GOVERNMENT POLYTECHNIC, SONEPUR

ELECTRICAL INSTALLATION AND ESTIMATING

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THE INDIAN ELECTRICITY RULES

Definitions

"**Ampere**" means a unit of electric current.

"**Accessible**" means within physical reach without the use of any appliance or special effort.

"**Apparatus**" means electrical apparatus and includes all machines, fittings, accessories and appliances in which conductors are used.

"**Bare**" means not covered with insulating materials.

"**Cable**" means a length of insulated single conductor (solid or stranded or of two or more such conductors, each provided with its own insulation, which are laid up together. Such insulated conductor or conductors may or may not be provided with an overall mechanical protective covering.

"**Circuit**" means an arrangement of conductor or conductors for the purpose of conveying energy and forming a system or a branch of a system.

"**Circuit breaker**" means a device, capable of making and breaking the circuit under all conditions, and unless otherwise specified, so designed as to break the current automatically under abnormal conditions.

"**Voltage**" means the difference of electric potential measured in volts between any two conductors or between any part of either conductor and the earth as measured by a suitable voltmeter and is said to be.

"Low" where the voltage does not exceed 250 volts under normal conditions subject, however, to the percentage variation allowed by these rules.

"Medium" where the voltage does not exceed 650 volts under normal conditions subject, however, to the percentage variation allowed by these rules.

"High" where the voltage does not exceed 33,000 volts under normal conditions subject, however, to the percentage variation allowed by these rules.

"Extra high" where the voltage exceeds 33,000 volts under normal conditions subject, however, to the percentage variation allowed by these rules.

"**Conductor**" means any wire, cable, bar, tube, rail or plate used for conducting energy and so arranged as to be electrically connected to a system.

"**Live**" means electrically charged.

"**Dead**" means at or about earth potential and disconnected from any live system.

"**Cut-out**" means any appliance for automatically interrupting the transmission of energy through any conductor when the current rises above a predetermined amount, and shall also include fusible cutout.

"**Conduit**" means rigid or flexible metallic tubing or mechanically strong and fire resisting non-metallic tubing into which a cable or cables may be drawn for the purpose of affording it or them mechanical protection.

"**System**" means an electrical system in which all the conductors and apparatus are electrically connected to a common source of electric supply.

"**Danger**" means danger to health or danger to life or any part of body from shock, burn or other injury to persons, or property, or from fire or explosion, attendant upon the generation, transmission, transformation, conversion, distribution or use of energy.

"**Installation**" means any composite electrical unit used for the purpose of generating, transforming, transmitting, converting, distributing or utilizing energy.

"**Earthed**" or "connected with earth" means connected with the general mass of earth in such manner as to ensure at all times an immediate discharge of energy without danger.

"**Earthing system**" means an electrical system in which all the conductors are earthed.

"Span" means the horizontal distance between two adjacent supporting points of an overhead conductor.

"**Volt**" means a unit of electromotive force and is the electric pressure, which, when steadily applied to a conductor, the resistance of which is one ohm, will produce a current of one ampere.

"**Switch**" means a manually operated device for opening and closing or for changing the connection of a circuit.

"**Switchgear**" shall denote switches, circuit breakers, cut-outs and other apparatus used for the operation, regulation and control of circuits.

GENERAL SAFETY PRECAUTIONS

Rule-29: Construction, installation, protection, operation and maintenance of electric supply lines and apparatus.

Rule-30: Service lines and apparatus on consumer's premises.

Rule-31: Cut-out on consumer's premises.

Rule-32: Identification of earthed and earthed neutral conductors and position of switches and cut-outs therein- Where the conductors include an earthed conductor of a two-wire system or an earthed neutral conductor of a multi-wire system or a conductor which is to be connected.

Rule-33: Earthed terminal on consumer's premises.

Rule-34: Accessibility of bare conductors- Where bare conductors are used in a building, the owner of such conductors shall.

Rule-35: Caution Notices (Danger Notices)- The owner of every medium, high and extra-high voltage installation shall affix permanently in a conspicuous position a danger notice in Hindi or English and the local language of the district, with a sign of skull and bones.

Rule-36: Handling of electric supply lines and apparatus.

Rule-40: Street boxes: Street boxes shall not contain gas pipes, and precautions shall be taken to prevent, as far as reasonably possible, any influx of water or gas.

