

## 6.1 INTRODUCTION

You must be familiar with the saying that electricity is a good servant but a very bad master. We use electricity every day but most of us do not know about how it actually works. This lack of awareness sometimes leads to serious accidents. Have we not heard of instantaneous death due to electrical shocks, life long disability due to severe burns or devastating fires turning precious assets to ashes? These could be prevented with the knowledge of electricity rules, regulations and safety procedures. Therefore, it is absolutely essential that you should know what precautions to take while using electricity, more so because you are in the electricity industry.

The dangers arising from the generation, transmission, distribution or use of electricity supplied as well as in the installation, maintenance or use of any electric line or electrical apparatus are many. You should know the safety procedures involved in eliminating or reducing the risk of personal injury and damage to the property. Therefore, in this unit, you will study about the electricity rules, electrical safety procedures and the earthing practices.

In the next unit, you will learn about accident prevention and fire-fighting techniques. We should describe the first aid techniques and discuss how to manage a particular situation after an accident has occurred.

## 6.2 INDIAN ELECTRICITY RULES

Electricity Rules in India were first made by the Central Electricity Board in exercise of powers conferred under the Indian Electricity Act, 1910. These rules have been retained in the Electricity Act, 2003 and will continue to be in force until the regulations/rules under Section 53 of the Electricity Act, 2003 are framed. There are 143 rules in all and we discuss the relevant ones in brief.

We first state the definitions of different gradations of voltages as given by these rules (Table 6.1).

**Table 6.1: Definition of Different Grades of Voltages**

VOLTAGE	DEFINITION
Low Voltage	Not exceeding 250 V
Medium Voltage	Not exceeding 650 V
High Voltage	Not exceeding 33 kV
Extra High Voltage	Exceeding 33 kV

The first two rules give the title and definitions of the IE Rules. Rule 3 pertains to authorisation of persons engaged in generation, transformation,

transmission, conversion, distribution or use of energy. As per rule 3(2A), **no person should be authorized to operate or undertake maintenance of any part or whole of a generating station of capacity 100 MW and above together with the associated substation and other substations of 132 kV and above unless s/he is adequately qualified and has successfully undergone the type of training specified in the Indian Electricity Rules, 1956.** According to these Rules all work on major electrical installations should be carried out under the **permit to work system**, which provides in-built safety to the workforce engaged in electrical work (Box 6.1).

#### Box 6.1: Permit to Work System

As per this system, the permit to work has to be issued from the Power System Control (PSC) to the person authorized to carry out a given work. All work has to be carried out under the personal supervision of an authorized person. If more than one department is working on the same apparatus, a permit to work should be issued to authorized persons in charge of each work.

This system ensures that the portion of the installation where the work is to be carried out is rendered dead and safe for working. Such work should only be carried out with proper equipment provided for the purpose and after taking necessary precautions as per safe operating procedures, by specially trained and experienced persons who are aware of the danger that exists when working on or near live mains or apparatus.

The qualifications and powers of Inspectors and his/her assistants are mentioned in the **Rules 4 to 10. Rules 11 to 28** spell out the procedure for applying and obtaining licenses. **Rules 29 to 46** pertain to the general safety requirements and we state, in brief, the important ones:

- All electric supply lines and apparatus should be constructed, installed, worked and maintained in such a manner as to ensure the safety of personnel and property.
- Identification of earthed and earthed neutral conductors and position of switches and cut outs is a must. In the double pole switches, link should be provided instead of fuse carrier on the neutral conductor.
- Earthed terminal must be provided on consumer's premises. Earth pits should be constructed and maintained strictly as per relevant standards. The earth resistance of earth electrodes should not exceed 5 ohms.
- Danger Boards as per IS 2551 should be affixed permanently in a conspicuous position on every motor, generator, transformer and other electrical equipment.
- Instructions for restoration of persons suffering from electric shock should be written in English or Hindi or local language of the district and be affixed

by the owner in a conspicuous place in every generating station, enclosed switched station, etc.

- If any accident involving a human being or an animal occurs, a telegraphic report within 24 hours of the knowledge of the occurrence of the fatal accident and a written report in the form set out within 48 hours of fatal and other accidents should be sent to the electrical inspector. Where practicable, a telephonic message should be given to the Inspector immediately.
- Periodic inspection and testing of consumer's installation must be done at intervals not exceeding five years either by an Inspector or any officer appointed to assist the Inspector or by the supplier as directed by the Central Government.

**Rules 47 to 59** pertain to the general conditions relating to supply and use of energy. As per these rules, electrical installation works of a consumer should be carried out by a licensed contractor, the insulation resistance should be above the prescribed limit, the supplier should not permit the voltage, at the point of commencement of supply, to vary from the declared voltage as per the stipulations given ahead:

- in the case of low or medium voltage by more than 6%;
- in the case of high voltage, by more than 6% on the higher side and by more than 9% on the lower side; and
- in the case of extra high voltage, by more than 10% on the higher side and by more than 12.5% on lower side.

Moreover, a supplier should not permit the **frequency of an AC supply to vary from the declared frequency by more than 3%.**

There are rules pertaining to electric supply lines, systems and apparatus for low and medium voltages, high and extra high voltages, and additional provisions of supply to high voltage luminous tube sign installations, high voltage electrode boilers, X-ray and high frequency installations. **The supply of energy should not be commenced by the supplier unless and until the inspector is satisfied and the written approval of the Inspector has been obtained.** Overhead lines are covered under the **Rules 74 to 93.** The factor of safety for various supports is as under:

1) Metal supports	1.5
2) Mechanically processed concrete supports	2.0
3) Hand-moulded concrete supports	2.5
4) Wood supports	3.0

The minimum clearance above ground of the lowest conductors along and across a street is given in Table 6.2 and shown in Fig. 6.1.

Table 6.2: Minimum Clearance above the Ground, of the Lowest Overhead Conductor across and along a Street

VOLTAGE LINES PLACE	Low and Medium Voltage Lines	High Voltage Lines
Across the street	5.8 m	6.1 m
Along the street	5.5 m	5.8 m

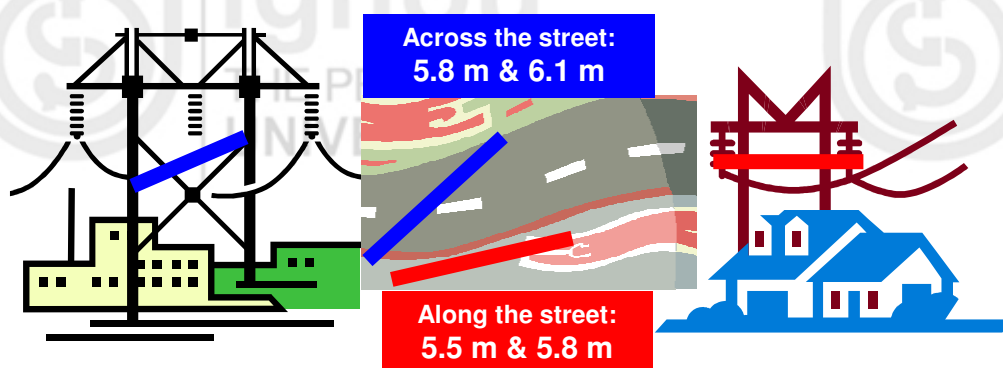


Fig. 6.1: Minimum Clearance of the Low, Medium and High Voltage Lines above the Ground across ( — ) and along ( — ) a Street

The clearance above ground of overhead line conductor erected elsewhere other than along or across street is given in Table 6.3.

