

THE UNIVERSITY OF SUSSEX
SAFETY PROCEDURES AND GUIDANCE FOR THE
SAFE OPERATION OF
ELECTROPHORESIS APPARATUS
SPG-21-09 Revised 2009

A. INTRODUCTION

The Electricity at Work Regulations necessitates that the University must ensure that the electrical energy is safely contained. The voltage and power levels used during in general electrophoresis techniques are generally sufficient to cause injury or death. For example routine agarose gel electrophoresis running at 100 volts (V) can cause a lethal shock at a current of 25 milliamps (mA) and minor leaks in gel tank devices can result in electric shock.. Other techniques such as electroporation and electrotransformation, which also apply electricity to biological materials, may present a similar electrical hazard. The potential seriousness of an accident involving electrophoresis, or similar, apparatus should not be underestimated.

As a user of the apparatus you must only operate it in such a way that it is not a danger to yourself or anyone else in its vicinity. The aim of this document is to increase your understanding of the dangers and to prevent accidents. Please seek advice if any point is not clear to you.

B. LEGISLATION

(1) **The Management of Health and Safety at Work Regulations**

These Regulations require research supervisors and faculty in charge of equipment, including electrophoresis apparatus used in teaching and research, to list the hazards associated with the electrophoresis apparatus in their charge and to undertake a careful assessment of the risks to health. The hazard and risk assessments must be recorded together with the safe system of work which must be followed to minimise the risks to health.

Where electrophoresis apparatus is to be used within interlocked enclosures designed and made in the School of Life Sciences workshop, it must be recorded in any risk assessment carried out for work with this equipment that the electrophoresis hazards, risks and safe systems of work are as set out in this document.

In preparing their hazard and risk assessments for electrophoresis equipment, research supervisors must be aware of the need to comply with the requirements of the Electricity at Work Regulations.

(2) **Electricity at Work Regulations 1989**

Regulation 4: This requires that all systems shall be constructed, so far as is reasonably practicable, to prevent **danger** and thereafter maintained by their operators to prevent **danger**.

Danger is defined in the Regulations as the **risk** of death or personal injury initiated by electrical energy.

Regulation 14: This prohibits work on (or so near that **danger** may arise) a live uninsulated conductor unless

- (i) it is unreasonable for it to be dead,
- (ii) it is reasonable in all the circumstances for a person to be at work on or near while it is live, and
- (iii) suitable precautions are taken to prevent **injury**. These precautions include the provision of clear information concerning the risk of injury, the requirement that only people who are properly trained and competent to work on live equipment safely should be allowed to do so. If necessary, protective equipment must also be provided, e.g. insulated gloves, insulated mats.

In each area where electrophoresis equipment is used, a '**designated person**' must be formally appointed. In the School of Life Sciences the '**designated person**' is the Technical Services Manager, or their nominee. The duties of the '**designated person**' are summarised in Appendix 1, but are also indicated in the relevant sections of this document.

The hazards associated with the use of electrophoresis apparatus may be controlled by a combination of design features on the equipment, strict adherence to a safe system of work, adequate training, and ongoing supervision.

C. APPLICATION OF THE PROCEDURES

These procedures apply to all electrophoresis equipment operating at voltages above 50 volts DC. The highest voltage power packs in use at present can produce up to 3,500 volts DC at high levels of power and must be operated with great caution.

D. RISKS TO HEALTH

The potential for accidents is clearly foreseeable. Apart from the normally-operating power production risks, undischarged capacitors in power packs which have been turned off may cause a shock which results in the operator being injured. An involuntary movement caused by electric shock may cause spillage of a dangerous substance, fire, etc., which could also result in personal injury.

Where there are high voltages within the system, very little current is needed (30-50mA) to induce a fatal electric shock. Most power pack outputs are 'floating', i.e. insulated from earth, and this reduces the risk of shock, though all power packs must be operated with caution. Even in the case of power packs protected with Residual Current Devices the possibility of shock remains, and reliance upon these must not be allowed to replace maintenance of a safe system. An RCD connected to the mains supply plug will give **no protection** from shocks received from the output terminals of most power packs. Approved shrouded connectors must be used to reduce this danger.

The presence of a buffer solution also presents a hazard as it acts as a live circuit conductor - hence the need, so far as is reasonably practicable, for electrophoresis work to proceed within an interlocked enclosure.

E. FUNDAMENTAL SAFETY REQUIREMENTS

It is recommended that electrophoresis only be carried out in clearly designated areas within each laboratory.

