SCHOOL OF ENGINEERING
LOCAL LABORATORY RULES

High Voltage DC (HVDC) Laboratory

To be read in conjunction with the School's safety handbooks, policies and guidance: School Policies, Guidance & Resources | School of Engineering | The University of Aberdeen (abdn.ac.uk)

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Areas covered by this document	
HVDC Laboratory	Fraser Noble 047

1. TRAINING & RISK ASSESSMENT

All persons commencing work in the lab must undergo a formal Laboratory Induction in addition to the Basic Induction they received on arrival at the School. In addition to records of induction training, records must also be kept of all further training provided necessary to operate equipment or work in the Dynamics Lab.

No work should commence in the lab until a risk assessment has been completed in conformance with School procedures as stated in the School Safety Handbook.

All personnel working in the Dynamics Lab must confirming they have read the Dynamics Laboratory Supplementary Safety |information handbook which will be recorded during the lab induction.

2. ELECTRICITY

The Estates Section is responsible for the provision and maintenance of a safe electrical supply.

When undertaking any maintenance work on electrically powered equipment, the power supply should either be isolated and padlocked off or, in the case of 13Amp plugs, plugs should be removed from their sockets and the plug and cable returned to the equipment being worked on. Risk assessments may determine alternative methods to be implemented such as, for example, isolating the supply and connecting the supply lines to earth however this may require additional installations as determined and installed in consultation with Estates.

Electrical equipment should **NOT** be opened without permission of the Resident Technician and only personnel with the necessary experience and knowledge are allowed to work on electrical equipment.

All electrical equipment must be inspected before use to ensure it is in a serviceable condition and damage free, report all problems to the Technician.

3. SLIPS AND TRIPS

Slips trips and falls is a major cause of accidents in the workplace and the main walkways and work areas must be kept clear of objects. There should be no trailing cables crossing walkways. If it is absolutely necessary to have trailing cables, they should be covered with a suitable ramp or rubber cable protector. All fluids and Oil spills must be cleared up immediately.

4. MANUAL HANDLING

Loading of the shakers or any other device in the lab must be included as part of the risk assessment and if necessary mechanical aids used to lift the equipment onto the shaker. Appropriate footwear should be used when handling heavy loads ie safety shoes.

5. CHEMICALS

A list of chemicals and their safety data sheets must be kept up to date and filed in the appropriate folder. Solvents and acids must be stored in separate cabinets.

All Chemicals used in both maintenance and experimental work must be addressed in the Risk Assessment.

6. HAND TOOLS

Hand tools must be maintained in good condition.

Safety goggles, footwear and gloves must be used when necessary.

7. FOOD AND DRINK

No food or drink is allowed in the Dynamics Lab.

8. VISITORS

All visitors should be cleared with the technician and briefed about all relevant hazards before entering the Dynamics lab. Visitors should not be left in the Dynamics lab on their own.

9. COMPETENT PERSONS

Only personnel who have been authorised and signed up as competent by the Academic in charge of the Electrical Laboratory is allowed to operate the Voltage Source converters, Current Source Converters and DC to DC converters.

All personnel working in the laboratory on energised equipment must have enough knowledge to operate the equipment competently or have a competent knowledgeable person supervising them.

10. HIGH VOLTAGE OPERATION

When voltages greater than 50V are being used, the red lights outside the access doors to the Electrical laboratory are to be switched on and the access doors closed and secured. All personnel requiring access to laboratory when the Red lights are on must wait until invited in by the personnel working within the Electrical Laboratory before entering.

11. LONE WORKING

No lone working is allowed when voltages greater than 50V are being used. No lone working is allowed when operating the Voltage Source Converters, Current Source Converters and DC to DC converters or DC Circuit Breaker test.

12. LIVE WORKING

Live working should be avoided where every possible and only carried out when there is no other possible way of carrying out the test.

All Live working must have a individual Risk Assessment for that

task signed by the TRO and Supervisor before any Live Working can be carried out.

