Electrical Safety Manual
for
Students, Faculty, and Staff

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BASICS OF ELECTRICAL SAFETY

The laboratory contains a wide variety of electrically-powered equipment including stirrers, shakers, pumps, hot plates, heaters, power supplies and ovens etc. Many laboratory electrical devices have high voltage requirements carrying even more risk. The major hazards associated with electricity are electrical shock and fire. All electrical devices used in the lab setting present a potential danger of injury due to improper procedures, poorly installed and/or maintained systems or fires due to sparks serving as an ignition source for flammable or combustible materials.

It can be dangerous if circuits are not properly protected. The major fault that appears in electrical network or equipment is termed as short circuit. In short circuit, the supply phase and neutral or earth is short circuited accidentally due to foreign metallic substance coming in contact with phase & neutral or earth or due to overload thereby damaging the insulation resulting in short circuit i.e. directly connected resulting in heavy current flow called "short circuit current". This high current heats up the terminations, switches, plugs & cable and associated circuits due to which temperature rises to such a high degree that it is sufficient to generate sparking which further leads to fire.

Electrical equipments and the electrical connections that supply power should always be treated with care. Careful consideration should always be given to the placing of equipment. Avoid damp conditions and use clean, well ventilated area on a solid level base for the equipment, which should be as near as possible to the electrical supply. The extension leads should be discouraged. Since most problems occur with the plugs, sockets and cables supplying electrical power.

Socket outlets and plugs

- A convenient and safe socket outlet should be available.
- Socket outlets should be at least 2 meter from a sink or wash basin.
- The socket outlet should be adequate for the electrical capacity for the equipment.
- There should be proper earthing in the sockets.
- Plugs should match the socket outlets.

Wiring of sockets and plugs

The wiring of a plug is colour coded to help guard against electrical accidents. The colour codes in India as per Indian Electricity Rules are as follows

- Phase (or Live) Red, Blue or Yellow
    - This carries the electrical drive current from the supply to the equipment. It is the most dangerous line. Only qualified staff should work with this.

- Neutral Black
    - This returns the current to the supply. It should not be connected to Earth.

- Earth (or Ground) Green OR Green with Yellow lines
    - This is used for safety and protection. If equipment is housed in a metal case, the earth line will generally be connected to the case. The earth line in a socket is connected to a pipe or plate buried in the ground.

Notes on earthing / Grounding:

The primary goal of earhing is safety of the user as well as of equipment. The earthing will depend upon the type of equipment being used:

- If there are only two wires in the power cable, no earth connection is required
- If the cable fitted has three conductors then equipment needs to be earthed properly

- Always make sure that the earth wire is longer than the other two so that if the cable is accidentally pulled out of the plug, the earth wire is the last wire to become disconnected
- It has been observed that in many industrial, domestic and commercial premises, grounding system has become unreliable. It is essential that earth

resistance should be as low as possible. It is specified that for protective purpose, the same should be around 0.2 to 0.5 Ohms.

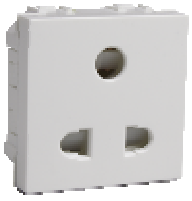
- Under no circumstances, earthing wire in the house/flats should be connected

  to water pipes. This not only gives shock in your premises but to someone else also. Water pipes are coming down from terrace and are not earthed.

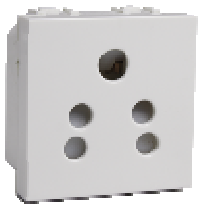
Sizes and types of sockets and plugs

The current rating (i.e. the amount and size of equipment they can supply) is measured in Amperes, written A. The rating and size of normally found plugs and sockets are:

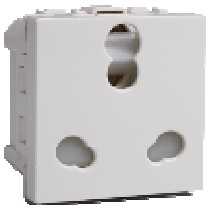
- For low power operations 5 Amperes small size
- For large power applications 15 Amperes large size



6A Three Pin Socket



6A Five Pin Socket



16A Three Pin Socket

16A 5 pin Switch Socket

6A Switch

Mains electricity comes at a specified voltage and is measured in Volts, written V. The voltage in India is 220-240 V for single phase and 440 V for three phase operations. It also is delivered at a specific frequency, measured in Hertz, written Hz Mains electricity in India is at 50 Hz.