Table 6.3: Clearance above the Ground of Overhead Line Conductors ELSEWHERE other than across or along a Street

VOLTAGE LINES	CLEARANCE ABOVE GROUND
Low, medium and high voltage lines up to 11kv (Bare)	4.6 m
Low, medium and high voltage lines up to 11kV (insulated)	4.0 m
High voltage lines above 11 kV	5.2 m
Extra high voltage lines	5.2 m plus 0.3 m for every 33kV

As per Rule 79, the minimum clearance from buildings of low and medium voltage lines and service lines is shown in Fig. 6.2.

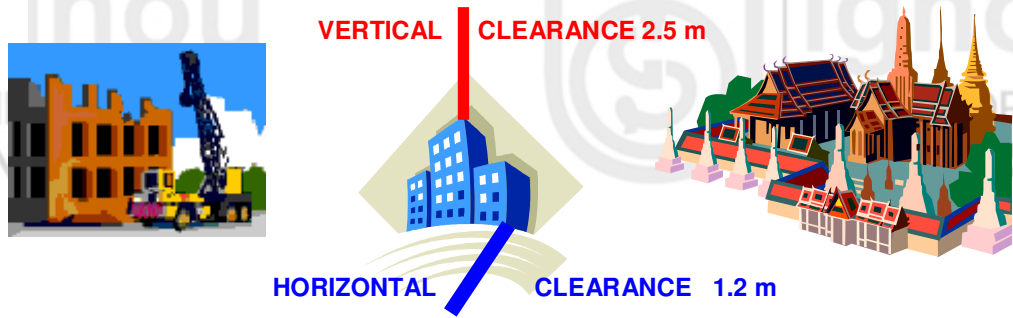


Fig. 6.2: Minimum Vertical and Horizontal Clearance of Low and Medium Voltage Lines and Service Lines from Buildings

Any conductor less than the above clearance should be adequately insulated and should be attached at suitable intervals to bare earthed bearer wire having a breaking strength of not less than 350 kg. As per Rule 80, the **clearance of high and extra high voltage lines from buildings** is as under:

- **Vertical clearance:**
  - a. **High voltage including 33kV** **3.7 m**
  - b. **Extra high voltage** **3.7 m + 0.3m**  
**for every additional 33kV or part thereof.**
- **Horizontal clearance:**
  - a. **High voltage up to 11 kV** **1.2 m**
  - b. **Voltage above 11 kV** **2.0 m**
  - c. **Extra high voltage lines** **2.0 m + 0.3m**  
**for every additional 33 kV or part thereof.**

**Rule 87** gives the minimum clearances between lines when crossing each other (Table 6.4).

Table 6.4: Minimum Clearance (in m) between Lines when Crossing Each Other

System Voltage	11 – 66 kV	110 – 132 kV	220 kV	400 kV	800 kV
Low and medium	2.44	3.05	4.58	5.49	7.94
11 – 66 kV	2.44	3.05	4.58	5.49	7.94
110 – 132kV	3.05	3.05	4.58	5.49	7.94
220 kV	4.58	4.58	4.58	5.49	7.94
400 kV	5.49	5.49	5.49	5.49	7.94
800 kV	7.94	7.94	7.94	7.94	7.94

Table 6.4 tells us, for example, that the minimum clearance between any two 11 – 66 kV lines should be 2.44 m. Similarly, the minimum clearance between the 11 – 66 kV lines and 110 – 132 kV lines should be 3.05 m when these cross each other, and so on.

**Rule 90** is about **earthing** and states that all metal supports and metallic fittings should be permanently and efficiently earthed. Each stay-wire should be efficiently earthed or an insulator provided in it at a height not less than 3.0 m from the ground.

**Rules 94 to 108** are about electric traction, **Rules 109 to 132** give the additional precautions to be adopted in mines and oil fields, and **Rules 133 to 143** cover miscellaneous aspects. **Rule 138 to 141** give the penalties for broken seal and for breach of other rules. **Rule 142** is about the application of rules and **Rule 143** about **Repeal**. Under this rule The Indian Electricity Rules, 1937 have been repealed: Provided that any order made, notification issued or anything done or any action taken under any of the said rules should be deemed to have been made, issued, done or taken under the corresponding provisions of the rules.

In this section, we have briefly acquainted you with the Indian Electricity Rules in force as on date. You may like to review them before studying further.

### SAQ 1: Indian Electricity Rules

State the Indian Electricity Rules related to the following:

- a) Reporting of fatal accidents.

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- b) Minimum clearances (vertical and horizontal) of various voltage lines from buildings and from each other.

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- c) General conditions relating to supply and use of energy.

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#### NOTE

The year 1789 is of great historical importance. It saw the outbreak of French Revolution and also ushered in the era of Industrial Revolution. The philosophy of that time was that accidents are an inevitable by-product of industrialization and that the worker is responsible for his/her own safety. However, in the year 1833, the world's **first Factory's Act** was enacted in **UK**. It was an important milestone in the evolution of the safety. The first successful **Workmen's Compensation Law** was enacted in the USA in 1911 which was another leap forward for mankind. The Factory's Act and Workmen's Compensation Act constitute the first phase of safety.

The Electricity Rules that you have studied in Sec. 6.2 reflect the overarching concerns for **SAFETY OF ALL INVOLVED IN WORKING WITH ELECTRICITY**.



We now discuss the safety procedures that should be followed by all persons working in the electricity industry.

### 6.3 SAFETY PROCEDURES

Let us begin by asking: **What do we understand by safety?**

**Safety means the state or condition of freedom from danger or risk. Safety can also be termed as freedom of persons from injury and of property from damage.** For this, you must first **create a safe work environment**, then **work in a safe manner**. Generally, it is best to remove the hazards altogether and create an environment that is truly safe. Safe work environments are created when the rules and regulations are followed strictly.

Always remember the motto of safety first as good work can be spoiled by an accident.



#### THE SAFETY MOTTO

**PREACH AND PRACTICE SAFETY AT ALL TIMES.**

But, you never know when materials or equipment might fail. Prepare yourself for the unexpected by using the safe work practices, which we now describe. Use as many safeguards as possible. If one fails, another may protect you from injury or death. **Certain important definitions related to various aspects of safety have been put together in Appendix 1 for ready reference.**

We first list the **general safety precautions** in Table 6.5 in the form of **DOs** and **DON'Ts**. The first and foremost requirement for safety is that **only qualified personnel should perform maintenance, inspection and repairs on any electrical equipment. Always evaluate personnel qualifications.**

Table 6.5: General Safety Precautions

DOs	DON'TS
Work deliberately and carefully. Haste causes many accidents; be sure of what you are doing.	Do not work on a pole or any elevated position if there is a live part on it, without the safety belt and rubber gloves and unless the authorized person stands on the ground nearby to direct operation and give warning.
Examine before use all safety appliances, such as rubber glove, mats, ladders, goggles, insulated pliers, etc., for their soundness.	Do not use a ladder without a lashing rope, otherwise the ladder should be held firmly by another person.