13. LEAVING THE LABORATORY

Before Leaving the Electrical Laboratory ensure all equipment is switched off, all loads have cooled down and the floor is obstruction free. The power capacitors

should be discharged. All tools are returned to the tool boxes. Good housekeeping prevents accidents.

14. WORKING WITH HIGH VOLTAGE EQUIPMENT

14.1. Introduction

The Electricity at Work Regulations 1989 made under the **Health and Safety at Work etc Act 1974** came into force on 1st April 1990. They apply to all places of work and to all work involving the use of electricity. The Regulations are primarily concerned with the prevention of *danger* and *injury* from electric shock, electrical burns, and fires of electric origin, electrical arcing and explosions initiated or caused by electricity. Burns in this context include radio frequency burns. Ultraviolet radiation due to arcing can also produce injury to which these Regulations apply. The Regulations are supported by the Health and Safety Executive (HSE) publication, '**Memorandum of Guidance on the Electricity at Work Regulations 1989**'.

HSE publication entitled, '**Electricity at Work *safe working practices' (HSG85) is*** available for relevant staff to consult.

The Regulations apply equally to systems of different voltages and do not distinguish between high and low system voltages.

The Regulations impose different levels of duty. In certain cases the requirements are absolute whilst others are qualified by the well-known phrase "so far as is reasonably practicable".

Electricity plays a part in almost everything we do and while it is a useful tool it must be treated, at all times, with great respect. Electrical equipment, which is under the control of this University, is in daily use both within and outwith University premises. The sensible use of such equipment will generally ensure that no person is exposed to a significant risk to health. Nevertheless it should be recognised that, under certain circumstances, the use of electrical equipment may become extremely hazardous to health.

Where the word *must* is used in this booklet the requirements are mandatory and must be followed at all times. Other recommendations must not be disregarded without compelling reason.

14.2. Working with electrical equipment and installations

Precautions which should be taken when working with electrical equipment.

1. Isolation from all points of supply.
2. Securing each point of isolation.
3. Earthing where appropriate.
4. Proving dead at point of work.
5. Demarcation of safe zone of work.
6. Where necessary, safeguarding from adjacent live conductors.
7. Release for work by the issue of a safety document e.g. a Permit to Work.
8. Employing trained and competent staff.
9. The provision of adequate information for such staff.
10. Using suitably insulated tools, equipment and protective clothing.

11. Using suitable insulated barriers or screens.
12. Using suitable instruments and test probes.
13. Accompaniment by another person if their presence can contribute significantly to ensuring that injury is prevented.
14. Effectively controlling the work area where there is danger from live conductors such as through restricting access and the use of special precautions such as free work areas.

14.3 Electrical Supplies and Equipment

The Estates Unit is responsible for the provision of safe electrical supplies within University buildings up to and including the electrical outlet sockets.

Where the fixed wiring system within a building is to be extended, the work must be carried out through Estates.

Staff with a concern regarding electrical safety should immediately bring the matter to the attention of an appropriate member of staff e.g. the TRO or Local Safety Coordinator. If any doubt exists about the safety of a piece of electrical equipment, it must be taken out of service immediately, labelled "DO NOT USE", and sent for repair by a competent person.

14.4 Competent Persons

Persons carrying out the testing and/or repair of electrical equipment or carrying out experimental work on electrical equipment or its associated connections must have appropriate knowledge, training and experience to enable them to work safely. Persons who are not thus qualified may work on electrical equipment provided suitable and sufficient supervision is provided by an appropriately qualified person.

General guidelines for competence are as follows:

- Experience in working with electricity.
- An adequate knowledge of the associated hazards.
- Knowledge of all relevant current safety standards.
- A clear understanding of the precautions required to avoid danger.
- Sufficient experience in the type of electrical work involved.
- The ability to recognise whether it is safe for work to continue, particularly in respect of unfamiliar equipment and unfamiliar locations.

14.5 Hazards to Persons

The dangers involved with the use of electricity are well known, these being shock, burns or other injuries potentially with fatal results.