Rule-41: Distinction of circuits of different Voltages - The owner of every generating station, sub- station, junction-box or pillar in which there are any circuits or apparatus, whether intended for operation at different voltages or at the same voltage, shall ensure by means of indication of a permanent nature that the respective circuits are readily distinguishable from one another.

Rule-43: Provisions applicable to protective equipment.

Rule-44: Instructions for restoration of persons suffering from electric shock.

Rule-45: Precautions to be adopted by consumers [owner's occupiers], electrical contractors, electrical workmen and suppliers.

Rule-46: Periodical inspection and testing of consumer's installation

GENERAL CONDITIONS RELATING TO SUPPLY AND USE OF ENERGY

Rule-47: Testing of consumer's installation.

Rule-48: Precautions against leakage before connection.

Rule-49: Leakage on consumer's premises.

Rule-50: Supply and use of energy.

Rule-51: Provisions applicable to medium, high or extra-high voltage installations- The following provisions shall be observed where energy at medium, high or extra- high voltage is supplied, converted, transformed or used.

Rule-54: Declared voltage of supply to consumer. - Except with the written consent of the consumer or with the previous sanction of the State Government a supplier shall not permit the voltage at the point of commencement of supply as defined under rule 58 to vary from the declared voltage(In the case of low or medium voltage, by more than 5 per cent).

Rule-55: Declared frequency of supply to consumer- Except with the written consent of the consumer or with the previous sanction of the State Government a supplier shall not permit the frequency of an alternating current supply to vary from the declared frequency by more than 3 per cent.

Rule-56: Sealing of meters, and cut-outs.

Rule-57: Meters, maximum demand indicators and other apparatus on consumer's premises.

Rule-58: Point of commencement of supply- The point of commencement of supply of energy to a consumer shall be deemed to be the point at the incoming terminal of the cut-outs installed by the consumer under rule 50.

Rule-59: Precautions against failure of supply: Notice of failures.

ELECTRIC SUPPLY LINES, SYSTEMS AND APPARATUS FOR LOW AND MEDIUM VOLTAGES

Rule-60: Test for resistance of insulation.

Rule-61: Connection with earth.

Rule-62: Systems at medium voltage- Where a medium voltage supply system is employed, the voltage between earth and any conductor forming part of the same system shall not, under normal conditions, exceed low voltage.

ELECTRIC SUPPLY LINES, SYSTEMS AND APPARATUS FOR HIGH AND EXTRA HIGH VOLTAGES

Rule-63: Approval by Inspector.

Rule-64: Use of energy at high and extra-high voltage.

Rule-65: Testing, Operation and Maintenance.

Rule-66: Metal sheathed electric supply lines. Precautions against excess leakage.

Rule-67: Connection with earth.

Rule-68: General conditions as to transformation and control of energy.

Rule-70: Condensers- Suitable provision shall be made for immediate and automatic discharge of every static condenser on disconnection of supply.

OVERHEAD LINES

Rule-73: Material and strength.

Rule-74: Joints: Joints between conductors of overhead lines shall be mechanically and electrically secure under the conditions of operation. The ultimate strength of the joint shall not be less than 95 per cent of that of the conductor, and the electrical conductivity not less than that of the conductor.

Rule-75: Maximum stresses: Factors of safety.

Rule-76: Clearance above ground of the lowest conductor.

Rule-77: Clearance between conductors and trolley wires.

Rule-78: Clearances from buildings of low and medium voltage lines and service lines.

Rule-79: Clearances from buildings of high and extra-high voltage lines.

Rule-80: Conductors at different voltages on same supports.

Rule-86: Lines crossing or approaching each other.

Rule-87: Guarding.

Rule-88: Service lines from Overhead lines- No Service line or tapping shall be taken off an overhead line except at a point of support.

Rule-89: Earthing.

Rule-90: Safety and protective devices

Fuses

Fuse is a short piece of metal, inserted in the circuit, which melts when excessive current flows through it and thus breaks the circuit.

The fuse element is generally made of materials having **low melting point**, **high conductivity** and **least deterioration** due to oxidation *e.g.*, **silver, copper** etc. It is inserted in series with the circuit to be protected. Under normal operating conditions, the fuse element is at a temperature below its melting point. Therefore, it carries the normal current without overheating. However, when a short circuit or overload occurs, the current through the fuse increases beyond its rated value. This raises the temperature and fuse element melts (or blows out), disconnecting the circuit protected by it. In this way, a fuse protects the machines and equipment from damage due to excessive currents.

