This content is only for academic/education purpose. This should not be copied or reproduced anywhere by other than author.

Electrical Safety at LPG Plants

Rajeev Narula, GM I/c (H,S&E), NR, IOCL (Mktg. Div.)

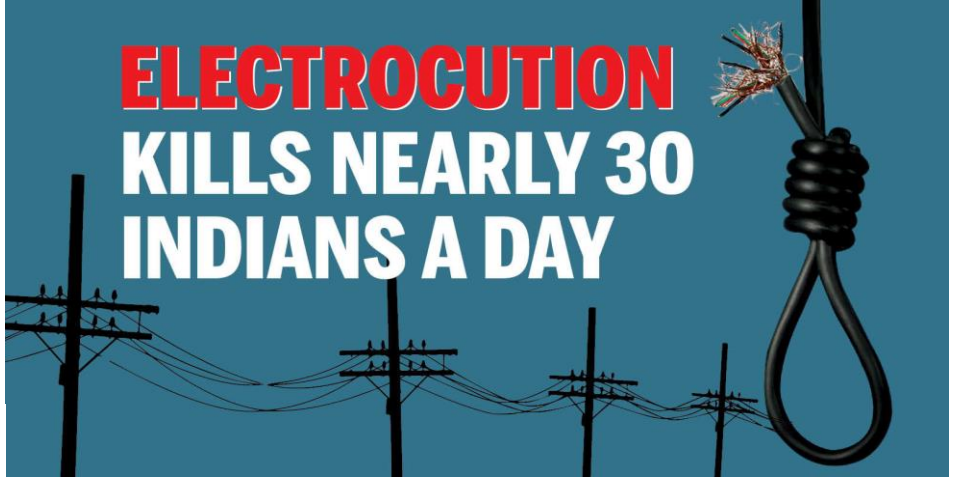
24.05.2024 (Friday)

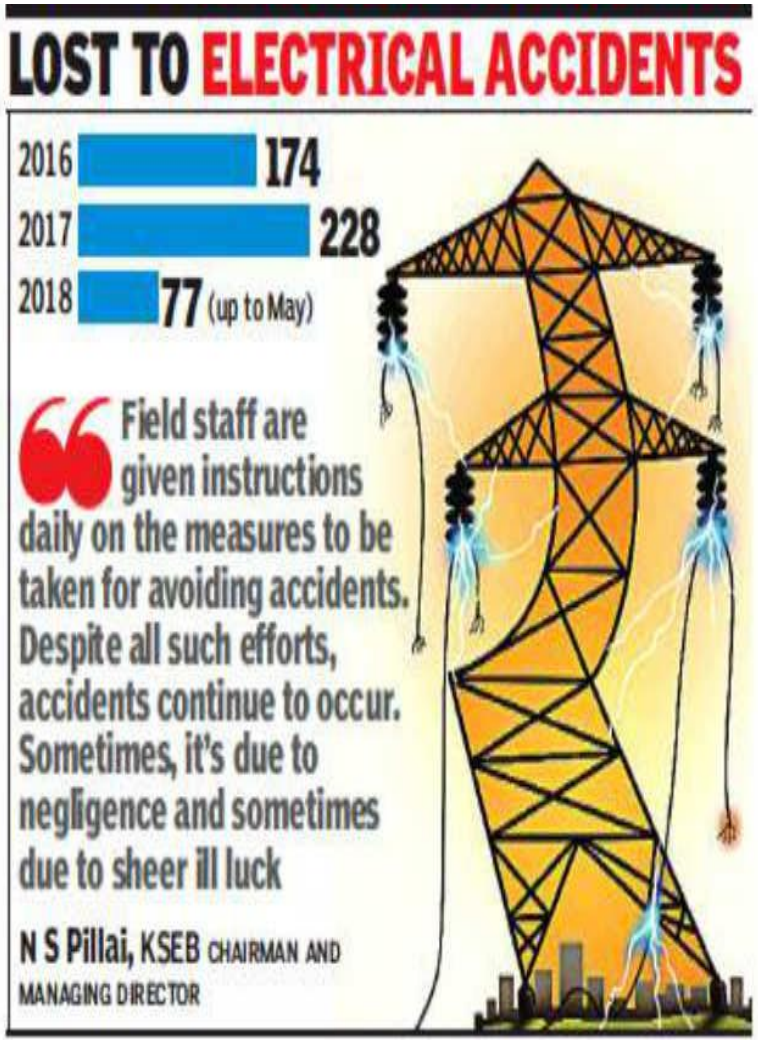
Agenda

- Overview of electrical hazards
- Electrical installation
- Statutory Requirements
- Best Engineering Practices

This content is only for academic/education purpose. This should not be copied or reproduced anywhere by other than author.

Overview of electrical hazards





Workplace accidents report nearly **13 electrocution deaths on an average day** in **India**. This is the highest in the world.

The **annual average** of electric-RELATED DEATHS IN workplaces in the **United Kingdom and the United States is 8 and 82**, respectively.

The Hindu Feb 9, 2019

- Shock : Primary & Secondary effects
- Burns : Thermal contact, Electrical, Arc/ flash
- Electrocution : Death
- Fire

1 mA	Barely perceptible
16 mA	Maximum current an average man can grasp and "let go"
20 mA	Paralysis of respiratory muscles
100 mA	Ventricular fibrillation threshold
2 A	Cardiac standstill and internal organ damage

