw and nut, not less than 4 mm, and either a solder tag or crimped terminal. This screw must not be used for fixing other parts.

Appropriate connections must be used, preferably choosing them such that it is not possible to connect them to an inappropriate source. (e.g. prohibiting the use of 240 V mains connectors for any purpose other than a 240 V connection). If the wire for the mains supply is to be brought directly into an enclosure, it should be through a well fitting cable gland and clamped securely.

Wire appropriate to the load must be chosen. A table is given in the Appendix.

To remove guarding or enclosure around dangerous parts must need the use of a tool – wing-nuts are not permitted. The guard or enclosure should have a label fixed to it to indicate the danger within. Where it may be necessary to open a cabinet to make adjustments, any live parts should be insulated or placed behind barriers, suitably labelled, to avoid inadvertent contact.

When equipment has been constructed in house it MUST be checked by a named competent person before it is brought into service. This person will wish to see the risk assessment that you carried out, the functional diagram, the circuit diagram and the equipment itself. He/she will be using the department assessment form as a guide.

4.4 Layout of equipment in the laboratory

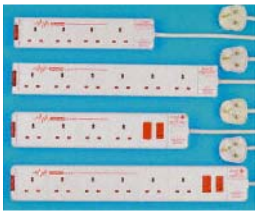
If possible, conductors should not be placed on the floor, since they are vulnerable to damage from water, liquid nitrogen, dropped items, and abrasion from people walking over them. Conductors that must go on the floor should be placed in a conduit or protected by some other means to prevent damage to the cable and avoid the trip hazard. Armoured cable may be used so long as the trip hazard is controlled.

If water is to be used in proximity to electrical apparatus, the junctions must be of high integrity (not jubilee clip or bent wire), and the layout must be planned so far as is possible to avoid water reaching the electrical apparatus in the event of a leak. Bear in mind that flowing cold water can attract condensation, which in certain weather conditions will accumulate and drip.

In EXTREMELY exceptional cases, live conductors may remain bare, provided they are out of reach. Before installing a system in this way, the department Electrical expert MUST be consulted and written approval obtained.

It is bad practice to have electrical energy supplied to a rack from more than one source, due to the possibility of a person believing that he has made the system dead, when parts of it are still live. Ensure that it comes from one source wherever practicable, and if it is not practicable ensure that it is very clearly labelled. The means to turn off the power must be accessible and it must be obvious, either by its position or by a clear label.

Daisy-chaining extension blocks is also bad practice – blocks are available for up to 12 outlets. However, it is also essential not to overload the incoming cable. The power requirements must be quantified. The use of multi-way adaptor blocks is PROHIBITED in the laboratories. See the pictures below that clarify what is meant!



The use of these extension blocks is permitted, but they must not be 'daisy chained'.

The use of these adaptors is NOT permitted in the laboratories

There must also be means to ISOLATE equipment so that work can be done on it while it is dead, in safety. Isolation is turning off the apparatus and making it secure so that it cannot be re-energised inadvertently. The means to isolate are likely to be:

- A switch that can be locked off with a padlock
- A plug and socket, where the plug can be removed and the person working on the equipment has control over the whereabouts of the plug.

5 Controlling the Risk in Work Practices

5.1 Housekeeping

Cupboards containing electrical switchgear must not be used as general store cupboards – they must be kept clear.

Gangways must be kept clear – preferably approximately one metre. Trip hazards must be removed or covered. In particular, if wires trail across the floor they must be protected from damage.

Access to the switches and isolators for equipment must be kept clear at all times (see section 4.4 which described the function of these).

5.2 Faults and problems

Mains driven electrical equipment, whether permanently wired or portable/transportable, requires periodic inspection and testing (see later section). Some equipment will also require maintenance. Appendix B gives details of the checks that the user should make.

When a piece of equipment appears to be faulty, it should be taken out of service, and the fault rectified. If the fixed wiring appears to be faulty, it should be reported to the Maintenance Dept.

Earth wires must NEVER be removed from equipment in order to solve an earth loop problem. Other solutions to the problem should be adopted – consult the Department Electrical Specialist for advice. Note that the removal of an earth wire can render a piece of equipment potentially lethal, and could lead to a manslaughter charge.