14.5.1 Effects of Electric Shock

Excessive electric current flowing through the body causes muscles to go into spasm, inhibits the respiratory centre in the brain, causes fibrillation of the heart and destroys body tissue. Electric shock can cause cardiac arrest or cessation of breathing, either of which can be fatal. This effect is related directly to the magnitude and duration of the current passed through the body and to the physical path taken by the current. Particularly dangerous paths are from hand to hand, or hand to foot, as they transverse the pacemaker system controlling the heart. This can lead to

fibrillation, that is a state of rapid, irregular contractions of the heart muscle, which reduces the effective pumping action of the heart and impairs blood supply to vital organs, particularly the brain.

Procedure for the safe treatment of an individual who has or is suspected of having suffered an electric shock.

- Check your own safety and the safety of others before approaching casualty.
- Assess if casualty is still in contact with the supply.
- If so, switch off the appliance at the mains or withdraw the plug from the outlet socket. Only if this is not possible should an attempt be made to pull the casualty away using insulating material e.g. piece of dry wood or scarf.
- Look for signs of life, for example, breathing, movement, cough or change in colour.
- If none of the above are evident phone for an ambulance dial 9999 and ask for the ambulance service. Advise the controller that ' a casualty has suffered an electric shock and that he/she has had a cardiac arrest' - do not hang up, answer any questions ambulance control asks and take advice.

If you have been trained in CPR commence 30 chest compressions followed by 2 breaths of mouth-to-mouth resuscitation - continue until Emergency Service staff arrive.

Note: Training in such techniques can be arranged through the Environmental, Health and Safety Services. In addition, as a supplement to training, a wall chart displaying these techniques should be posted in a prominent position in relevant areas.

14.5.2 Burns

Burns can occur externally or internally. External burns can be caused by the passage of an electric current through the skin or as a result of an electric arc or a short circuit. Burns resulting from short circuits are often made worse by pieces of molten metal, from vaporised conductors, embedding in the skin. Internal burns are caused by the passage of electric current through blood vessels and internal organs. In addition, some forms of electro-magnetic radiations such as radio-frequency and microwave radiation can produce burns at a distance. The actual depth of the burn caused by the passage of an electric current is likely to be greater than it appears, with damage to underlying tissue, although its area may be relatively small.

First-Aid

If possible, cool the burn by immersion in clean cold water for at least 10 minutes then cover with a clean polythene bag or cling film. All cases of electrical burns require immediate medical attention.

14.5.3 Other Injuries

Other injuries can occur for example when a person falls from a ladder after receiving an electric shock. Quite often the injuries from the fall can be more serious than the initial shock.

14.6 Hazards to Buildings and Equipment

14.6.1 Fire

Fires are frequently started by electrical apparatus and can be caused by sparks, arcs, short-circuits, overloading and old wiring.

Sparks

A spark is the sudden discharge or passage of electricity through air between two conductors or from a conductor to earth or nearby metal.

Since the current produced is usually small, sparks rarely cause serious fires except in cases where there is an explosive gas nearby or where highly flammable material is in contact with the conductor. An explosion can be caused by the ignition of flammable gases by a spark from an electric contact. In all cases where a flammable or ignitable atmosphere or vapour is present, special care is necessary in the design and selection of the electrical equipment.

Arcs

An arc is a much larger and brighter discharge in which the current flow may be very large. It usually arises when a circuit is broken, e.g. when switch contacts separate, or when a conductor melts or fractures leaving a gap across which electricity continues to flow. When an arc is established, the air in the vicinity becomes ionized and forms a conductor which may allow current to continue to flow to a nearby metal framework. A large arc can cause serious burns both to an operator nearby and to any adjoining material. It can also produce molten metal splashes which can cause additional injury.

Short-Circuits

A short-circuit is formed when the current finds a path from the live conductor wire to the return wire other than the intended route through the apparatus. Since the resistance of the leads to the by-passed apparatus is low, the current flow may be large; and because the contact is probably poor, an arc may be established. Components can become white hot and cause the adjoining insulation to burn. The burning may then spread rapidly to any adjacent flammable material. Accumulators wired in series can give rise to extremely damaging high currents should a short-circuit occur; protection with circuit breakers or fuses is necessary. High current may cause large electromagnetic forces and some equipment may move or bounce.