The function of a fuse is to carry the normal current without overheating but when the current exceeds its normal value; it rapidly heats up to melting point and disconnects the circuit protected by it. In order that it may perform this function satisfactorily, the fuse element should have the following desirable characteristics:

1. Low melting point *e.g.*, tin, lead.
2. High conductivity *e.g.*, silver, copper.
3. Free from deterioration due to oxidation *e.g.*, silver.
4. Low cost *e.g.*, lead, tin, copper.

Current rating of fuse element: It is the current which the fuse element can normally carry without overheating or melting. It depends upon the temperature rise of the contacts of the fuse holder, fuse material and the surroundings of the fuse.

Fusing current: It is the minimum current at which the fuse element melts and thus disconnects the circuit protected by it. Obviously, its value will be more than the current rating of the fuse element.

For a round wire, the approximate relationship between fusing current I and diameter d of the wire is

$$= k\, d^{3/2}$$

Where k is a constant, called the fuse constant. Its value depends upon the metal of which the fuse element is made.

Fusing factor. It is the ratio of minimum fusing current to the current rating of the fuse element *i.e.*

$$\text{Fusing factor} = \frac{\text{Minimum fusing current}}{\text{Current rating of fuse}}$$

Cut off current. It is the maximum value of fault current actually reached before the fuse melts.

Protective relay

The detection of a fault and disconnection of a faulty section or apparatus can be achieved by using fuses or relays in conjunction with circuit breakers.

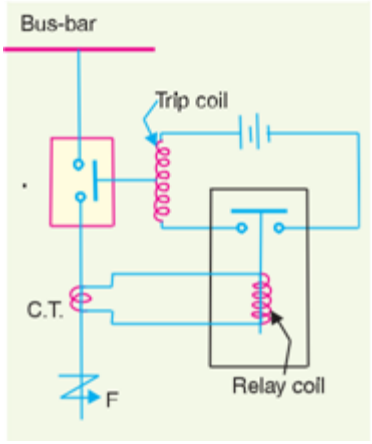
Protective relay is a device that detects the fault and initiates the operation of the circuit breaker to ioslate the defective element from the rest of the system.

This diagram shows one phase of 3-phase system for simplicity. The relay circuit connections can be divided into three parts,

First part is the primary winding of a current transformer (C.T.) which is connected in series with the line to be protected.

Second part consists of secondary winding of C.T. and CB . the relay operating coil.

Third part is the tripping circuit which may be either a.c. or d.c. It consists of a source of supply, the trip coil of the circuit breaker and the relay stationary contacts.



When a short circuit occurs at point *F* on the transmission line, the current flowing in the line increases to an enormous value. This results in a heavy current flow through the relay coil, causing the relay to operate by closing its contacts. This in turn closes the trip circuit of the breaker, making the circuit breaker open and isolating the faulty section from the rest of the system. In this way, the relay ensures the safety of the circuit equipment from damage and normal working of the healthy portion of the system.

Circuit Breakers

A circuit breaker is a piece of equipment which can

(i) make or break a circuit either manually or by remote control under normal conditions

(ii) break a circuit automatically under fault conditions

(iii)make a circuit either manually or by remote control under fault conditions

Wire and Cable

Electric power can be transmitted or distributed either by overhead system or by underground cables. The underground cables have several advantages such as less liable to damage through storms or lightning, low maintenance cost, less chance of faults, smaller voltage drop and better general appearance.

Underground Cables

An underground cable essentially consists of one or more conductors covered with suitable insulation and surrounded by a protecting cover.

Although several types of cables are available, the type of cable to be used will depend upon the working voltage and service requirements. In general, a cable must fulfil the following necessary requirements,

(1) The conductor used in cables should be tinned stranded copper or aluminium of high conductivity. Stranding is done so that conductor may become flexible and carry more current.

(2) The conductor size should be such that the cable carries the desired load current without overheating and causes voltage drop within permissible limits.

(3) The cable must have proper thickness of insulation in order to give high degree of safety and reliability at the voltage for which it is designed.