From NIOSH
(National Institute for Occupational Safety and Health), US

Electrical Burns



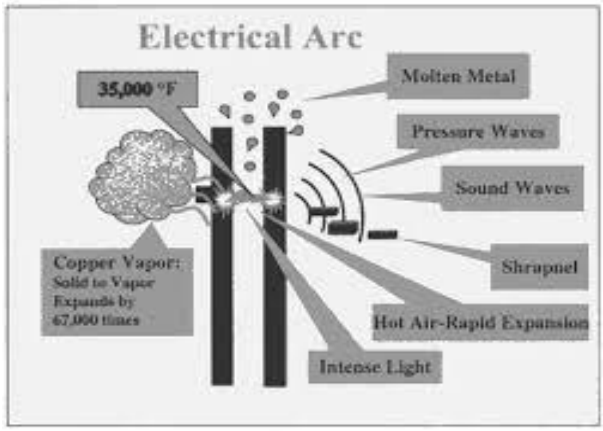


Thermal contact Burns

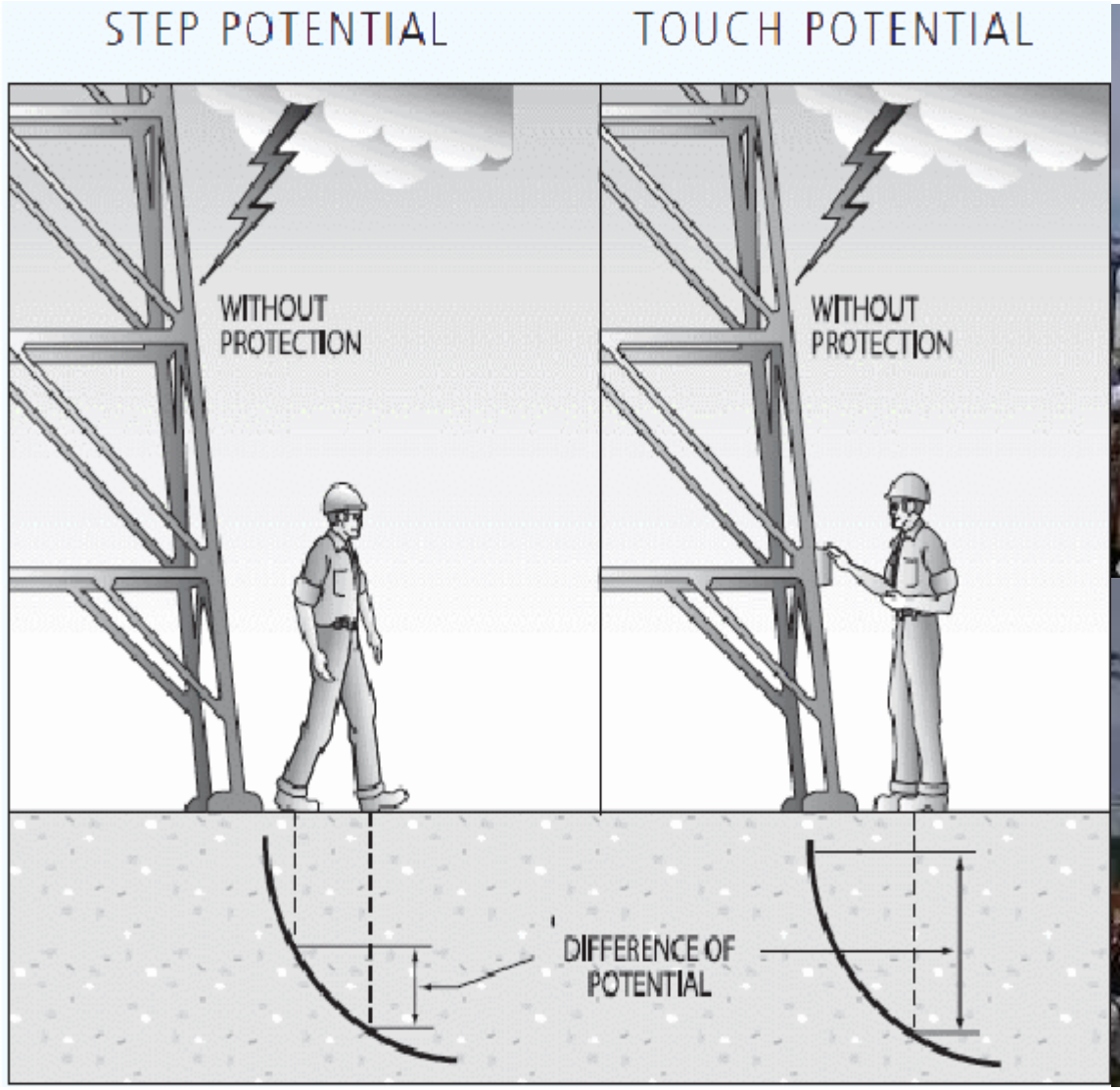


Arc/ Flash Burns





ELECTROCUTION





Reasons for most electrical accidents

- **Unsafe equipment or installation**

- equipment/ cables rated lower than loads,
- use of non-standard materials,
- wiring by untrained electricians
- Unsuitable test equipment
- - Poor maintenance

- **Unsafe environment**

- no guarding,
- no grounding,
- no tripping devices

Unsafe work practices

-inspection / repairs on energized equipment,
-not following LOTO,
-Unsafe system of work
-not maintaining electrical tools,
-working near energized lines without precautions,
-not using appropriate PPE,
-engaging non trained electricians
-Inadequate information
-Poor control of work activities

Statistics shows approximately 40 % fires in buildings are due to electrical reason viz. short circuit in low voltage system (up to 250 V).

1 kg of plastic insulation material used in electrical system creates almost 500 cubic meters of thick toxic smoke.

Causes of short circuits :

- vermin or pests chewing through wires
- water or other fluids coming into contact with electrical wiring
- loose connections in an electrical box
- old or damaged outlets, switches, lights, appliances, or other electrical devices
- nails or screws piercing through walls and coming into contact with wires
- deterioration of electrical cable sheathing
- build-up or electricity surges

Solutions

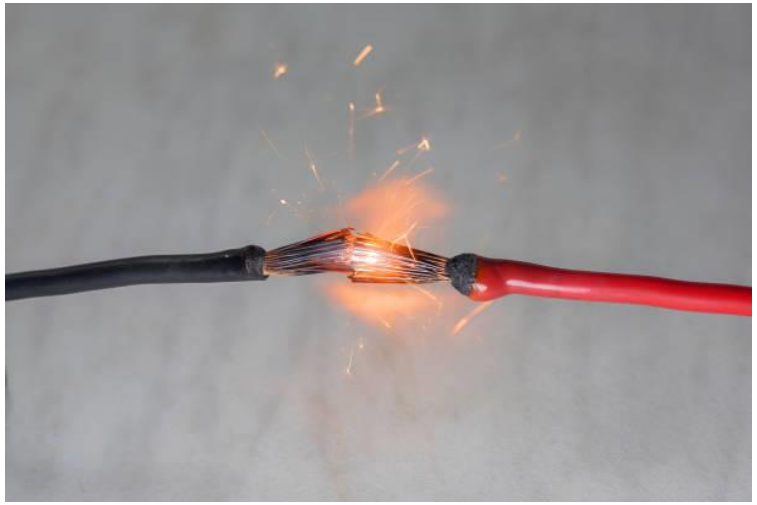
- Vermin proofness of panels
- Providing covers
- Periodic checks & M&R thru qualified electricians
- Electrical inspections & audits
- Cable insulation resistance test
- Provision of surge arrestors

Types of Short Circuits

1. **Phase to neutral short** : the phase or hot wire touches a neutral wire.