14.6.2 Electrical Fire Fighting

Firstly switch off the power to the equipment; then, if necessary, use a carbon dioxide extinguisher. Do not use water because of its electrical conductivity. Even if the appliance e.g. TV set, refrigerator, is switched off, an electrical capacitor can still administer a dangerous shock.

Although the primary task is to extinguish the fire, the planning of fire precautions should always take into account salvage of the damaged items. A residue-free, non-

corrosive extinguishing agent is always to be preferred, particularly where delicate apparatus or materials may be present. Powder extinguishers should only be used as a last resort; it is almost impossible to remove the finest powder from complicated equipment e.g. switches and relays during salvage operations.

14.7 General Safety Measures

14.7.1 Fixed Wiring Installations

Staff should familiarise themselves with the positions of the main isolating switches for their area. In the event of an electrocution accident, fire or flood, it may be necessary to disconnect the supply. In the case of fire or flood never restore the supply yourself, contact Estates.

14.7.2 Fuses and Circuit Breakers

These devices afford protection against excess current flow e.g. due to short circuit, before the overload has persisted long enough to cause damage. If a newly fitted fuse or a circuit breaker again blows upon reconnection the associated equipment must be taken out of service and the fault reported.

Single fuses (and also single pole switches) must be located in the live conductor.

A fuse must be of the correct rating for the equipment. Cartridge fuses normally rupture at about 60% overload so a 5-amp fuse fails at about 8 amps. This overload current must be within the current carrying capacity of the circuit or serious damage can occur.

Replacement fuses must be readily available to avoid any temptation to replace spent fuses with anything other than a fuse of the correct rating.

The primary purpose of a fuse is to protect equipment against overload and consequent damage by fire. Additional measures, such as earthing and/or earth-leakage circuit breakers are necessary to provide protection from shock.

14.7.6 Earthing

The external metal casing of electrical apparatus must be earthed as a legal requirement. The casings or screens of all electrical equipment must be fastened so that it is impossible to touch electrically live parts and if the equipment is disconnected from earth, a notice must be attached which makes this quite evident to any unsuspecting person. Only persons with appropriate experience should work with unearthed equipment.

All earthing wire must be capable of carrying the maximum possible fault current. Whenever practicable, apparatus should be provided with a protective device which will break the circuit should a dangerous fault to earth occur.

Great care must be exercised when using electrical equipment in high earth leakage areas such as cold rooms, washing-up rooms, and in medical/biological laboratories where "wet" experiments are in progress.

The continuity of earth connections, particularly on portable equipment, must be checked periodically.

14.7.7 Residual Current Devices (RCD's)

The application of a residual current device to a conventionally earthed system should be considered where it is vital to provide an additional backup protection against failure of the primary earthing system. A RCD will prevent a person from being subjected to a lethal shock from a

fault current to earth, by limiting the duration of the shock, usually to 30 milliseconds.

Note: a fuse is also required as RCD's do not protect against short-circuits between live and neutral.

A standard residual current device is designed to operate on a.c. current only. Many modern appliances such as power-tools, VDU's and teleprinters contain solid state devices which may create a pulsating d.c. current affecting the operation of a standard RCD and this may lead to loss of protection. Pulsating d.c. fault current sensitive RCD's are now available and should be employed wherever necessary.

RCD units are packaged either as fixed installations fitted to the incoming supply or in the form of a power breaker 13 amp fused plug. Every RCD unit is fitted with a test button which should be operated regularly to prove breaker operation.

14.7.9 Isolation from the Mains Supply

It is necessary to provide means of disconnecting cables or apparatus from the source of supply.

For portable apparatus, with a non-inductive load of < 3kW at 240V AC, pulling the plug out is the best method, but for fixed equipment it is necessary to have manual isolating switches.

More than one circuit or motor should not be disconnected by the same isolating switch, unless it is clear that under no circumstances will it be necessary to use one while work is being carried out on the other.