5.3 Working dead

It is essential to establish by testing that the equipment is in fact dead, to ensure that a mistake has not been made in identifying the means of isolation. Isolation must be secure, either by locking off, or by removing the plug, and having personal control over its whereabouts, to prevent reconnection, e.g. by a third party.

Testing to prove that apparatus is dead must be done by a piece of equipment whose integrity is proved both before and after the test.

Work must be undertaken to a competent standard, so as not to jeopardise the safety of the equipment when it is re-energised. Any alteration to the equipment must be recorded, preferably stored with the original circuit diagram if it is home-made. The alteration must be the subject of a risk assessment, and if a piece of commercial equipment has been altered then it becomes equivalent to home-built equipment. The insulating covers must be replaced before the equipment is re-energised.

5.4 Working live

Live working, defined as working on or near a live conductor that can constitute a danger, is **illegal** under the terms of Regulation 14 of the Electricity at Work Regulations, unless

- it is not technically feasible for the work to be done with the system dead, ***and***
- it is necessary for the person to be close to it, ***and***
- the person has the correct tools and protective equipment.

Dangerous voltages would include anything in excess of 50 V AC or 120 V ripple-free DC in DRY NON-CONDUCTIVE CONDITIONS. (The limits must be lowered for other conditions.)

Only competent persons are permitted to work live, and competence would be judged by:

- A practical experience of working with electricity and the type of equipment being used,
- An adequate knowledge of the hazards,
- A knowledge of the current safety standards and a clear understanding of the precautions required to avoid danger, and
- The ability to recognise whether it is safe for work to continue.

If it proves necessary to work live, then first a risk assessment MUST be carried out to establish the justification for the work, the hazards, and how the risks are to be controlled. Access to the area must only be allowed to authorised persons – others should be excluded by physical barriers, doors, warning signs or other effective means. A suggested procedure for working live is in the Appendix.

6 Undertaking Risk Assessment for Work That Includes Electrical Apparatus of Any Kind

Work activities must be the subject of a risk assessment which analyses what the work activity entails, the reasonably foreseeable risks that might arise and whom they affect. The assessment should address the legal requirements, and record what measures are going to be taken to ensure a safe system of work. These will consist of a combination of engineering measures and procedural measures, some of which will be selected from this code.

The safe system of work must contain some provision for emergency arrangements which include sources of assistance, means of raising the alarm, access for those coming to assist, location of power cut-off devices and evacuation routes.

The risk assessment must encompass all other significant hazards and risks, e.g. chemical, falls from height, handling, pressurised equipment, cryogens.

The general risk assessment form, and a form designed to assist you in integrating the electrical apparatus in your laboratory are in the appendices.

Step 1
Look for the hazards – use this code of practice as an inspiration, but do not be confined to the hazards that it mentions. Hazards are those things that can cause harm.

Step 2
Decide who might be harmed and how. Do not forget people other than your immediate colleagues, such as first aiders and visitors (invited and uninvited).

Step 3
Evaluate the risks and decide whether the existing precautions are adequate or whether mode should be done. The risk is the chance that someone will be harmed by the hazard, and the evaluation need be no more precise that assigning it a high, medium or low assessment. In reducing risks, you should apply the hierarchy of measures below:

- Try a less risky option – for example by using an isolating transformer
- Prevent access to the hazard – for example by guarding or insulation
- Issue personal protective equipment – for example safety spectacles

And do check that you have satisfied the legal requirements!

Step 4
Record your findings – on the risk assessment form or in a laboratory notebook.

Step 5
Review your assessment and revise it if necessary. This is especially relevant if there has been a mishap or a near miss, or if the layout or nature of the experiment is to be materially changed.

7 Maintenance and Testing

Electrical equipment must be kept in safe working condition. In general, this means that there must be a programme of inspection and testing to check equipment at regular intervals. The fixed wiring is inspected and maintained by Maintenance and the University Estate Management Department. The portable and transportable equipment is the responsibility of the individual research groups.

Research Groups must have a programme of inspection and (where necessary) testing of electrical equipment. All members of the Department should be aware of the user checks in the appendix. The formal inspection can be arranged by way of 'PAT' testing. Research groups may choose whether to be included in the Department contract (for which they will be charged per item inspected and tested) or they may arrange their own. Doing nothing is not an acceptable option.

The frequency of inspection can vary – equipment kept in a warm, dry office, where it is not subject to rough handling, may be inspected and tested at intervals that can be as long as 5 years. However, if equipment is found to fail the inspections the interval should be shortened. Laboratory equipment should be on an annual schedule.