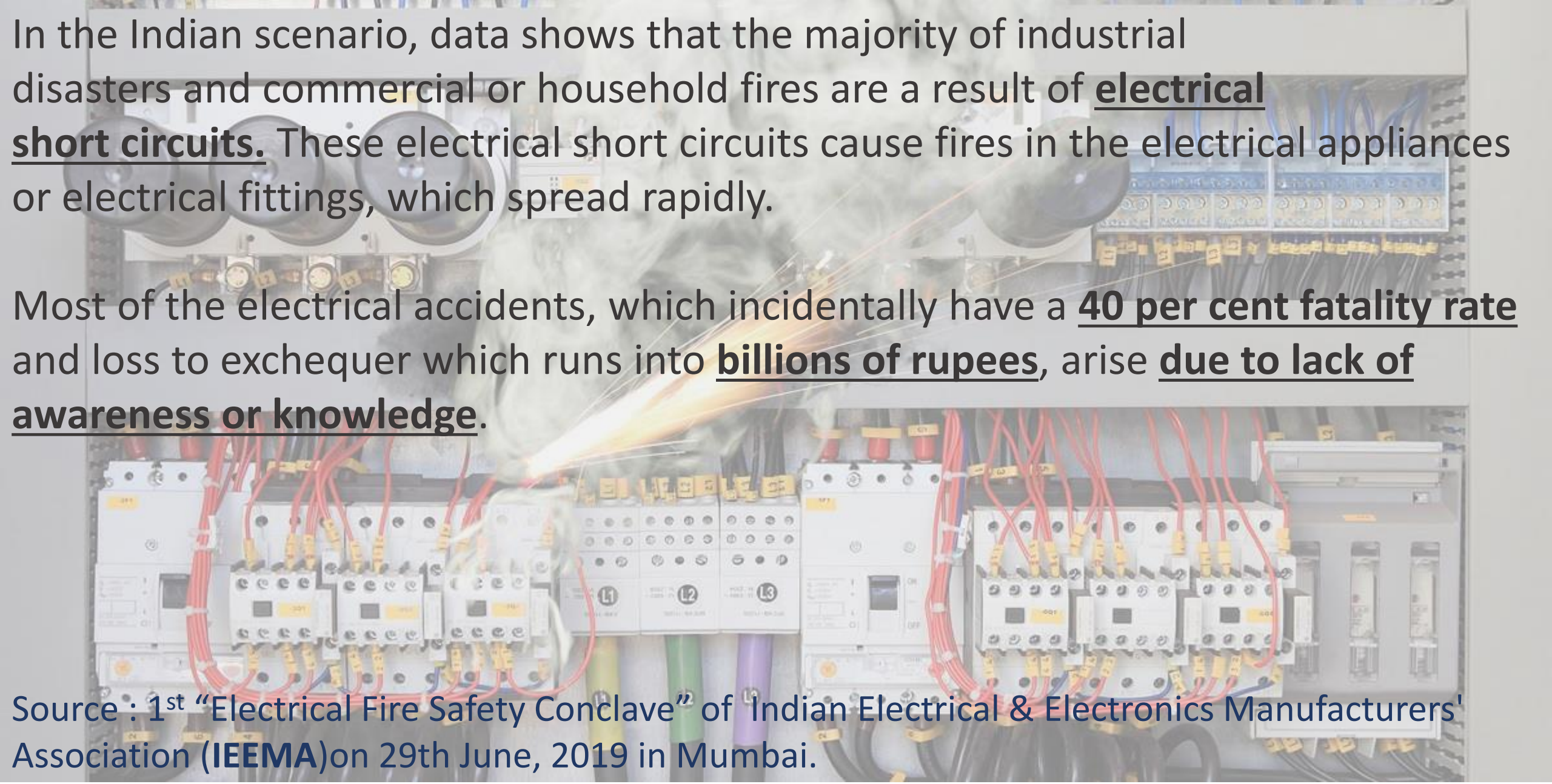
2. **Phase to earth short** : the phase or hot wire touches the enclosure body.

When a short circuit occurs, **electrical current experiences little or no resistance** because its path has been diverted from its normal direction of flow. This in turn produces excess heat and can damage or destroy an electric appliance.



In the Indian scenario, data shows that the majority of industrial disasters and commercial or household fires are a result of **electrical short circuits.** These electrical short circuits cause fires in the electrical appliances or electrical fittings, which spread rapidly.

Most of the electrical accidents, which incidentally have a **40 per cent fatality rate** and loss to exchequer which runs into **billions of rupees**, arise **due to lack of awareness or knowledge**.



Source : 1st "Electrical Fire Safety Conclave" of Indian Electrical & Electronics Manufacturers' Association (**IEEMA**)on 29th June, 2019 in Mumbai.

CASE STUDY

At an LPG BP during construction activities, hot work was planned during night shift. Around midnight, the SEB supply got tripped & the DG set was started by the contractor. However, while the ACB of DG got ON, the power supply to the busbar could not get ON as the bus coupler could not be put ON. It was repeatedly tripping each time it was attemped to be put ON.



The Engineering I/c was called on phone, who advised to get the panel checked by a local electrician. A local electrician from the nearby village was called & he tried to check the power supply between the bus bars on input & output of the bus coupler using a test lamp.

As soon as he put the test lamp across the bus bars, the lamp exploded & he got electrocuted.