Power packs

- (a) All power supplies should be clearly labelled with their maximum output voltage.
- (b) It is recommended that electrical supply to the power pack should be protected with a Residual Current Device (RCD). This will protect against faults with the main 230V AC electrical supply to the power pack.
- (c) All power packs must incorporate a safety device that disables the high voltage supply to the electrophoresis equipment when the cover of the gel tank is opened or removed.
- (d) It is recommended that power packs also have the following additional safety features. They should:
 - (i) be isolated or 'floating', meaning that terminals are not referenced to the case (earth).
 - (ii) have a load detection system, preventing power being supplied if there is no load on the output terminals.
 - (iii) have a 'reset on / turn on' feature, meaning that if the electrical supply is turned off and then on, the apparatus must be reset to recommence the electrophoresis run.
- (e) Power packs capable of operating at 1000 volts and above must utilise 2mm shrouded connectors on the high voltage outlets so that they cannot be connected to apparatus which is not designed for this voltage range. However, a given supplier's power pack, used exclusively with the same supplier's dual moulded 4mm plug connectors is regarded as satisfactory.
- (f) Multi-purpose power packs are frequently purchased to fulfil a number of functions in the laboratory but their use must be strictly monitored by supervisors. Where, for example, a maximum voltage of 200 volts is required for a process it is inappropriate to use a power pack supplying 2000 volts. In such cases a low voltage power pack should be purchased for low voltage work.

Gel equipment

- (a) Gel equipment must be used with a cover in place such that neither electrodes nor buffer chambers are accessible.
- (b) Gel equipment should be interlocked with the power supply. Removable covers must be fitted with deep insulated sockets that engage with contact pins in the electrophoresis tanks and be so arranged that the current is cut off to the tank immediately the cover is removed.

The live parts of the sockets must not be inadvertently accessible. An integrity check of the cover must be performed before use.

(c) Apparatus that is not designed for use above 1000 volts must not be fitted with leads that can be plugged into a power pack capable of delivering more than 1000 volts. The use of adaptors which convert 4mm plugs to 2mm plugs is prohibited.

(d) During operation all electrophoresis apparatus should have prominently displayed safety warning signs to indicate that the equipment is 'live'.

(e) Electrophoresis apparatus **must** be operated within an approved interlocked enclosure. Where operation within an approved interlocked enclosure is not practicable, then the apparatus must only be used by trained, qualified faculty, technicians, post-doctorate or postgraduate research workers and closely supervised third year project students within a segregated and clearly defined area within the laboratory. **A copy of the risk assessment for each special electrophoresis area must be displayed within that area.**

5. High voltage cables

(a) All connecting cables between power packs and gel equipment must be fitted with shrouded connectors so that live parts are inaccessible. Stackable plugs must not be used. Both the cable and connectors must be correctly rated for the maximum voltage that the power pack can deliver in use.

(b) Electrophoresis sets fitted with their own set of permanently attached connector leads that eliminate jacks and plugs entirely are acceptable.

(c) Leads must be regularly inspected to ensure that there is no damage to insulation and that all parts of the conductor are covered.

(d) Leads must never be left connected to power packs when the electrophoresis run is complete.

Every electrophoresis apparatus must be accompanied by a **written** set of **operating instructions** to ensure that users are aware at all times of the safe procedure for operating the equipment.

Only approved designs of electrophoresis equipment may be manufactured in University of Sussex workshops. Designs are deemed to have been agreed only when written approval has been obtained from the School's '**designated person**' (see above).

H. CONTROL OF THE USE OF ELECTROPHORESIS EQUIPMENT

Training

Only trained individuals should be allowed to operate electrophoresis apparatus.

Supervisors are responsible for providing those under their supervision with appropriate instruction and training. Instruction should clearly identify the apparatus to be used, and its location, and include the manufacturer's specific operating instructions and the safe systems of work to be followed throughout the process. These factors are in addition to the

consideration of non-electrical hazards (e.g. chemicals), the requirement for personal protective equipment (lab coats, gloves, and eye protection), and any applicable emergency procedures.

Supervisors must ensure that these operational requirements are observed by routine checks on equipment and monitoring of procedures.

Departmental action

Departments should review the use of electrophoresis apparatus against the requirements of this policy. Particular attention should be paid to older equipment. Any equipment not conforming to this Policy Statement should be removed from service immediately.

Electrophoresis apparatus should be the subject of annual electrical testing and this should include testing of interlock function.

Supervisors must ensure that all electrophoresis apparatus has been risk assessed. They must develop a safe system of work for electrophoresis procedures and ensure their staff are given adequate training.

Water cooled gels

Whenever reasonably practicable, water cooled gels must also be operated within an approved interlocked enclosure. The Life Science workshops produce excellent interlocked enclosures for water cooled gels. It is therefore recommended that each water cooled or buffer recirculating apparatus is examined as an individual problem. If this approach is taken, it is anticipated that the workshops will be able to design an enclosure which is acceptable to the user, whilst at the same time achieving compliance with the Electricity at Work Regulations (see SPG-13-09) and with this document.