Test dates for integrity of equipment and protective clothing in an independent safety lab.	
<p>Ensure that operating procedures are up to date and appropriate for the given conditions.</p> <p>Always obey the safety instructions given by the person in charge.</p>	Do not remove Safety Tags or other signs or interface with safety barriers or go beyond them.
Wear required personal protective clothing (i.e., long sleeve shirt and long pants)- flame resistant materials for clothing (different weights for protection dependent on fault levels and clearing times).	Do not wear loose clothing, metal watch straps, bangles or finger rings while working on appliances.
Always report immediately to the person in charge or to any other proper authority of any dangerous condition or a practice, which you may observe.	Do not allow visitors and unauthorized persons to touch or handle any equipment or to come near the danger zone.
Ensure that all portable appliances are provided with 3 pin plug and socket connections. Also the metal work of the apparatus is effectively earthed.	Do not disconnect a plug by pulling the flexible cable or when the switch is on.
Always add the acid or soda to water and not vice-versa when mixing sulphuric acid or caustic soda and water.	Do not go carelessly near running belts on machines.
<p>Always be cautious while lifting or removing heavy apparatus or material.</p> <p>Before working on motor or other rotating machine, make sure that it cannot be set in motion without your permission. Motors with thermal protection can restart without warning, always lockout the motor before working on it.</p>	Do not hang clothes and such other things on electric fittings. Do not enter excavations which give out obnoxious smell.
Warn others when they seem to be in danger near live conductor or an apparatus.	Do not bring naked light near battery. Smoking in the battery room is prohibited.
Attend at once to all injuries however slight they may be.	Do not work in badly lit, badly ventilated and congested areas.



You may like to pause here and think: **How many of these safety procedures are followed meticulously by personnel in your utility?**

We now spell out the safety measures and recommendations that must be taken by personnel working on the mains and electrical apparatus for maintaining safe working conditions at the site.

### **6.3.1 Safety Procedures for Working on Electrical Mains and Apparatus**

Work on live mains should not be commenced unless it is specifically intended and done by specially trained staff. In such cases all possible precautions should be taken to ensure the safety of the staff engaged for such work, and also of others who may be directly or indirectly connected with the work. A safe work environment is created by controlling contact with electrical voltages and the currents they can cause. Electrical currents need to be controlled so they do not pass through the body. In addition to preventing shocks, a safe work environment reduces the chance of fires, burns, and falls.



#### **Create a Safe Work Environment**

**ALWAYS GUARD AGAINST CONTACT WITH ELECTRICAL VOLTAGES AND CONTROL ELECTRICAL CURRENTS TO CREATE A SAFE WORK ENVIRONMENT.**

You can make your environment safer by simply observing the following **preliminary precautions**:

- Treat all conductors – even "de-energized" ones – as if they are energized until they are locked out and tagged (see Box 6.2).
- Lock out and tag out circuits and machines.
- Prevent overloaded wiring by using the right size and type of wire.
- Prevent exposure to live electrical parts by isolating them.
- Prevent exposure to live wires and parts by using insulation.
- Prevent shocking currents from electrical systems and tools by grounding them.
- Prevent shocking currents by using Ground Fault Circuit Interrupters (GFCIs).
- Prevent too much current in circuits by using over-current protection devices.

### Box 6.2: Lock Out and Tag Out of Circuits and Equipment

### IE Rules and Safety Procedures

Locking out and tagging out circuits and machines is a must while working with electrical mains and apparatus. **Before working on a circuit, you must turn off the power supply.** Once the circuit has been shut off and de-energized, **lock out the switchgear to the circuit** so the power cannot be turned back on inadvertently. Then, **tag out the circuit with an easy-to-see sign or label that lets everyone know that you are working on the circuit.** If you are working on or near machinery, you must lock out and tag out the machinery to prevent startup. Before you begin work, you must test the circuit to make sure it is de-energized.



We would like to narrate a real-life incident to drive home the point about safety.

Two electricians working at an automobile assembly plant were replacing bulbs and making repairs on light fixtures in a spray paint booth. The job required them to climb on top of the booth and work from above. The top of the booth was filled with pipes and ducts that restricted visibility and movement. Flashlights were required.

The electricians started at opposite ends of the booth. One electrician saw a flash of light, but continued to work for about 5 minutes, then climbed down for some wire. While cutting the wire, he smelled a burning odor and called to the other electrician. When no one answered, he climbed back on top of the booth. He found his co-worker **in contact with a single-strand wire from one of the lights.** Needle-nose wire strippers were stuck in the left side of the victim's chest. Apparently, he had been stripping insulation from an improperly grounded 530-volt, single-strand wire when he contacted it with the stripper. In this case, the electricians knew they were working on energized circuits. The breakers in the booth's control panel were not labelled and the lock used for lock-out/tag-out was broken. The surviving electrician stated that locating the means to de-energize a circuit often takes more time than the actual job.

What lessons do you draw from this story? The electrician would be alive today if the following rules had been observed.

- **The circuits should always be shut off and then tested to confirm that they are de-energized before starting a job.**
- **Switch gear that shuts off a circuit must be clearly labelled and easy to access.**
- **Lock-out/tag-out materials must always be provided, and lock-out/tag-out procedures must always be followed.**

Table 6.6: Safety Precautions in Handling Mains and Apparatus

DOs	DON'Ts
Place Safety Tagging or other warning boards on main switch before commencing work. For example, place sign 'People at work' on the main switch.	Do not allow visitors and unauthorized person to touch or handle electrical apparatus or come within the danger zone of high voltage apparatus.
Before replacing a lamp or handling a fan, make sure that the supply is switched off.	Do not use a lamp in a metal holder fixed to the end of a loose flexible wire as a portable hand lamp.
For earthing and short-circuiting while working on dead mains and apparatus only appropriate methods (earthing chains, earthing rods etc.) should be used. Measures should be taken against the inadvertent energizing (back charging) of the mains and the apparatus.	Do not connect single pole switch or fuse in a neutral circuit, but always connect in the live or phase wire.
Use correct size and quality of fuse wire when renewing blown fuse.	Do not renew a blown fuse until you are satisfied as to the cause and have rectified any irregularity.
When removing fuse, pull out the supply end first and when replacing put the supply end at last.	Do not use copper wire as a substitute for fused wire.
Before working on any circuit or apparatus, make sure that the controlling switches are opened and locked or the fuse holders withdrawn.	<p>Do not touch or tamper with any electrical gear or conductor, unless you have made sure that it is dead and earthed. High voltage apparatus may give leakage shock or flashover even without touching.</p> <p>Do not close any switch, unless you are familiar with the circuit which it controls and know the reason for its being open.</p>
Always treat circuit as live until you have proved them to be dead, the insulation of the conductor may be defective.	Do not work on live circuits without the express orders of the person-in-charge. Make certain that all safety