Can we identify the violations that led to this incident ?

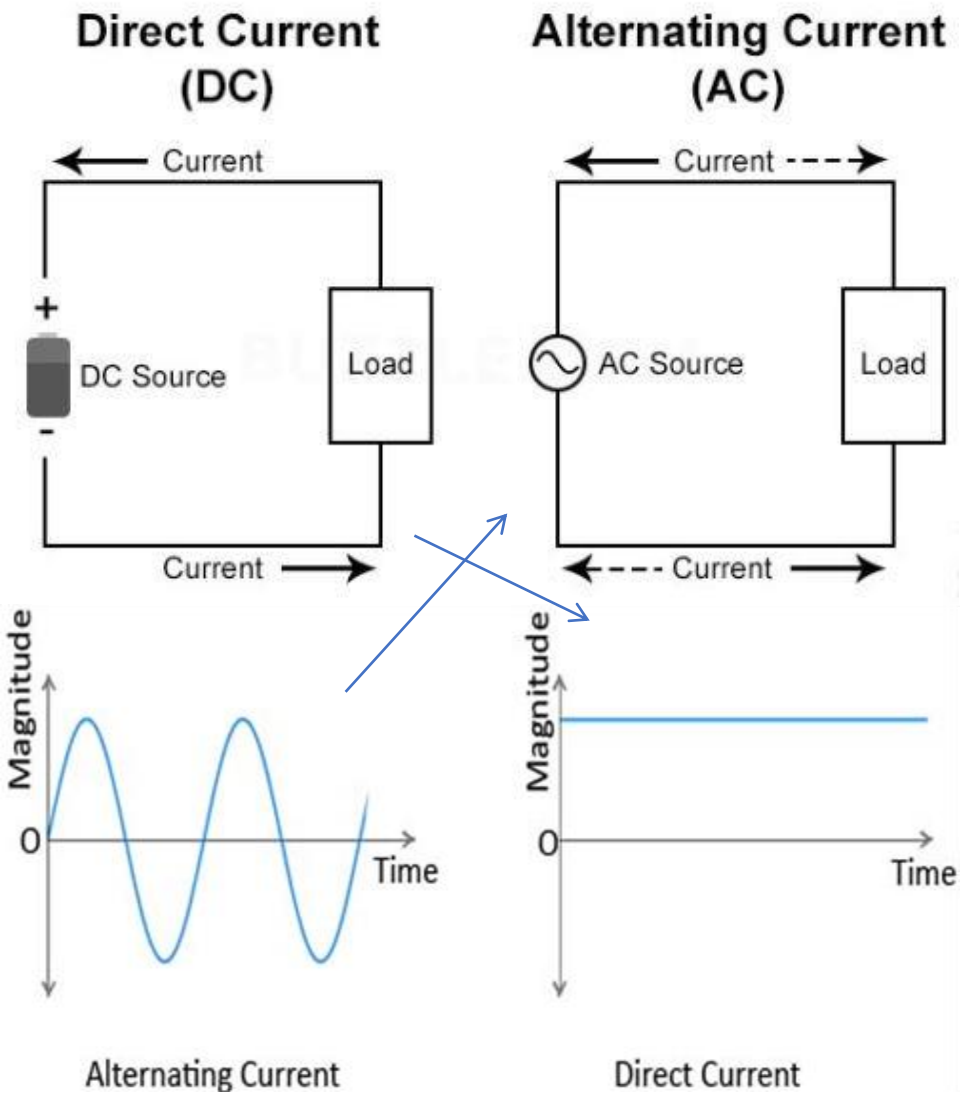
What else could have been done to avoid this incident ?

This content is only for academic/education purpose. This should not be copied or reproduced anywhere by other than author.

Electrical installation

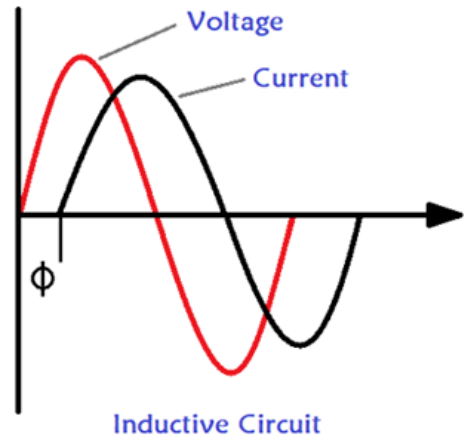
Electrical equipment in use & the circuit configuration

Gang Operated Switch/ 3 pole isolator VCB (Vacuum circuit breaker) CT/PT (current transformer/ potential transformer)	**High Voltage side**
Power Transformer	**Voltage transformation**
ACB (Air circuit breaker) CT/PT DG (Diesel generator)/ Solar PV (phot voltaic) MCC (Motor control centre) Motors Lights Electronic equipment	**Medium & low voltage side**