8 Waste

Electrical waste must not be put in the normal waste skips or waste bins. There are dedicated bins outside the Link Building into which all electrical waste must be placed.

9 Further Reading

Available as free downloads:
Memorandum and Guidance on the Electricity at Work Regulations, 1989 ISBN 0 7176 1602 9
Electricity at Work, Safe working practices, HSG 85, ISBN 0 7176 0442 X

British Standards, available from the University IHS subscription (consult Jane Blunt for details)
BS EN 60204 Safety of machinery – electrical equipment of machines
BS EN 60065 Audio, video and similar electronic apparatus. Safety requirements
BS EN 60529 Degrees of protection provided by enclosures (IP codes)

Appendix A

First Aid for Electric Shock and Burns

Most electric shocks are minor, and the casualty will probably just be jumping around, swearing or joking. Call a first aider, and get the casualty checked over.

However, if it is more serious, as evidenced by their clearly not being their normal selves, or being found in a collapsed condition, proceed as follows.

> Assess the situation. Does it appear that the casualty's life is in danger?
> If so, send for help if there is anyone who can do this for you. Your messenger, or you, should phone direct for an ambulance 1 999, then call 37499 for a first aider.
> Make the area safe. Turn off the electricity, and ensure that the casualty is not touching anything that could be live. Unplug (i.e. 'isolate') the equipment, or turn off the isolation switch if unplugging is not possible (e.g. to hard wired equipment).

For an unconscious casualty:

> Ensure that someone has called for an ambulance and a first aider
> Open the airway and check for breathing.
> Give artificial ventilation if required, but if the casualty is breathing turn him/her into the recovery position.
> Check for circulation. If the pulse is absent, go for help if it is not already on its way.
> Then commence CPR if you know how to do this
> Do not give up – victims of electric shock will frequently recover after quite lengthy periods of resuscitation (even up to one hour in exceptional cases).
> A casualty who has been unconscious should go to hospital in an ambulance.

Conscious casualty

> Send for a first aider: call 37499.
> Check for burns – these may be red, white or black.
> Sit the person down and be ready to treat for shock.
> Immerse any burns in cool water.
> A casualty with electrical burns should go to hospital in an ambulance.

A less severely injured casualty, who has no burns, and who did not lose consciousness, should be kept under observation, and if in any doubt taken to a doctor. The first aider will advise.

An accident form, available in the Main Stores, should be completed (preferably by a first aider, if one is in attendance) and the accident book, also held in the Main Stores, should be filled in.

Appendix B

User Checks For Electrical Apparatus

All the following checks can be carried out by the user. They do not require special equipment. The frequency of inspection depends on the kind of equipment and its use. An electric drill used out of doors on a building site should be inspected at least weekly, but a piece of equipment in a warm dry laboratory, that has not been moved around might only merit inspection every year. These checks supplement the formal testing regime.

Visual Inspection

While the equipment is disconnected from the mains, ensure that the plug:

- Is not damaged,
- Has no discolouration of the body, pins,
- Has the correct fuse fitted,
- Has been connected with the correct polarity,
- Wires are secured in the terminals,
- The cable grip is firmly secured around the outer insulating layer,

And when the equipment is connected, that the plug runs cool.

Ensure that the cable is

- Fully flexible,
- Not discoloured or bearing other signs of overheating,
- Of the correct current rating,
- Not coiled (fire risk),
- Has no cuts, nicks, etc.

Ensure the appliance has

- Not suffered external damage,
- No missing covers or panels,
- No missing shrouds or shield on live terminals,
- No corrosion.

If a fault is found take the equipment out of service and take it to the electronics section to assess what should be done before using it again.

Appendix C

Suggested Procedure for Working Live

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

In general, it is unlikely that a student would be given permission to work live, except under the constant supervision of a competent person.

First establish that live working is justified. Note that four criteria must always be met:

1. It must be unreasonable in all the circumstances to do the work when the equipment is dead.
2. It must be reasonable in all the circumstances for someone to be near it while it is live
3. The person carrying out the work must be competent to do it (and this includes having an understanding of the limits of their own competency).
4. The person doing the work must have the right tools and equipment.

Working live on your own, or out of hours, is FORBIDDEN.