	precautions have been taken and you are accompanied by a second person competent to render first-aid and artificial respiration.
<b>Guard against arcs as well as high voltage. Remember that burns from arcs may be very severe.</b>	<b>Do not disconnect earthing connection or render ineffective the safety gadgets installed on mains and apparatus.</b>
<b>Cultivate the habit of turning your face away whenever an arc or flash may occur.</b>	<b>Do not expose your eyes to an electric arc. Painful injury may result even with short exposure.</b>
<b>See that all the splices and connections are securely made.</b>	<b>Do not tamper with the meter boards and cut-outs, unless you are authorized to do so.</b>
<b>Use extreme care when breaking an inductive circuit as dangerously high voltage is likely to result.</b>	<b>Do not close or open a switch or fuse slowly or hesitantly; do it quickly and positively.</b>
<b>Thoroughly discharge to earth all cables before working on the cores.</b>	<b>Do not place any part of your body in circuit either to ground or across the terminal when making a connection or doing operation.</b>
<b>Test rubber gloves periodically.</b>	<b>Do not touch an electric circuit when your hands are wet or bleeding from a cut or abrasion.</b>  <b>Do not touch the circuit with bare fingers or hand or other makeshift devices to determine whether or not it is live.</b>
<b>Place rubber mats in front of electrical switch boards.</b>	<b>Do not work on energized circuits without taking extra precautions such as the use of rubber gloves and wooden handles.</b>

You may like to review these procedures before studying further. Attempt the following SAQ.

## SAQ 2: General safety procedures

- a) List the safety precaution you should take in each of the following case:
  - i. while replacing a fuse;
  - ii. while handling a fan;
  - iii. when you are near an arc; and
  - iv. when you have live circuits nearby.
- b) What should you not do
  - i. when breaking an inductive circuit?
  - ii. when working on live circuits?
  - iii. while handling high voltage apparatus?
  - iv. when replacing fuse?

## 6.4 EARTHING

We now discuss earthing, which is very important to ensure safety at your workplace. First and foremost, you must understand that electricity is always trying to get to the ground. If something that conducts electricity (like your body) gives electricity an easy path to the ground, it will take it. So if you touch an electric circuit and the ground at the same time, you will become electricity's easiest path. Electricity will flow through you, and you could be seriously hurt or killed. Earthing is carried out to provide a path to the electric current to flow to the ground. It thus ensures

- a) safety of personnel;
- b) prevents or at least minimizes damage to equipment as a result of flow of heavy fault currents; and
- c) improves reliability of power supply.

The systemic requirements for providing safe earthing are:

1. The systems designed and constructed for earthing should be capable of carrying current under normal and fault conditions to ground.
2. The earth path should be capable of handling the magnitude and duration of current as per the over-current protection of the system without any fire or flash or explosion.
3. Persons in the vicinity of earthed structures and installations should not be exposed to the dangers of electrical shocks.

Earthing practices adopted at Generating Stations, Substations, Distribution structures and lines are of great importance. Before discussing the earthing practices, we would like to state some definitions.

**Box 6.3: Definitions related to Earthing**

**Dead:** The term used to describe a circuit / equipment to indicate that a voltage is not applied.

**Live Part:** A conductor or conductive part intended to be energised in normal use including a neutral conductor.

**Neutral Conductor:** A conductor connected to the neutral point of a system and capable of contributing to the transmission of Electrical Energy.

**Earth Grid:** A system grounding electrodes consisting of inter connected connectors buried in the earth to provide a common ground for electrical devices and metallic structures.

**Earth Mat:** A grounding system formed by a grid horizontally buried conductor / plate, which serves

- dissipate the earth fault current to earth and
- as an equipotential bonding conductor system.

**Step Potential:** Step Potential is the difference in the voltage between two points which are one metre apart along the earth when ground currents flowing.

**Touch Potential:** Touch Potential is the difference in voltage between the object touched and the ground point just below the person touching the object when ground currents are flowing.

An effective grounding system must:

- provide a low impedance path to ground for personnel and equipment.
- withstand and dissipate repeated faults and surge currents.
- provide ample corrosion allowance to various chemicals to ensure continuous service during life of the equipment being protected.
- provide rugged mechanical properties for easy driving of earth electrodes with minimum.

All non current carrying metal parts associated with installation should

- be effectively earthed to a grounding system or mat which will limit the touch and step potential to tolerable values.
- limit the ground potential rise to tolerable values so as to prevent danger due to transfer of potential through ground, earth wires, cable sheath fences, pipe lines etc.
- maintain the resistance of the earth connection to such a value as to make operation of the protective device effective



The **statutory stipulations** for earthing are given below:

- All medium voltage equipment should be earthed by two separate and distinct connections.
- As far as possible, all earth connections should be visible for inspection.
- Each earth system should be so designed that testing of individual earth electrode should be possible.
- Resistance of earth system should conform to degree of shock protection desired.

#### **6.4.1 Safety Precautions for Earthing**

The precautions mentioned below should be adopted to the extent applicable and possible.

- **General Earthing Precautions**

1. Examine earthing devices periodically and always prior to their use.
2. Use only earthing switches or any other special apparatus where provided for earthing.
3. Verify that the circuit is dead by means of a discharging rod. The indicator itself should first be tested on a live circuit or proving unit before and after the verification.
4. Earthing should be done in such a manner that the persons doing the job are protected by earth connections on both sides of their working zone.
5. All the three phases should be effectively earthed and short circuited though work may be proceeding on one phase only.

- **Earthing of Overhead Lines**

- All metal supports and all reinforced and pre-stressed cement concrete supports of overhead lines and metallic fittings attached thereto should be permanently and effectively earthed. For this purpose a continuous earth wire should be provided and securely fastened to each pole and connected with earth ordinarily at three points in every km, the spacing between the points being as nearly equidistance as possible.
- Alternatively, each support and the metallic fitting attached thereto should be efficiently earthed.
- Metallic bearer wire used for supporting insulated wire of low and medium voltage overhead service lines should be efficiently earthed or insulated.
- Each stay wire should be similarly earthed unless insulator has been placed in it at a height not less than 3.0 m from the ground.

- **Earthing and Short – Circuiting Mains**

- High voltage mains should not be worked upon unless they are discharged to earth, after making them dead are earthed, short-circuited with earthing. Short circuiting equipment is adequate to carry possible short circuit currents. All earthing switches wherever installed should be locked up.
- If a cable is required to be cut, a steel wedge should be carefully driven through it at the point where it is to be cut.
- After testing the cable with DC voltage the cable should be discharged through 2 MΩ (mega-ohms) resistance and not directly owing to dielectric absorption, which is particularly prominent in the DC voltage testing of high voltage cables. The cable should be discharged for sufficiently long period to prevent rebuilding up of the voltage.
- The earthing device when used should be first connected to an effective earth. The other end of the device should then be connected to the conductors to be earthed.
- Except for the purpose of testing, phasing etc. the earthing and the short-circuiting devices should remain connected for the duration of the work.