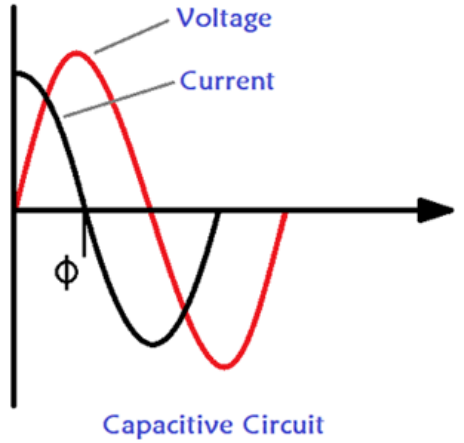


Lagging

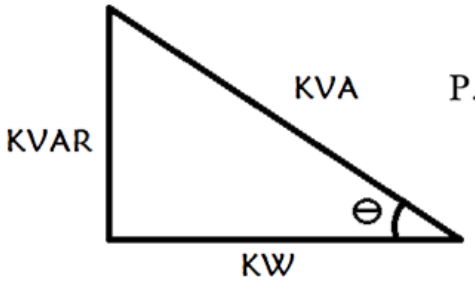
Leading



Inductive Circuit

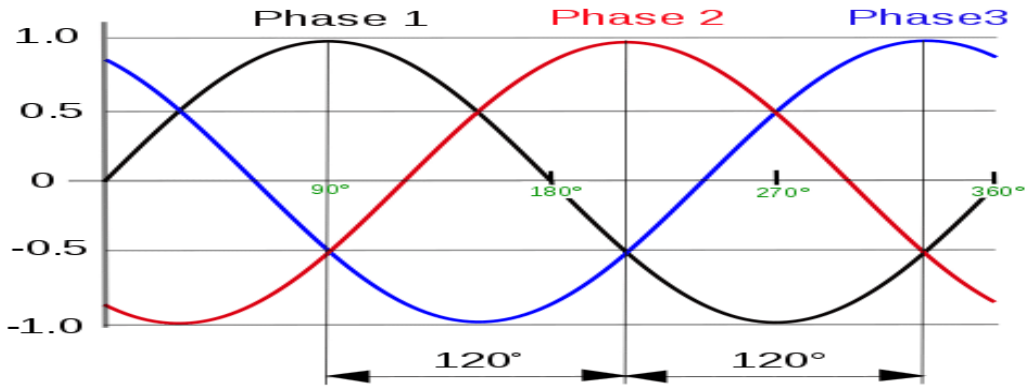


Capacitive Circuit



$$P.F. = \frac{\text{Actual Power}}{\text{Apparent Power}} \quad \text{or} \quad P.F. = \text{Cos}\Theta$$

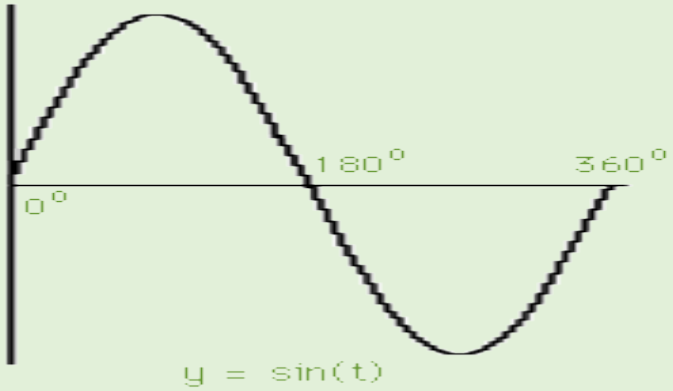
KW = KVA x PF



Cos 0 = 1,
Cos 30 = √3/2 (0.866),
Cos 45 = 1/√2 (0.707),
Cos 60 = ½ (0.5),
Cos 90 = 0

MCC receives 3 phase ac supply from transformer or DG set in the form of a 4 wire system : 3 phases (Red, Yellow & Blue) & neutral (Black) wires.

Voltage between phases is 415/ 440 V & between phase & neutral is 220/ 230 V.
Frequency is 50 Hertz (cycles/sec)







SINGLE LINE DIAGRAM

M/s INDIAN OIL CORPORATION LIMITED
ROORKEE TERMINAL, HARIDWAR (UTTARAKHAND)- 247664

DRAWING TITLE:- SINGLE LINE DIAGRAM

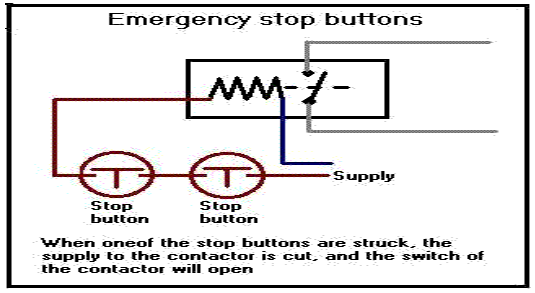
M/s TECHELECTRO CONSULTING
New Delhi-110072
Mob:-9958425615, 9971223549
E- Mail:- info@techelectro.in, techelectro.consulting@gmail.com

PREPARED BY :-	Mr. SHYAM SUNDER SINGH		SCALE:-	Not t
CHECKED BY :-	Mr. AKANSHA SINGH (Sr. Ops. Officer)	Drawing no:- TEC/D-30	DATE:-	14/

Interlocking of two supply sources

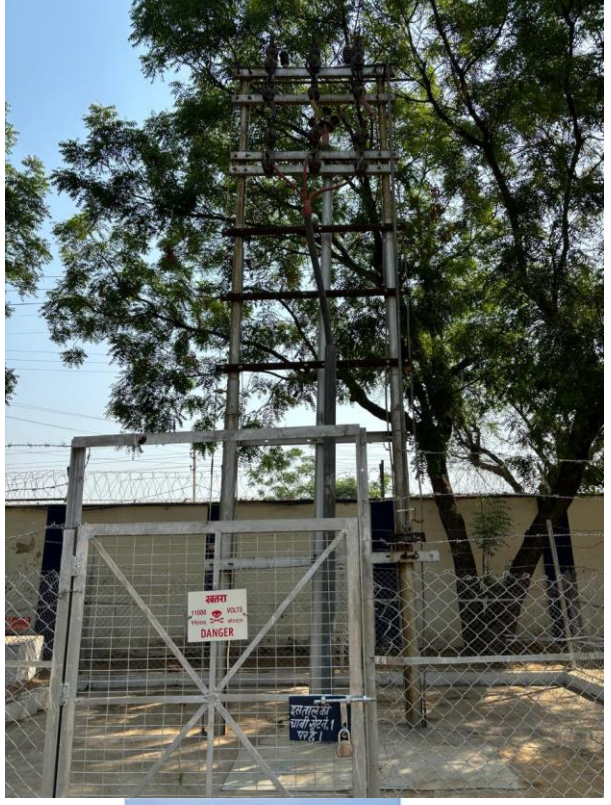






Electrical Isolator

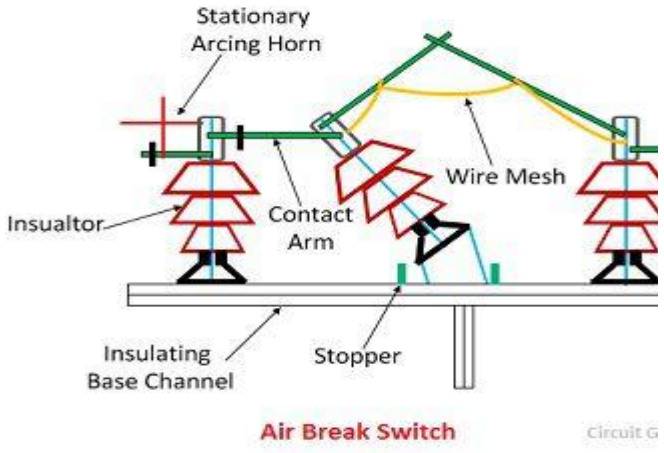
It is a type of mechanical switch used to isolate a fraction of the electrical circuit. Isolator switches are used for opening an electrical circuit in the no-load condition. It is not proposed to be opened while current flows through the line.