Do a risk assessment, which will incorporate at the very least the following in its safe system of work:

1. Plan the work, obtaining information about the electrical system
2. Establish an adequate clear working space, head room, lighting, with no tripping hazards or obstructions. At least 3 ft (approx. 0.9 m metric) clear working space is recommended for parts live at 415 V, or 4 ft 6 in (approx. 1.4 m metric) for parts live on both side of the work, although this situation should be avoided wherever possible by, for example, screening.
3. Access to the area should be prohibited to all those not directly involved with the work. The live equipment should not be left unattended unless adequate security arrangements can be made (e.g. locking the door and erecting a warning sign)
4. A warning sign should be erected to indicate that live working is being undertaken
5. 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.
6. Ensure adequate training and competence of those doing the work – they should recognise their own limitations
7. Only properly insulated tools should be used, with insulation robust enough to be proof against mechanical damage. Test instruments should have insulated probes and fused leads – see GS 38 (available as a free download).
8. Protective equipment and clothing should be provided and used where it would reduce the risk of contact with live parts or earth.
9. Horizontal surfaces and projections inside control cabinets should not be used for temporary storage of tools and other equipment
10. There should normally be someone close by who is aware of what you are doing, can make the equipment dead and render first aid or get assistance.

Appendix D

IP Ratings (BS EN 60529)

(The first two elements only)

Element	Numeral or letter	Meaning in relation to equipment	Meaning in relation to persons
Code letters	IP		
First numeral		***Protection against ingress of solid objects***	***Protection against access to hazardous parts with -***
	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
Second numeral		***Protection against ingress of water with harmful effects***	
	0	No protection	
	1	Vertical dripping	
	2	Dripping, tilted at 15^o	
	3	Spraying	
	4	Splashing	
	5	Jetting	
	6	Powerful jetting	
	7	Temporary immersion	
	8	Continuous immersion	

Example: IP41 is protected against ingress of wire, and vertical dripping water.

Flexible Cables, to BS 6500

Cable size	Current Rating (maximum current)	Typical Uses
0.5 mm^2	3 A	Light duties, table lamps, radio, etc
0.75 mm^2	6 A	Electronic equipment
1 mm^2	10 A	Electronic equipment
1.5 mm^2	15 A	All extension leads, heavy electrical equipment (welders, heaters, kettles)

Appendix E

Assessment form for Design and Construction of Electrical Equipment

The Cavendish Laboratory

Description of the item …………………………………………………………….

Intended Function/Location …………………………………………………….
Designed by ……………………………………………………………………..

Protection against direct contact

	Yes	***No***
Are the incoming supply terminals insulated, shrouded or not accessible when any cover is removed or door opened?		
Are any adjusting or setting devices segregated into a separate panel or cubicle, where there are no exposed bare conductors?		
Are all live conductors insulated, protected against mechanical damage or placed inside enclosures, so that access is not gained to them when live or energised?		
Are any capacito+r banks inside sheeted enclosures?		
Do any capacitor banks discharge to less than 60 V in less than 5 s? *If no, then there must be a permanent warning sign in place*		
Does the enclosure have the minimum degree of protection required for the application?		

Protection against indirect contact

	Yes	***No***
Is the equipment fused, with a fuse of the correct type and of the minimum current (having regard to the requirements of the apparatus)?		
Is the equipment protected by equipotential bonding?		
Is the equipotential bonding by copper conductor, of rugged construction, without links or fuses?		
If the equipment is not protected by equipotential bonding, record here the measures taken to protect against indirect contact:		

General Measures

	Yes	*No*
Has the designer done a risk assessment to establish that the design does not pose danger under both the normal use, and the reasonably foreseeable misuse, or fault conditions? (attach design calculations where appropriate)		
Is there a circuit diagram? Is there a functional diagram? (Please store both with this document).		
Are plugs and sockets provided of such design as to ensure that the wrong connections are not made, if necessary to prevent danger?		
Are plugs and sockets suited to their purpose?		
Does the equipment have appropriate warning signs?		
Is the general construction mechanically sound?		

Testing

Test	**Pass**	**Fail/ not appropriate (give reasons below)**
Continuity of protective bonding circuit (record p.d. measured)		
Insulation resistance		
Voltage test: At ……………V Items disconnected are recorded below		
Residual voltages Record discharging arrangements below		
Functional tests		
EMC compatibility tests (where appropriate)		

Space for Observations and Clarification:

This equipment appears to be constructed to be fit for purpose.