- **Removing the Earth Connections**

On completion of work, removal of the earthing and short circuiting devices should be carried out in the reverse order to that adopted for placing, that is, the end of earthing device attached to the conductors of the earthed mains or apparatus should be removed first and the other end connected to earth should be removed last. The conductor should not be touched after the earthing device has been removed from it.

- **Testing and Record**

1. All earthing systems belonging to the utility should in addition, be tested for resistance on dry day during the dry season not less than once every two years.
2. A record of every earth test made and the result thereof should be kept by the utility for a period of not less than two years after the day of testing.
3. It should be available to the Electrical Inspector or any officer appointed to assist the Inspector and authorized.

Electrical repair and maintenance work should only be carried out with proper equipment provided for the purpose and after taking necessary precautions. We now describe the safety instructions for personnel working at the site. But before studying further, you may like to check your understanding.

### **SAQ 3: Earthing**

State whether the following statements about earthing are true or false:

- b) Proper earthing and use of insulated tools could avoid a majority of fatal accidents.
- c) If there is proper earthing, then there is no need for lightning arrestor.
- d) The difference in the voltage between two points which are one meter apart along the earth when ground currents are flowing is called step potential.
- e) The difference in voltage between the object touched and the ground point just below the person touching the object when ground currents are flowing is called touch potential.
- f) All metal supports and all reinforced and pre-stressed cement concrete supports of overhead lines and metallic fittings attached thereto should be permanently and effectively earthed.
- g) Only the phase on which work is being done should be effectively earthed and short circuited.

### **6.5 SAFETY AT THE WORK SITE**

Electrical maintenance work at the site should be done by specially trained and experienced persons who are aware of the danger that exists when working on or near live mains or apparatus. The safety equipment must always be in order. For this purpose, regular inspection and maintenance of the equipment is a must. We state below the safety procedures for the inspection of equipment.

#### **Inspection of Safety Equipment**

- All equipment used for working on overhead lines and apparatus should be surveyed every month by a responsible official and s/he should make random checks on the equipment to satisfy herself/himself that the equipment is in good condition.
- Special attention must be paid to the safety equipment such as safety belt, gloves, ropes used for hoisting, etc. as per schedule. Any replacement due to wear and tear should be made immediately.
- Every authorized person / in charge of a working party before commencing his/her work should ensure that all equipment being used is in safe condition and not weakened by deterioration, abrasion, etc. S/he should not permit the work to be carried out if, for any reason, s/he is in doubt that the equipment is unsuitable or deteriorated to the extent that it is likely to cause a hazard.

The safety precautions for **working on mains and apparatus** for different voltage ranges are different and you must know about all of them. Here we describe them briefly. **In each case only a competent and experienced person who is authorized to do so can be allowed to work. Such persons should take all safety measures as are required under the Indian Electricity Rules 1956.**

#### A. SAFETY INSTRUCTIONS FOR WORK UP TO AND INCLUDING 650 V

- **Work on dead mains and apparatus:** All mains and apparatus to be worked upon should be isolated from all sources of supply before starting work.
- **Work on live mains and apparatus:** Safety Tags should be attached on or adjacent to the live apparatus and at the limits of the zone in which work may be carried out, immediately before starting work. Rubber gauntlets, if used, should be thoroughly examined by authorized person / user to see whether they are in sound condition. Under no circumstances should a person work with unsound gauntlets, mats, stools, platforms or other accessories and proper testing should be carried out as per manufacturer's guidelines.
- **Connecting dead mains to live mains:** When dead mains are connected to live mains, all connections to the live parts should be made last, and in all cases the phases sequence should be checked to ensure that only like phases are connected together by testing Phase Sequence tester Rod and Phase Sequence Meter for HT and LT, respectively. Before inserting fuses or links in distribution pillar controlling the cable on which a fault has been cleared, each phase should first be connected through a test switch fuse lower than the value of the load.

#### B. SAFETY INSTRUCTIONS FOR WORK AT VOLTAGES ABOVE 650 V

##### General

- All high voltage mains and apparatus should be regarded as live and a source of danger and treated accordingly, unless it is positively known to be dead and earthed.
- No person should work on, test or earth mains or apparatus unless covered by a **permit to work** and after providing the mains dead except for the purpose of connecting the testing apparatus, etc. which is specially designed for connecting to the live parts.
- While working on mains, the following precautions should be taken:
  - When any live mains is to be earthed, the prescribed procedure should be followed scrupulously.

- The earths and short circuits, specified on the permit to work should not be removed or interfered with except by authority from the person in charge of the work.

#### **Minimum Working Distance**

- No person should work within the **minimum working distance** from the exposed live mains and apparatus. The minimum working distance depends upon actual voltages.
- Exposed live equipment in the vicinity should be guarded off and the guarding should be done in a manner so that it does not hinder the movement of the personnel. If necessary, a person for observing safety could be posted.
- All barriers, shutters, etc. of high voltage equipment should be kept locked except when required for carrying out work under a permit to work. The keys should be kept under the control of authorized persons only.

### **C. OPERATIONS OF SWITCHES AND ISOLATORS**

#### **General**

- No high voltage switch, isolator or earthing switch should be operated or earth connection attached or removed without the sanction of an authorized person, except in the case of moveable earth connection on high voltage overhead lines, which may be fixed or moved by an authorized person under the direction of the permit to work, which authorizes him to carry out the work.
- When a switching operation has to be carried out, the authorized person should convey his/her instructions to the operating person detailed to carry out the operations. On receipt of the instructions, the operating person should notify the authorized person of any objections to the carrying out of such instructions; the authorized person should then decide whether the work is to proceed.
- The authorized person should immediately after this, inform the Power System Control of his instructions and the objections if any. The authorized person should also inform the same receiving station of the operations he is to perform just prior to carrying them out, with objections if any. The procedure for delivering the message and logging them should be carried out in all cases. The two messages should be checked by Shift in charge / Shift Officer of Grid / PSC and clearance given for carrying out the work, if in order. On completion the authorized person should report back to the grid station and perform operations according to the guide lines of Power System Control.

#### **Emergency**

- In case of danger to life, switches may be opened without instructions but in no case must a switch be closed except with previous written



instruction or special permission from an authorized person or when a switch trips on temporary faults, and then only twice in succession.

- When any operation is carried out in an emergency in case of grave danger without the permit to work being issued or without emergency authorization or in case of trapping due to temporary faults, the grid station from which supply is received should be informed as soon as possible and the message logged on the log sheet. The number of the message on the log sheet should be marked in the report of occurrence. Such messages should also be conveyed immediately to higher authorities or the person authorized by them on their behalf.

#### D. TESTING OF MAINS AND APPARATUS

- No person should apply test voltage to any mains unless he has received a permit to work and has warned all persons working on the mains of the proposed application of the test voltage. If any part, which will thus become alive is exposed, the person in charge of the test should take due precautions to ensure that the exposed live portion does not constitute danger to any person. It should also be ensured before the application of test voltage, that no other permit to work has been issued for working on this main.
- **Authorization for Testing:** When equipment is isolated from the mains supply for the testing, the official responsible may give sanction for the operation of switches, isolators, earthing switches, earth connections, etc. and for the application of testing supplies to the isolated section, without reference to her/him. The person in charge of the testing then becomes wholly responsible for the safety precautions within the isolated sections but no switch or isolator connecting any isolated sections to the main supply system should be operated without direct sanction of the responsible official except for purpose of obtaining testing supplies.