Load Break Switch

A load break switch or LBOR is designed to switch the power "on or off" or change the position when the transformer is energized.

Types of LBOR : Air, RF, SF6





Overhead uninsulated line

Onstream inspection item	Frequency
• Condition of hardware, supporting structure & conductors • Abnormal sagging & clearances • Joints in Over Head line • Continuity of earth conductors • Provision of guards, anticlimbing devices, danger sign & phase markings • Presence of vegetation • Damage to insulator/ other devices • Earthing of stay wire	Quarterly
Inspection of OH line & ground clearance of guard wire	Turn around

OISD STD 137

Switchyard equipment : Isolator, CT, PT, LA, Support insulators

Onstream inspection item	Frequency
• Overheating & sparking of contacts, Visual inspection of earth connection, Cleanliness & damages, availability of grass	Weekly
Shutdown inspection item	
• Condition of insulators, alignment between contacts of isolator, insulation resistance, earth resistance	Annual



Outdoor switchboard

Onstream inspection item	Frequency
• Earthing of fence, gauge, insulator support & metallic structure • Corrosion of fence & metal structures • Locking of fence gate & isolator handles • Condition of fire partition walls • Condition of earth electrodes • Accessibility for operation & maintenance	Half yearly
Illumination	Yearly



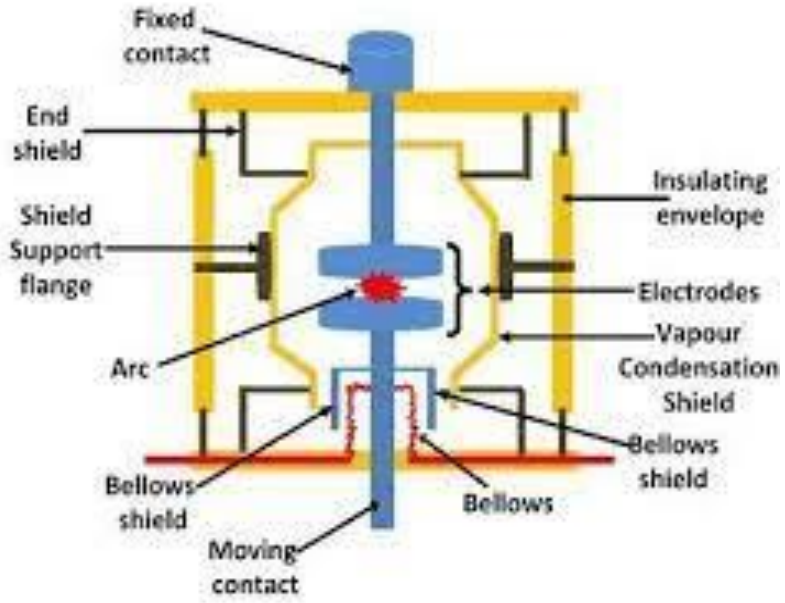
Vacuum circuit breaker (VCB)



VCB are used for voltages in the range of 11 kV to 33 kV. They use vacuum as an arc quenching medium. The vacuum chamber is a steel arc chamber in the center-symmetrically arranged ceramic insulators. Copper-bismuth or copper-chrome are the ideal material to make VCB contacts.
The vacuum of the order of 10^{-6} torr is used (1 torr = 1mm of Hg). The breaker's movable contacts travel a distance of 5 to 10 mm.
They have better arc quenching features than ACBs/ OCBs & have a longer expected life (ACB – 10 to 15 years, OCB – 25 years, VCB - 30-40 years).







Protection provided in VCBs

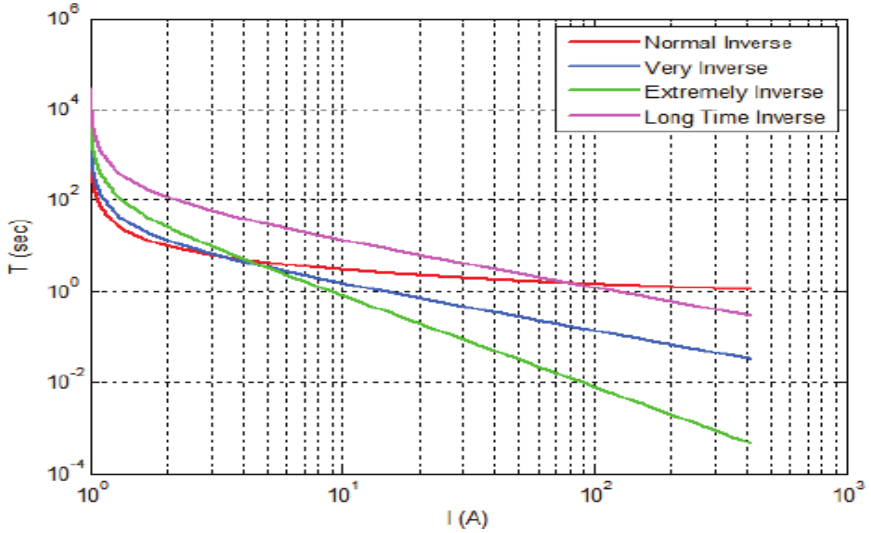
For 11 KV - Non-directional IDMT 2 no over load and 1 no earth fault relays.
For 33 KV - Non-directional IDMT 3 over load and 1 earth fault relays.