Assessment carried out by ……………………………… Date ……………

Assessment Form for Integration of Electrical Equipment into an Experimental Rig

The Cavendish Laboratory

Location of rig ……………………………………………………

Intended function …………………………………………………

	Yes	*No*
Add up the power (or current) requirements of the individual items in the rig Is the incoming supply cable of the correct rating and fused correctly? Note: recording currents to the nearest 0.5 A is sufficient, and 13 A at mains voltage is equivalent to approx 2.9 kW.		
Is the rig powered from a single source (preferred)? If not, is it clear which parts are powered from which source(s)? ……….		
Is the incoming line placed to avoid slips, trips, damage from abrasion, liquid nitrogen, immersion of live parts in water?		
Has the earth connection been checked to establish its integrity? If safety is to be achieved by some other means record this below.		
Is the equipment placed in the rig so as to avoid overheating?		
Have the items of equipment been connected to distribution boards so as to avoid daisy-chaining and the use of adaptor blocks?		
Is it obvious how to disconnect the apparatus in an emergency (to people other than the users)? If not obvious by position, is there adequate labelling?		
Is it obvious how to disconnect the apparatus from all other sources of energy or associated hazards (e.g. water, compressed air, cryogens)		
Is the means to turn off the electrical supply in an emergency readily accessible and free from obstacles?		

Continued:

	Yes	*No*
Is there a means to isolate the equipment so that it remains dead? (could be the same as the disconnection – if it is powered from a plug/socket arrangement the answer will be yes provided sufficient steps are taken to prevent inadvertent reconnection).		
Are all live conductors (that might constitute a danger) on any associated apparatus shrouded or insulated to prevent contact?		
Is any associated apparatus earthed where necessary to prevent danger?		
Are all high voltage connectors (if any) arranged so that contact cannot be made with them while live (e.g. if the connector is removed from the rig while the power supply is 'on'.)?		
Have any radiation sources (e.g. RF) been assessed quantitatively, suitable shielding measures taken, and the shields tested? (enter details below)		
Is an RCD required? (in general for locations where water may increase the hazard, or where conductors are easily damaged, such as a workshop floor)		
Is an emergency red button needed? (e.g. where live electrical work is foreseeable)		
Have the users of the rig been shown this risk assessment, and the risk assessment(s) pertaining to the items that constitute the rig? Name the users:		
Have they been told of the necessity for the conditions described in this assessment (i.e. that all answers remain YES) to be maintained at all times?		
Have they been told what to do in an emergency? Detail below:		
Have they been told to report faults and get them fixed? Detail below:		
Have the users of the rig been warned of the prohibition on working live where there is danger? (danger being defined as a risk of injury)		

Appendix F: General Purpose Risk Assessment Form (annotated version)

This form is suitable for most experiments and general work areas. However, if the experiment is principally concerned with radiation, chemicals or biological work, the specialised risk assessment forms may be more suitable.

Building	**Room**	**Name of assessor(s):**

Title of activity/experiment/work area:	*Helpful information when reviewing.*

Brief description of activity/experiment	*Failing to identify the activity can lead to the risk assessment becoming worthless – make sure it is clear.*

Identification of hazards

Identify all significant hazards, who or what might be affected by each and identify how the risk of being affected will be reduced so far as is reasonably practicable. The following lists may help in identifying hazards, but are not intended to be comprehensive.

Mechanical

- *Abrasion*
- *Cutting*
- *Trapping*
- *Entanglement*
- *Crushing*
- *Impact*

Also consider lifting, tripping hazards, repetitive movements & the condition of the work environment.

Chemical

- *Toxicity, burns*
- *Carcinogens or substances that can harm reproduction*
- *Allergies, dermatitis*
- *Asphyxiation*
- *Fire*

Look at the foreseeable routes of entry to the body. Do not forget to address spillages and waste.

Electrical

- *Fire*
- *Electrocution*
- *Falls, subsequent to shock*
- *Arcing*
- *Burns*
- *Explosion*

Remember to look at fault conditions, where you place the conductors, how the system has been put together, and by whom.