**There are special devices for testing that the mains and electrical apparatus is dead.** We describe them briefly in the Box 6.4.

#### E. WORKING ON CABLES

- **Identification of Cables to be Worked Upon:** A cable should be identified as that having been proved dead prior to cutting or carrying out any operation which may involve work on or movement of the cable. A neon-contact indicating rod, induction testing set may be used for proving the cable dead. Simply with the help of neon-contact indicating rod, the cable should be checked after being switched off.
- **Working on High Voltage Cable:** Work on high voltage cables should be only permitted on receipt of the permit to work. In addition to the precautions taken, the person carrying out such work should be personally instructed on the spot by an authorized person who should first satisfy himself/herself that the cable has been made dead, isolated



and earthed and if possible, the switch controlling the cable drawn from the cubicle and suitable danger boards installed in position.

**Box 6.4: Devices for Proving Mains and Apparatus Dead**

**Voltage Indicators Rods (Neon Tester)**

**High voltage neon lamp contact indicator**

**rods** are used for proving exposed mains and apparatus dead. Each rod is fitted with an indicating neon bulb, (it should always be tested before using) which glows, when the contact end of the rod comes in contact with exposed live parts. Each rod is clearly marked for maximum voltage on which it may be safely used and should not, under any circumstances, be used on higher voltages.



**Contact Indicator and Phasing Rods**

**Contact indicator and phasing rods** are provided for phasing and proving exposed mains and apparatus dead. A set consists of two rods connected in series by a length of insulated rods. Both rods are fitted with contact tips and indicating tubes. When the contact tip of one rod is applied to exposed live part and that of the other to earth or other exposed live part provided there is sufficient voltage difference between the two, the indicating tubes should glow. Each set of rods is normally marked for the maximum voltage on which it can be safely used and should not, under any circumstances, be used on higher voltages.



**It should be ensured that all devices for proving high voltage mains and apparatus dead are marked clearly with the maximum voltage for which they are intended and should be tested periodically as per manufacturer guidelines.**

- **Working on Underground Cables**

- For isolation of cables, at least one set of disconnecting switches or fuses in every source through which the cables can be made alive including leads to the cable of potential transformers should be opened and then the cable should be discharged to the earth.
- Cable route indicators should be provided and cable route records maintained. It would access the particulars of all underground cables correctly in the vicinity of the faulty cable.
- **Use of sharp edged crowbars or pick axes should be avoided** during excavation while locating the faulty cable or laying new cable.
- All the cables in the vicinity in the fault area should be exposed and identified to establish the identification of the faulty cable.

- Before any high voltage joint or chamber is to be opened in circumstances where it is not desirable to spike the cables or earthing the joint or chambers, the authorized person should satisfy from cable route record and, if necessary, by approved tests that the joint or chamber is associated with the particular cable which has been made dead and it is safe to work on it.
- Employees should not step on live cables even though those are insulated and enclosed in a lead sheath. Tools and materials should not be rested against the sheath of the cable.

## **F. WORKING AT A HEIGHT**

Before any work is begun on any pole or tower of a high voltage overhead line, which is adjacent and parallel to any other high voltage overhead line with conductors “alive” or any pole or tower which supports, more than one set of high voltage conductors “alive” the following special precautions, in addition to the foregoing, should be taken in every case:

- The authorized person in charge of the work should ensure that each workman who is to work on the poles or towers is definitely informed and thoroughly understands on which set of conductors the work is to be carried out.
- A “red” flag / Caution Tape (or lamp at night) which are available with maintenance crew, should be displayed on the side of the pole or structure on which the conductors are “alive”.
- Work should not be performed on any higher position of tower / line when a line below is energized.

## **G. WORKING ON HIGH VOLTAGE APPARATUS AND OVERHEAD LINES**

**Work on high voltage apparatus:** Before commencing any work of repairs, alterations, extensions, additions or cleaning of high voltage apparatus, the following operations should be carried out in sequence.

1. The apparatus or cable or transmission line should be switched out and isolated from all points of supply under the direction of the authorized person.
2. The switches, isolators and control links should be locked in position by the keys provided for the purpose.
3. Safety Tags should be placed at all points where apparatus can be made alive.
4. All apparatus should be discharged to earth and efficiently connected to earth near all points from which supply could be connected to it or between such points and the place of the work. All earthing should be done by the approved methods. The earthing leads used for earthing should be of adequate cross section according to voltage levels to

enable passage of the fault current without fusing. Safety Tags should be removed only by an authorized person.

5. Earthing should also be carried out at the point of work by means of temporary earths on each phase and in no case should the temporary earths be removed from two phases simultaneously while the work is being carried out.

#### **H. WORKING ON LOWER PORTION OF TOWERS CARRYING LIVE LINES**

Painting and other work on the lower portion of towers or supports carrying live lines, and above the anti-climbing device may be permitted under the permit to work card provided that suitable precautions are taken to ensure that all persons carrying out work are acquainted with the distinctive marks (caution order) that have been placed on the tower and the support. For this purpose all the towers and the supports should be distinctly marked either by colour or by other positive manner above which no operation should be carried out without making the line dead. Distinctive marking should be so provided that it is not possible to get nearer than a minimum distance of 6 feet from a live conductor.

#### **I. WORKING ON DEAD LINES AND EQUIPMENTS**

- **Grounding of Lines and Equipments**

- Before doing any work on dead lines or equipment where there is a possibility of their becoming energized from any source, such line or equipment should be short circuited and grounded between the location of work and all possible sources of energy.
- Conductors to be grounded should be checked for potential by an approved method before the ground is installed.
- Temporary grounding cables should be flexible stranded copper not less than No.10 and should be equipped with approved clamps at each end.
- Grounding cables should be inspected before each use.
- When grounding lines or equipment, the connection to the ground should be made first and that to the circuit or equipment last. In removing grounds, first remove the connection to the circuit or apparatus and then remove the ground connection. Insulated hot-sticks should be used in making the ground connection to the circuit or apparatus.
- Grounds should be placed on all phases even if work is to be carried out on one phase only.
- For work on the line, ground should be placed at nearest tower on each side of the point of work, but in no case should earths be

more than six spans apart. As an additional safety measure, if possible, in addition to above grounds, line should also be grounded on the tower where the work is to be carried out.

- When work is to be carried out on lines of all-insulated construction and grounding point is not provided at point of work, temporary grounds should be connected at point of work to an efficient portable earth stake driven into the ground. The line should also be grounded at the nearest line grounding point on either side of the point of work.
- Where two or more crews are working independently on the same line or equipment, each crew should properly protect themselves by placing their own temporary grounds.
- **Line Work on Poles and Towers**
  - Before climbing any elevated structure, every employee should first assure himself that the structure is strong enough to sustain his weight safely.
  - If poles or cross arms are apparently unsafe because of decay or unbalanced tensions of wires on them, they should be properly braced or guyed before they are climbed.
  - Linemen should wear their safety lines while working on the poles and towers (Fig.6.3a). Wire hooks should not be attached to linemen's belts (Fig.6.3b).
  - Safety straps should not be placed above the top cross arm when it is at the top of the pole.