Most of the imported equipment functions in two different setting 110-120V and 220-240V. These equipments have a switch for setting the input supply voltage. In our country the supply voltage is 220-240V, hence make sure that the switch is in the correct position i.e. 220-240V otherwise equipment will be damaged. If the said equipment does not have voltage selection switch, use a voltage reducing device which converts 220-240V to 110-120V.

Mains cables

Electricity is carried to the equipment through the mains cable. Points to be taken care of are:

- Use good quality (ISI) wires/cables.
- No bare metal or internal colored wire should be visible, the plastic insulation is there for safety.
- Cable should not be repaired with insulating tape water can still get inside.
- Avoid joints in wiring - soldering and proper mechanical joints should be made if the same cannot be avoided.
- Do not allow cords to contact hot surfaces to prevent melting insulation.
- Long flexible leads are dangerous, leads should be as short as possible.
- The cable, plug and socket should never be allowed to get wet. Water can conduct electricity.
- Multi-plug adapters are for temporary use only for short periods of time and should be discouraged.
- No more than two high current drawing devices such as ovens and centrifuges should be plugged into the same outlet to prevent an overloaded circuit.
- All wiring should be renewed after ageing.
- Fuses used for protection should be of adequate capacity. The ratings should not be increased without ascertaining reason of fuse blowing.

- Fuse boards should be away from combustible materials like paper, oil, curtains etc.

Fuses

Fuses and circuit breakers prevent over-heating of wires and other electrical components. Fuses are used as protection. If the current through fuse is greater than its specified rating, it blows. This breaks the circuit and stops the current, making the equipment safe. Points of safety regarding fuses are:

- Always use the correct rating of fuse voltage V (volts) and current A (amperes)
- Always use the correct size of fuse, keep the old one to check against.
- NEVER replace the fuse with bare wire it will not be safe
- Circuit breakers are fuses that have buttons or switches for reset they do not normally need replacing

It is strongly recommended that fuse wires of correct current rating should be used. **DO NOT INCREASE THE FUSE CAPACITY FOR PREVENTING OR ELIMINATING FREQUENT FUSE BLOW-UPS.** It is essential to locate the causes and eliminate the same. Replacing fuse wires of higher capacity may invite troubles in the form of fire & damage to supply system and surroundings.

HRC Fuses: High Rupturing Capacity (HRC) fuses are capable of clearing short circuit & arcs. However, they are much costlier and hence, application is mostly restricted to commercial & industrial wiring or higher capacity loads.

MCBs: Miniature Circuit Breakers are gaining increasing prominence in labs, household and distribution wiring in shops & commercial establishments as it effectively forms combination of switch & fuse with specified level of fault clearing capacity. It can be

used to protect individual circuit. MCB works as circuit breaker in case of overload/short circuit. It has an advantage since no replacement is required and it can be reset on elimination of fault and switched on again.

MCBs Characteristics are:

- Rated current not more than 100 A.
- Trip characteristics normally not adjustable.
- Thermal or thermal-magnetic operation.

MCB MCCB

MCCBs (Molded Case Circuit Breakers): Used for commercial purpose

MCCBs Characteristics are:

- Rated current up to 1000 A.
- Trip current may be adjustable.
- Thermal or thermal-magnetic operation.

ELCB

ELCB Stands for Earth Leakage Circuit Breaker: ELCB works as a circuit breaker in case of only Earth Leakage.

- Phase (line), Neutral and Earth wire connected through ELCB.
- ELCB is working based on Earth leakage current.

RCD (Residual Current Device**)/ RCCB** (Residual Current Circuit Breaker), which works as a circuit breaker in case of Earth Leakage, Over Load/ Short circuit. Residual current operated circuit breaker is used for protection against electric shock.

RCD/ RCCB Characteristics

- Phase (line) and Neutral both wires connected through RCD.
- It trips the circuit when there is earth fault current.
- The amount of current flows through the phase (line) should return through neutral.
- Any mismatch between two currents flowing through phase and neutral is detect by RCD and trips the circuit within 30 Miliseconed.
- If a house has an earth system connected to an earth rod and not the main incoming cable, then it must have all circuits protected by an RCD (because you might not be able to get enough fault current to trip a MCB)
- RCDs are an extremely effective form of shock protection

Electrical accidents are caused mainly by careless use of electricity, such as:

- Lack of knowledge about functioning of equipment.
- Using faulty electrical cords/sockets.
- Use of extension cords without taking proper precautions.
- Improper earthing of the device.