Electrophoresis apparatus - safe systems of work

Location	<ul style="list-style-type: none"> • Apparatus should be located on non-conducting benches (e.g. solid laminate such as 'Trespa'), and ideally situated in an area separate from other laboratory activities. • Unintentional grounding points and conductors should be avoided (e.g. sinks and other water sources, metal plates, aluminium foil, jewellery, metal equipment). • Locate equipment where it will not be easily be knocked or tripped over. Prevent leads from dangling below the lab bench. • Place the electrophoresis device and its power supply so that the on /off switch is easy to reach and the power-indicator light is easily seen. • Position the power supply to avoid reaching across the electrophoresis device to make connections or to turn the power on or off. Whenever possible, set the power supply on a shelf above the device, at a height suitable for the operator. If the unit is too high the operator may be unable to insert or remove plugs cleanly and securely. • Maintain adequate clearance around the apparatus and ensure that any vents at the rear or sides of the power pack are not covered. • Avoid using power supplies in extremely humid conditions. Avoid condensation by letting units equilibrate to ambient temperature when taking the power supply from a colder to a warmer environment. • Apparatus operating on cold-room circuits should be protected by an earth leakage circuit breaker (ELCB). Not all equipment is suitable for cold-room work and users must select equipment carefully and follow the manufacturer's recommendations. • Power supplies must be kept dry and clean. If wetted then unplug the power supply until it is completely dry.
Pre-operation	<ul style="list-style-type: none"> • Ensure that ALL system components are compatible with each other (correct voltage rating) and that they are suitable for the intended use. • Test the power supply to ensure that all switches, lights, safety interlock features and alarms (if present) are functioning properly. Report immediately any suspicious faults in the power pack and take the unit out of operation until checked by a competent person and repaired. • Equipment without a valid portable appliance test (PAT) label must be taken out of service until tested. • Inspect insulation on the high voltage leads for signs of deterioration (e.g. exposed wires, cracks or breaks, etc.). • Ensure that all contacts are clean and free of corrosion. All connecting leads must be shrouded. • Inspect the buffer tanks for cracks or leaks, exposed connectors, or missing / damaged covers, and correct deficiencies prior to use. • Ensure that there is adequate buffer in the gel tank to avoid arcing. • Leads should be inserted or removed from power packs only when the power is switched off at the wall socket. • Gloved hands must be dry while connecting leads or touching appliances, and connections made one lead at a time using one hand only. • Do not turn on the power supply until all connections are made and the cover of the electrophoresis device correctly fitted. • Power supplies may produce high voltage surges when first turned on, due to changes in load, equipment failure, or power surges. Voltage

	regulators, wherever possible, should be set at zero initially and increased gradually to the required voltage.
During operation	<ul style="list-style-type: none"> • Do not touch any cooling devices connected to a gel since current may be conducted through the tubing. • If buffer is spilled or leaks from the electrophoresis device, switch the power off to stop the run and clean the bench immediately. • Never disable safety interlock features and always follow the manufacturer's operating instructions. • Ensure that the fingers do not touch the metal casing of power packs to avoid completing a potential circuit to earth. • Use warning signs to alert others of the potential electrical hazard. • Never touch, interfere with, or move operating electrophoresis apparatus. • Electrophoresis apparatus should not be left running unattended routinely. • If equipment must operate overnight, for example, then it should be clearly identified with emergency contact information and succinct instructions for isolating the power supply
Postoperation	<ul style="list-style-type: none"> • Switch off the power pack BEFORE disconnecting both leads. Operators should wait 15 seconds (to ensure that internal capacitors have completely discharged) before making any disconnection and before removing the cover of the electrophoresis device and accessing the chamber. • The voltage regulator should be wound back to zero after a run and before • removing the leads. • Leads must always be removed from power packs when not in use.

I. SERVICING/MAINTENANCE OF ELECTROPHORESIS EQUIPMENT

Repair or testing may be undertaken only by **authorised persons** who have the appropriate **technical qualifications, experience and training** and who have received a written statement of authorisation which defines the limitations of their work. See Safety Procedures and Guidance for the Implementation of the Electricity at Work Regulations SPG-13-09

APPENDIX 1

Appointment and Duties of the 'designated person'

Appointment

Appointed in writing by the Technical Services Manager.

Duties

- (1) To advise on the risks to health from individual electrophoresis units.
- (3) To approve the design and construction of interlocked enclosures for electrophoresis apparatus (electrophoresis units).
- (4) To give written approval for designs of enclosures or electrophoresis equipment to be manufactured by the appropriate University workshop.
- (5) To approve the design of connecting leads, terminals and sockets between power pack and electrophoresis units.