**Fig. 6.3: a) Full Body Safety Harness; b) This should not be Allowed**

- **Working on Lines Under Adverse Weather Conditions**

In the event of the near approach of lightning or thunderstorm all work on overhead lines should cease immediately.

## **J. WORKING ON SWITCHING OPERATIONS**

- Every message relating to the switching operations on the high voltage system should, wherever practicable, be written down. Every such message should be repeated in full to the sender to ensure that the message has been accurately received.
- A record of high voltage switching will be entered in station log.
- All breakers and isolators should bear lettering or sign boards to indicate the circuit they control.
- When releasing the electric circuits, breakers or equipment for work on them, the associated breaker and disconnecting switches should be opened in the following order:
  - the breaker will be opened first.
  - the isolator will be opened, but before operating the isolator, it should be made sure that the breaker is open.
- After opening isolators and air break switches, check carefully to see that all blades are in full open position.
- When lines and circuits are taken out of service, the breaker control circuit should be opened either by operating the opening device or by removing the control circuit fuses.
- If the circuit is controlled by automatic reclosing breaker, the reclosing mechanism should be made inoperative.
- Isolators should be closed in firm positive manner, using sufficient force to make full contact of blades.
- Before removing fuses, switches should be opened if provided. Removing fuses from inductive circuit carrying current without opening the switch is hazardous.

## **K. WORKING IN SUBSTATIONS**

- Safety Tags should be placed on all enclosures of high voltage equipment and wherever necessary warn persons of the presence of high voltage equipment. Safety audits should be conducted from time to time.
- Gates in switchyard fences and doors to switch gear and other enclosures containing live equipment, or other hazards, should be kept locked at all times except when Authorized Person has entered for working inside.
- When carrying ladders, pipes, conduits, reinforced rods and other long material into stations, switchyards, switch gear rooms and other places where there is a danger of touching the live parts, the material should



be held by two men, one at each end, and carried in the hands and not on the shoulders.

- When working in the vicinity of circuit breakers or buses every precaution should be used to avoid injury from arcing.
- The area where personnel are working on H.T. equipment should be guarded off wherever possible.

#### **L. WORKING ON TRANSFORMER**

1. When work is to be carried out on a transformer, both low and high tension breakers and isolators should be opened. Similarly, during isolation of transformers to which potential transformers are connected, such potential transformers should be isolated.
2. Before starting any work on a transformer installation, it is important to check carefully for back feed, abnormal voltage or other dangerous conditions. Unusual circuit conditions may exist which require special consideration.
3. Whenever transformers are replaced, the new transformer should be checked carefully for voltage, polarity and phase sequence before taking into service.
4. Area should always be cordoned off and Safety tagging should be done prior to starting the job on the transformer.

- **Working on Instrument Transformers**

- The cases of all instrument transformers should be grounded.
- The secondary coils of current transformers should never be open circuited when current is flowing in the primary.
- The secondary circuit of current transformers should be connected to ground at all times when the transformer is in service.
- The secondary coils of potential transformers should never be shorted.
- The low voltage winding of potential transformers should always have one side permanently and effectively grounded.

- **Working On Pole Mounted Substations (Distribution Transformer)**

The following precautions should be observed in case of carrying out work on the pole-mounted substations (i.e., distribution transformers).

- The work should be carried out under a permit to work.
- Before changing or replenishing oil or painting, all exposed live parts of the transformers should be disconnected.
- While working on poles that have lightning arresters installed on them, the workman should avoid touching lightning arresters and lightning arresters jumper.



- **Working on Filtering of Transformer Oil**

When carrying out the work of filtering the oil in transformers, care should be exercised that all exposed live conductors are suitably barricaded so that no person and no apparatus such as flexible hose etc. that is being handled comes in contact with the live parts. All such work should be carried out under the direct supervision of an authorized person.

### **M. WORKING ON CIRCUIT BREAKERS**

For isolation purposes it should be ensured that

- Disconnecting switches on sides, control switches, relay trip blocking switches and compartments' doors are open.
- Mechanical blocking, wherever necessary, to prevent unauthorized movement of the mechanism is installed.
- In OCBs trip-free feature should be blocked.

### **N. WORKING ON METAL CLAD, SWITCH GEAR AND CONTROL PANEL**

- While working on manually operated panel mounted circuit breakers when the operating handle is on the front and the circuit breaker is on the rear of switchgear or on another panel, a danger notice should be placed on the handle.
- When the work is to be carried out on the bus bars spouts the following operations should be carried out:
  - The section of bus bars on which the work is to be carried out should be made dead and should be isolated from all points of supply.
  - The isolating arrangements and the shutters of live spouts should be locked so that they cannot be operated.
  - Where duplicate switches in one tank or on load bus bar isolators are installed and is impossible to isolate them from all points of supply, then all switches and selectors that could be closed on the bus bars on which work is to be carried out should have their mechanism locked in the open position and the closing mechanism should be made inoperative.
  - The bus bar should be earthed with approved earthing equipment at a panel other than at which work is to be done and the isolated section of the bus bars.

### **O. WORKING ON OUTDOOR STRUCTURES**

- **Bus Bars**
  - In isolating the point of work from supply, care should be taken to disconnect right points in case of sectionalized, and/or mesh

schemes of bus bars. Isolators/switches closing on the section of bus bars on which work is to be carried out should be locked in open position and the closing mechanism rendered inoperative.

- While working on the outdoor structure at a height more than 3 m from the ground level, safety equipment such as safety belts, handling, etc. should be used.
- No person should stand directly below the place of work when the work is in progress in the outdoor structure to avoid any tools or bolts or nuts or clamps, etc. falling on their heads.
- Helmets should be invariably used while working on the outdoor structures, both by the persons stationed at the ground and those on the structures.

- **Capacitors**

- Every capacitor should be treated as hot until proved otherwise. Capacitors store energy and are not necessarily dead when disconnected from the line. Once charged, a capacitor may retain its charge for several hours after it has been disconnected.
- When a capacitor is to be worked on, first open all cutouts or disconnecting devices to the capacitor, then wait for at least five minutes for the internal resistors to reduce the voltage. Next, using the hot stick (discharge rod), short circuit and ground all terminals of the capacitors. These terminals should remain short circuited and grounded while work is being done on the capacitor.
- To bring the capacitor banks back into service, first remove the jumpers with hot sticks, and then close the cut-outs.

- **Lightning Arrestor**

No work should be done on the lightning arrestor unless it is disconnected from the line circuit and grounded at both the lines and ground terminals.

## **P. WORKING ON STORAGE BATTERIES**

- When making electrolyte for storage batteries always pour acid into the water. The reverse method may cause an explosion. Suitable goggles or face shields should always be worn when making electrolyte. Ensuring the usage of Personnel Protection Equipment by staff is the responsibility of the Shift Officer.
- Smoking and use of matches or other open flames are not permitted in battery rooms or while inspecting filling, testing or handling batteries.