Isolators should be designed so that they can be locked in the open position to ensure that no one can switch on while another person is working on the apparatus; isolators should always be 'suitably located' as near to the controller or starter as possible. Isolators must never be locked in the 'ON' position; the occasion may arise when speedy isolation is imperative.

If the isolating switch is under the immediate and sole control of the operator, no special requirements exist. If the isolating switch is remote, care must be exercised to ensure that the supply is not reconnected; it will usually be sufficient to remove the fuse and leave a note in its place. If the supply is not drawn through fuses, the supply

14.8 Work on 'Live' Electrical Equipment

This section covers the risks and protective measures associated with work on live conductors with voltages at or below 415V phase to phase or 240V phase to earth. There are many reasons why it may be of use to work on a piece of equipment whilst there are accessible live parts. There are four main areas.

1. Testing during assembly or production.
2. Fault finding during repair.
3. Research or development work using oscilloscopes and similar instrumentation.

4. Work at fuse boards and electrical distribution boards.

In some of these cases it may be convenient, but not absolutely necessary, to work on equipment while it is still live. Personnel doing this type of work are reminded that under the Electricity at Work Regulations 1989, they may only do such work if there is no reasonably practicable alternative.

All persons who work on or close to live conductors must follow the safe working practices recommended by the Health and Safety Executive in the publications entitled, 'Memorandum of guidance on the Electricity at Work Regulations 1989 and 'Electricity at work - safe working practices' (HSG85). All such work carried out by Estates staff and electrical contractors employed by Estates must also comply with relevant health and safety rules produced by the University and Estates.

14.9 Inspection of Portable Electrical Apparatus

All portable equipment, including extension leads, should be inspected at regular intervals. When setting the frequency of an inspection account should be taken of any recommendations which the manufacturer may make along with the use and service conditions

All such inspections should be recorded. A suitable record will include the following information:

a) Means of identifying the unit, e.g. serial number.
b) Frequency of inspections.
c) Electrical tests (including statement of pass/fail criteria).
d) Result of test (pass or fail).
e) Name of the person who carried out the inspection.
f) Date of the inspection.

Whenever practicable a unit should be labelled to show when its inspection and maintenance are due. Guidance on the frequency of inspection/testing of portable electrical equipment is given in the University publication, 'Guidance Notes on Inspection and Testing of Portable Electrical Equipment'.

14.10 Safety Measures

14.10.1 General

The risk of sustaining an electric shock can be minimised by adopting good working practices:

- Due care must always be exercised when switching off main power supplies to ensure that only the intended circuits are isolated. Lock-off systems must be used, where necessary.
- Switch off and withdraw the plug prior to carrying out any repair work or modification to portable electrical equipment.
- If equipment is suspected of having become live, switch off, and have it tested by a competent person.
- Do not handle any electrical equipment with wet hands and do not work in close proximity to water supplies or other earthed metalwork.
- Do not use equipment which you suspect as being faulty.

- Equipment should be repaired by a competent person where possible in a properly equipped workshop.
- Inspection covers must not be removed from equipment except by a competent person as even when disconnected equipment may be dangerous.
- Special attention should be paid to earth connections. Consider if the use of residual current devices (RCD's) or isolating transformers would be an advantage.
- Electrical equipment must not have exposed live terminals.
- Beware of capacitors. High grade capacitors must always be shorted before being handled.

14.10.2 Design and Construction of Electrical Equipment

The Health and Safety at Work Act, 1974, places a duty on any person who designs, manufactures, imports or supplies any article for use at work to ensure, so far as is reasonably practical, that the article is so designed and constructed as to be safe and without risks to health when properly used. All apparatus constructed by School/Unit staff should be inspected and approved by an authorised person before being placed into service and thereafter inspected at regular intervals to ensure that the installation remains in a satisfactory condition.

Electrical/electronic equipment produced for sale must comply with the requirements of all relevant EC and UK legislation.

The standard of safety in electrical and electronic apparatus generally applied in this country is that laid down in the current relevant British Standard.

Review Record

Issue	Who	Date	Reason for Review
2	ES	22/01/2024	General update. Reviewed and approved by the Lab Coordinator.