The major factor which plays a vital role in severity of electric shock is amplitude of current, and part of human body through which it passes. For accident to happen, current of sufficient magnitude must flow through vital organ thus impairing its function. When a person accidentally touches a live wire, the severity depends upon the skin resistance of that person, which varies from 1 K Ohm to 11 M Ohms. Generally current amplitude more than 30 milli Amps is sufficient to give shock which can be fatal.

Maintenance or modifications to commercial appliances, instruments, and equipment must be performed by the manufacturer or the maintenance department qualified electricians and not by laboratory personnel.

Unauthorized alterations to commercial electrical equipment:

- **Voids the manufacturer's warranty.**
- **Voids the manufacturer's liability.**
- **Increases the liability of the owner**.

SAFE WORK PRACTICES

Safe work practices are an administrative hazard control used to prevent injury and accidents. The following safe work practices will reduce risk of injury or fire when working with electrical equipment. Personnel must understand and be trained to practice the following procedures:

1. Avoid contact with energized / live electrical circuits.
2. Treat all electrical devices as if they are live or energized.
3. Disconnect the power source before servicing or repairing electrical equipment.
4. Use only tools and equipment with non-conducting handles when working on electrical devices.
5. Never use metallic pencils or rulers, or wear rings or metal watchbands when working with electrical equipment.
6. When it is necessary to handle equipment that is plugged in, be sure hands are dry, if possible, wear nonconductive gloves and shoes with insulated soles.
7. If it is safe to do so, work with only one hand, keeping the other hand at your side or in your pocket, away from all conductive material. This precaution reduces the likelihood of accidents that result in current passing through the chest cavity.
8. Minimize the use of electrical equipment in cold rooms or other areas where condensation occurs. If it is necessary to use equipment in such areas, mount the equipment on a wall or vertical panel.
9. If water or a chemical is spilled over the equipment, shut off power at the main switch or circuit breaker and unplug the equipment.

10. If an individual comes in contact with a live electrical conductor, do not touch the equipment, cord or person. Disconnect the power source from the circuit breaker or pull out the plug using a leather belt.
11. Equipment producing a "tingle" should be disconnected and reported promptly for repair.
12. “Shorts” (ground faults) are extremely hazardous especially where in contact with metal frame-work of an exhaust hood or damp floor.
13. Do not rely on grounding to mask a defective circuit nor attempt to correct a fault by insertion of another fuse or breaker, particularly one of larger capacity.
14. Keep length of extension cords to a minimum.
15. Never work on live equipment.
16. Drain capacitors before working near them by short circuiting the terminals to prevent electrical shock. Care must be taken that the supply to the system is disconnected.
17. Never touch another person’s equipment or electrical control devices unless instructed to do so.
18. Enclose all electric contacts and conductors so that no one can accidentally come into contact with them.
19. Never handle electrical equipment when hands, feet, or body are wet or perspiring, or when standing on a wet floor.
20. When it is necessary to touch electrical equipment (for example, when checking for overheated motors), use the back of the hand. Thus, if accidental shock were to cause muscular contraction, you would not "freeze" to the conductor.
21. Do not store highly flammable liquids near electrical equipment.
22. Be aware that interlocks on equipment disconnect the high voltage source when a cabinet door is open but power for control circuits may remain on.
23. De-energize open experimental circuits and equipment to be left unattended.
24. Unplug cords by gripping the plug end, do not pull on the cord.
25. Do not wear loose clothing or ties near equipment.

Troubleshooting – Electrical Safety

Fault	Possible Cause	Solution
Equipment is not running	The on/off switch is in the off position No power from mains socket Electrical cable fault Internal problem	Check power switch is on. Check mains power is present at socket or Contact electrician Check the cable or Contact electrician for rewiring if power not present. Replace fuse with correct voltage and current rating if blown. Refer to technician
Fuse or circuit breaker blows a second time after replacement	Internal equipment fault	Refer to electrician or technician
Colored or metal wire visible in cable, socket or plug	Insulation damaged	Remove item and refer to electrician for repair. DO NOT cover with tape.
Cracks visible in socket or plug	Damaged cover	Remove item and refer to electrician for repair. DO NOT cover with tape.
Electrical shocks	Wiring fault	Refer to electrician

References :

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INDIANA UNIVERSITY. Laboratory Safety Guideline, Electrical Safety