### Q. WORKING ON PORTABLE LAMPS AND APPLIANCES

- Ensure that all portable appliances are provided with 3-pin plug and socket connections and the metal work of the apparatus is effectively earthed.
- Always use portable hand-lamps of the insulated safety type and provided with a rubber, plastic or wooden handle and wire-guard.
- Do not use a lamp in a metal holder fixed to the end of a loose flexible wire as a portable hand-lamp.
- Do not disconnect a plug by pulling the flexible cable or when the switch is ON.
- Do not plug in any portable lamp or apparatus before making sure that the switch is **OFF** and that the wall plug is properly inserted in the socket.

So far, we have explained to you the various safety procedures that have to be strictly followed while working with electrical mains and apparatus. You may like to review these procedures in real-life situations. Here is an exercise for you.

#### SAQ 4: How safe is your work environment?

Observe the personnel working on electrical mains and apparatus in various sections of the utility described in this section. Go through the procedures described for that particular part. Are those being observed faithfully? Assess the safety of your work environment through this survey.

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With this we would like to end the unit and present its summary.

### 6.6 SUMMARY

- In this unit, you have learnt about the Indian Electricity Rules that, in essence, spell out the requirements of working in electrical installations. As per rule 3(2A), **no person should be authorized to operate or undertake maintenance of any part or whole of a generating station of capacity 100 MW and above together with the associated substation and other substations of 132 kV and above unless s/he is adequately qualified and has successfully undergone the type of training specified in the Indian Electricity Rules, 1956.**

- According to these Rules all work on major electrical installations should be carried out under the **permit to work system**. **These rules cover various aspects such as** the qualifications and powers of Inspectors and their assistants, the procedure for applying and obtaining licenses, the general safety precautions, the general conditions relating to supply and use of energy, minimum clearances of overhead lines, **earthing**, electric traction, additional precautions to be adopted in mines and oil fields, penalties for broken seal and for breach of other rules, repeal and miscellaneous aspects.
- There are rules pertaining to electric supply lines, systems and apparatus for low and medium voltages, high and extra high voltages, and additional provisions of supply to high voltage luminous tube sign installations, high voltage electrode boilers, X-ray and high frequency installations. **The supply of energy should not be commenced by the supplier unless and until the inspector is satisfied and the written approval of the Inspector has been obtained.**
- The Electricity Rules that you have studied in Sec. 6.2 reflect the overarching concerns for **SAFETY OF ALL INVOLVED IN WORKING WITH ELECTRICITY**. You have learnt about the **general safety precautions**. The first and foremost requirement for safety is that **only qualified personnel should perform maintenance, inspection and repairs on any electrical equipment. Always evaluate personnel qualifications.**
- The safety measures and recommendations that must be taken by personnel working on the mains and electrical apparatus for maintaining safe working conditions at the site have been spelt out.
- The objectives of earthing, its requirements and stipulations as well as earthing practices at various sites have been explained.
- You have also learnt about safety procedures involved in working at various voltages, with electrical equipment such as switches and isolators, cables, testing of mains and apparatus, working at a height, on towers, deadlines and equipment, switching operations, substations, transformers, circuit breakers, metal clad, switch gear and control panel, outdoor structures like Bus Bars, capacitors, lightning arrestor, storage batteries, portable lamps and appliances.

## 6.7 TERMINAL QUESTIONS

1. Point out the violations of electricity rules and safety procedures in the two incidents described below:
  - A worker was replacing a V-belt on a dust collector blower. Before beginning work, he shut down the unit at the local switch. However, an

operator in the control room restarted the unit using a remote switch. The worker's hand was caught between the pulley and belts of the blower, resulting in cuts and a fractured finger.

- An employee was cutting into a metal pipe using a blowtorch. Diesel fuel was mistakenly discharged into the line and was ignited by his torch. The worker burned to death at the scene.

2. Fill in the blanks in the check list given below using the words given in the box in the margin:

shut-offs  
unlocked  
key  
grounding  
re-energize  
qualified  
sources  
switchgear  
tag  
generators  
de-energized

- Identify all .....of electrical energy for the equipment or circuits in question.
- Disable backup energy sources such as .....and batteries.
- Identify all .....for each energy source.
- Notify all personnel that equipment and circuitry must be shut off, locked out, and tagged out. (Simply turning a switch off is NOT enough.)
- Shut off energy sources and lock .....in the **OFF** position. Each worker should apply his or her individual lock. Do not give your .....to anyone.
- Test equipment and circuitry to make sure they are..... This must be done by a .....person.
- Deplete stored energy by bleeding, blocking, ....., etc.
- Apply a .....to alert other workers that an energy source or piece of equipment has been locked out.
- Make sure everyone is safe and accounted for before equipment and circuits are ..... and turned back on. Note that only a qualified person may determine when it is safe to .....circuits.

3. Discuss electrical safety procedures for working with

- a) voltages up to 650 V and beyond
- b) transformers
- c) overhead lines
- d) underground lines
- e) switchgear
- f) towers
- g) high voltage equipment

4. Explain the earthing requirements in a substation.

5. Describe the safety precautions related to the earthing of various electrical installations.



## APPENDIX: IMPORTANT DEFINITIONS

**AUTHORIZED PERSON:** An authorized person is a person authorized under Rule No.3 of the Indian Electricity Rule 1956 to carry out such duties incidental to the transmission, distribution and use of electrical energy, the nature of which should depend upon the technical knowledge and experience of the individual and he should not be less in authority than a linesman, jointer, fitter and mechanic.

**HAZARD:** It is any unsafe act or unsafe condition that may lead to injury of persons or damage to property.

**EMERGENCY:** Emergency means that an unusual condition exists which endangers life and / or property.

**PROTECTIVE DEVICES:** It means equipment specially designed for the protection of workmen and includes fire extinguishers.

**APPROVED:** When applied to articles of protective equipment mean that these articles have been specified for use as per IS Codes or by the approval authority (i.e. Safety Concerns Committee) established by the Head (Operations).

**QUALIFIED:** Qualified means any person who has adequate knowledge of the hazards involved in any operation.

**EARTH:** Earth means the conducting mass of earth or a conductor / strip / wire connected to it through very small impedance.

**ELECTRICAL EQUIPMENT:** It means all the electrical apparatus pertaining to the sub transmission, distribution and utilization of electrical energy.

**EMPLOYEE:** Employee means a person who is in receipt of pay, salary and other benefits from the company time to time in lieu of services rendered by him.

**ISOLATED:** It means physically disconnected from all possible sources of supply.

**PERMIT TO WORK:** It means a form of declaration issued by an Authorized Person to another Authorized Person (sub transmission / distribution) of a work to be carried out on any equipment in normal and break down conditions.

**POWER SYSTEM CONTROL:** It means the main controlling agency which controls & coordinates all switching operations of entire network (sub transmission and distribution) including issue of PTW.

**WORKING PARTY:** It means the persons under the immediate supervision of an Authorized Person.