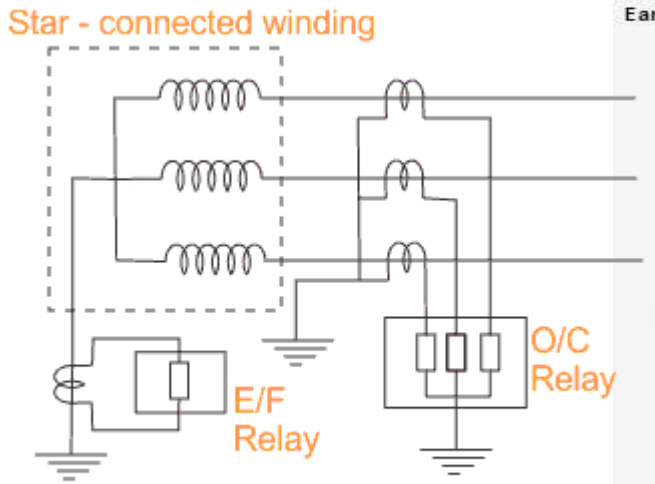


Alstom Earth Fault Relay

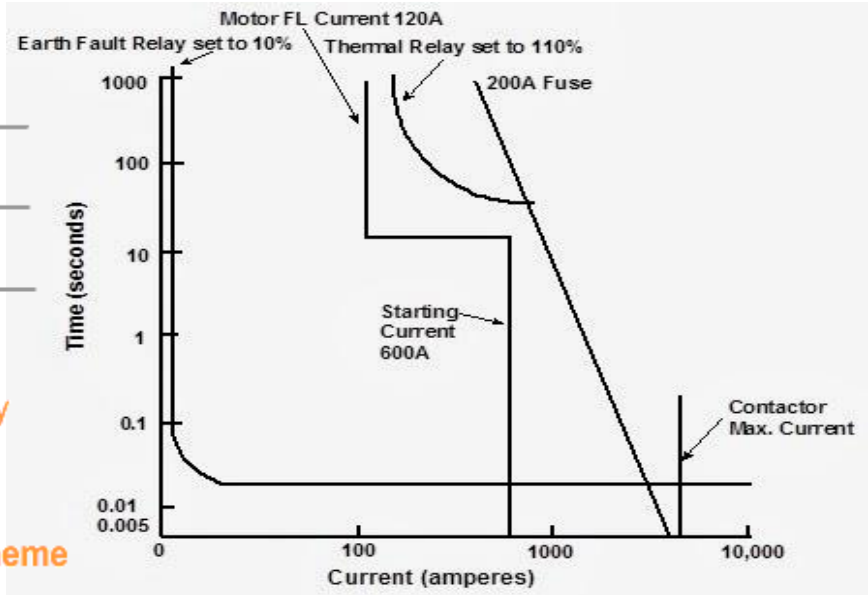
Time-current characterstics of IDMT overcurent relays



IDMT means inverse definite minimum time.



O/C & Unrestricted E/F Protection Scheme

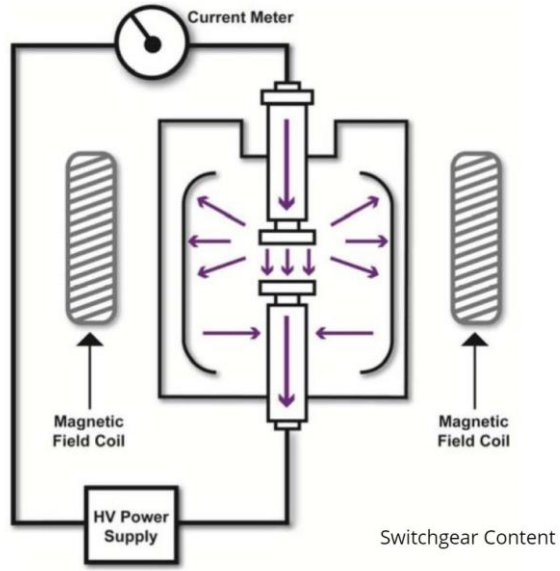


Switchboard & panels : Circuit breakers

Onstream inspection item	Frequency
• availability of control supply	Weekly
Thermography	Half yearly
Insulating mat condition	Yearly
Shutdown inspection item	**Annual**
Condition of panel & door earthing, Insulation & earth resistance, Breaker electrical resistance, Internal damages (damaged barrier/ arc chute/ jammed solenoid/ dust accumulation), Operation of protection, control & interlock circuits	
Vacuum bottle integrity (dielectric withstand voltage) test	**Every 3 years**

For 15 kV switchgear, testing is performed at 27 kVac for metal clad switchgear & at 37kVac on station type switchgear for 15 sec. 38kV gear is usually tested at 60kVac.
The test object either holds the voltage or fails. Loss of vacuum results in complete breakdown across an open vacuum contact @ < 30 KV.





Switchgear room/ substation building

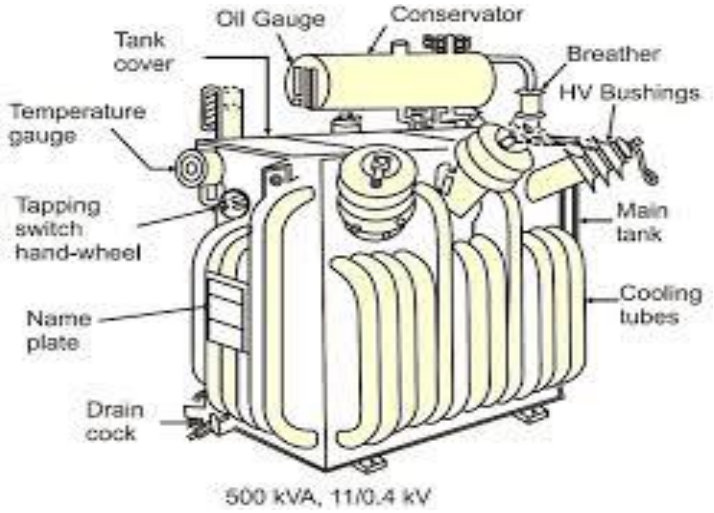
Onstream inspection item	Frequency
Housekeeping including movement of doors/ shutters	Monthly
• Illumination • Emergency lighting & auto changeover arrangement • Ventilation & pressurization system • Insulating mats, shock treatment chart, SLD (single line diagram), fire extinguishers, sand buckets, MCP (Manual call points), earthing rods, PPE, telephone • Condition of trench, covered slabs, chequered plates • Identification markings • Damages, corrosion	Half yearly
• Roof leakage (pre-monsoon pond test) • Sealing of bus duct & cable entry • Water drainage arrangement	Yearly

Power transformers are used in transmitting electrical power from one circuit to another without changing the frequency. They operate by the principle of electromagnetic induction.