The Location

- *Falls from a height*
- *The working environment – hot, cold, humid*
- *Traffic hazards*
- *Trip hazards etc*
- *Noise, vibrations*
- *Lighting conditions*

Radiations

- *Ionising radiation*
- *Lasers*
- *Microwaves/RF*
- *Heat or UV*

Biological Hazards

- *Any planned biological work*
- *Waterborne diseases, when working outdoors*
- *Rodents, moulds, spores, fungi*

Hazard Identified	**Who or what is affected**	**How the risk will be controlled**
It helps to list the hazards using numbers – especially if some of them are likely to affect different groups of people. It also helps when using the final column.	*Don't forget people such as visitors, cleaners, first aiders, etc, where relevant.*	*Control measures sometimes cover more than one hazard, and here is where you reap the benefits from numbering your hazards.* *Don't forget that good housekeeping is an excellent control measure for a large number of hazards, including slips, trips and fire.* *Don't forget the hierarchy of controls, and don't forget to check for breaches of statute – e.g. bare accessible conductors at voltages sufficient to do serious harm, rooms that could become oxygen deficient without any means for the occupants to be aware of it happening.*

Hazard Identified	Who or what is affected	How the risk will be controlled
Don't forget reasonably foreseeable fault conditions. The risk assessment needs to make plans for these before they happen.		*It is legitimate to restrict access to an area with certain hazards, either permanently (e.g. in the case of laser operations) or temporarily (e.g. in the case of cordoning off an area to deal with a spill).* *For any substances hazardous to health check the data sheet, and note if there are any carcinogens or substances with statutory exposure limits. Check the relevant code of practice to see what must be done in these instances.* *It is good practice for laboratory doors to have notices outside. These should give the following information:* • *Any alarms inside the room, what they are for and what people should do if they sound* • *Any major hazards in the room (e.g. gas cylinders, magnets, radioactive substance stores)* • *Names and telephone numbers of people to contact in emergencies.* *Do not forget the role of training in your control measures – the test of whether a risk assessment is sound is whether the significant risks have been identified, whether the system of work adequately addresses those risks and whether the person carrying out the system of work is competent.*

Is special monitoring required? (e.g. hearing test, eye test, health surveillance? Enter details	*You need to check the legal requirements to be able to fill this in.*
What personal protective equipment is required? (e.g. overalls, gloves, respiratory protection, eye protection)	*Gloves etc need to be chosen so that they are the CORRECT type for the hazard.*
Waste disposal (if applicable)	*Very important section – never get into the situation where you do not know!*
Action to take in case of reasonably foreseeable emergencies (e.g. overheating, loss of electricity, flooding):	*It is essential that people know what to do, and if the equipment is ever left unattended you need to post notices*
Any special first aid measures required (e.g. HF)	

Signature of assessor		**Date:**
Signature of supervisor		**Date:**

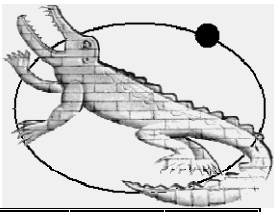
Review: This document should be reviewed every 12 months, or earlier is there is a material change to the process, the equipment, the location or to relevant safety technologies. It should also be reviewed if new people join the group.

Date	Reviewed by	Date	Reviewed by	Date	Reviewed by

Appendix G

Suggested Patrol Check Sheet to Maintain Good Practices

Location of Inspection …………………………………………….



	Item	Yes	No
1	Is there free access to switches to make the equipment dead?		
2	Is it obvious which of these switches 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:

	Item	Yes	No
11	Has the equipment been isolated securely and proved to be dead?		
12	Is the person working on the equipment suitably experienced to do so, and if not, taking advice?		
13	If the work is being done live, is it (a) essential that it is done live (b) being done with adequate precautions to prevent injury– correct tools, in a cordoned off labelled area or closed room, (c) being done by someone with adequate experience for such work		

Comments, observations or recommendations arising from above

Inspection carried out by ……………………………….Date ……………………..

Appendix H

Named Persons Who Verify the Electrical Safety of Home-Built Apparatus Before it is Used

Department Electrical Specialist Mr C J Moss   cjm20@cam

The following will act within their own sphere of expertise, and in general within their own research group:

Dr A C Irvine	ME	aci20@cam
Dr W G Proud	PCS	wgp1000@phy.cam
Mr D M Astill	IRC	dma1001@hermes.cam.
Dr G A C Jones	SP	gaj1@cam
Mr R Gymer	OE	rwg11@cam.