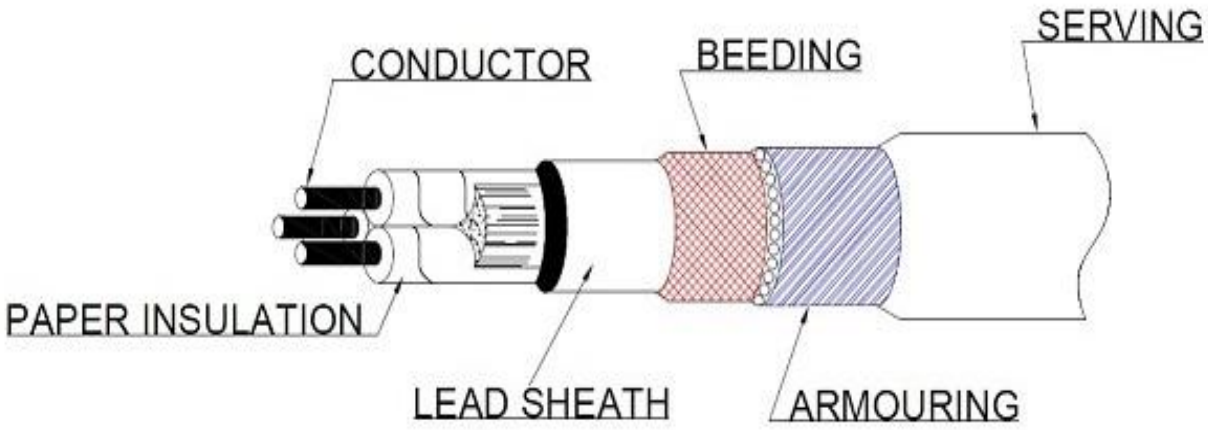
(4) The cable must be provided with suitable mechanical protection so that it may withstand the rough use in laying it.

(5) The materials used in the manufacture of cables should be such that there is complete chemical and physical stability throughout.

Construction of Cables

Cores or Conductors: A cable may have one or more than one core (conductor) depending upon the type of service for which it is intended. For instance, the 3-conductor cable shown in Fig. is used for 3-phase service. The conductors are made of tinned copper or aluminium and are usually stranded in order to provide flexibility to the cable.

Insulation: Each core or conductor is provided with a suitable thickness of insulation, the thickness of layer depending upon the voltage to be withstood by the cable. The commonly used materials for insulation are impregnated paper, varnished cambric or rubber mineral compound.



Metallic sheath: In order to protect the cable from moisture, gases or other damaging liquids (acids or alkalies) in the soil and atmosphere, a metallic sheath of lead or aluminium is provided over the insulation as shown in Fig.

Bedding: Over the metallic sheath is applied a layer of bedding which consists of a fibrous material like jute or hessian tape. The purpose of bedding is to protect the metallic sheath against corrosion and from mechanical injury due to armouring.

Armouring: Over the bedding, armouring is provided which consists of one or two layers of galvanised steel wire or steel tape. Its purpose is to protect the cable from mechanical injury while laying it and during the course of handling. Armouring may not be done in the case of some cables.

Serving: In order to protect armouring from atmospheric conditions, a layer of fibrous material (like jute) similar to bedding is provided over the armouring. This is known as serving.

Classification of Cables

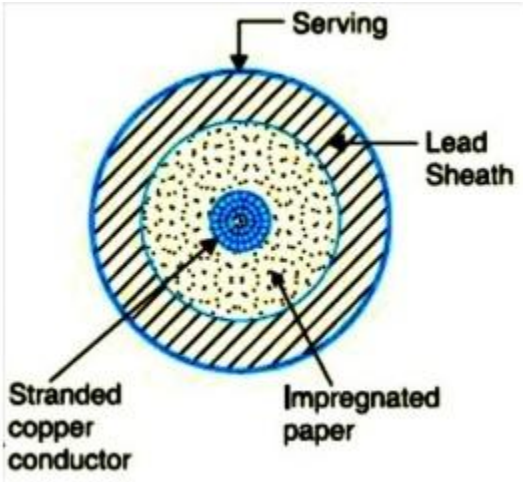
Low-tension (L.T.) cables — upto 1000 V

High-tension (H.T.) cables — upto 11,000 V

Super-tension (S.T.) cables — from 22 kV to 33 kV

Extra high-tension (E.H.T.) cables — from 33 kV to 66 kV

Extra super voltage cables — beyond 132 kV



A cable may have one or more than one core depending upon the type of service for which it is intended. It may be (*i*) single-core (*ii*) two-core (*iii*) three-core (*iv*) four-core etc. For a 3-phase service, either 3-single-core cables or three-core cable can be used depending upon the operating voltage and load demand.