A step-down power transformer converts high voltage (transmission line) to a medium/ low voltage (consumer).

Parts of a transformer :

- core,
- windings,
- insulating materials,
- transformer oil,
- tap changer,
- conservator,
- breather,
- cooling tubes,
- Buchholz Relay and
- explosion vent.









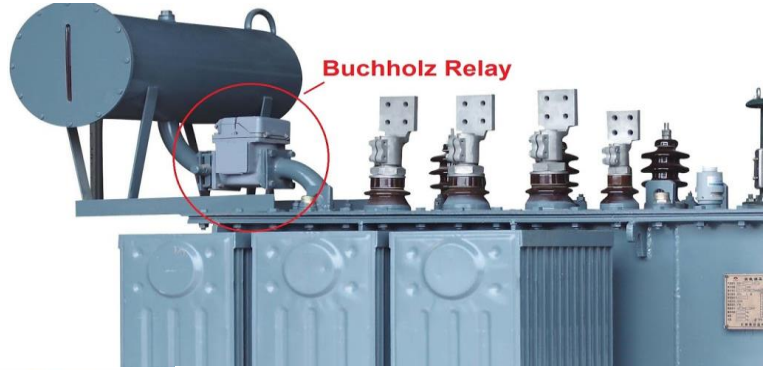
Power transformer protection :

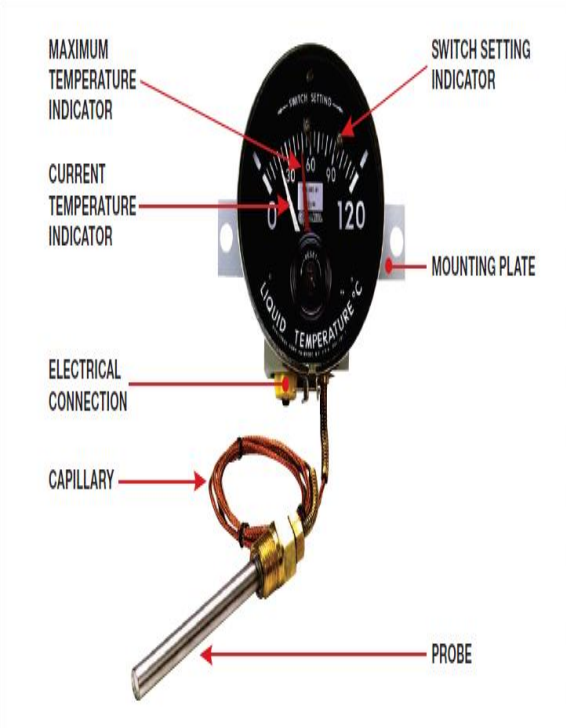
Oil temperature relay
Winding temperature relay
Buchholz relay

Alarm, trip & annunciation are provided in VCB.

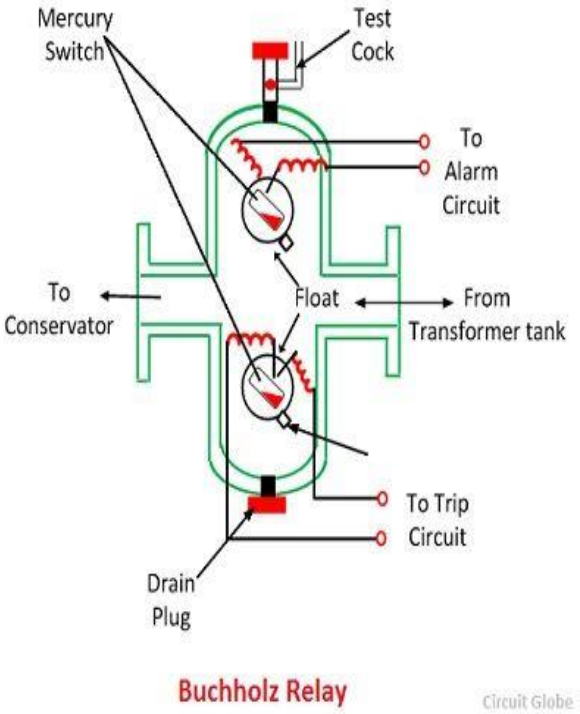












Transformer oil testing

National Accreditation Board for Testing and Calibration Laboratories
(A Constituent Board of Quality Council of India)

SCOPE OF ACCREDITATION

Laboratory	Transgear Electrical Services, # 40/3, J C Industrial Layout, Yelachenahalli, Kanakapura Road, Bangalore, Karnataka
Accreditation Standard	ISO/IEC 17025: 2005
Certificate Number	TC-6358 *(in lieu of T-2005)* Page 1 of 1
Validity	26.10.2017 to 25.10.2019 Last Amended on --

ELECTRICAL TESTING

Sl.	Product / Material of Test	Specific Test Performed	Test Method Specification against which tests are performed	Range of Testing / Limits of Detection
I.	ELECTRICAL MATERIALS–LIQUID DIELECTRIC MATERIALS			
1.	Transformer Oil (Mineral Insulating Oil)	Inter Facial Tension (IFT)	IS 6104	0.015 N/m to 0.090 N/m
		Acidity (Neutralization Value)	IS 1448 (Part 2)	0 to 1.0 mg KOH/g
		Sludge/Sediment	IS 1866 (Clause 4.3, Annexure A)	0.01 mg to 2 gm
		Water (Moisture) Content	IS 13567	4 mg/kg to 500 mg/kg
		Flash Point	IS 1448 (Part 21)	27 °C to 360 °C
		Dissolved Gas Analysis (Carbon monoxide, Carbon dioxide, Ethane, Methane, Ethylene, Acetylene, Hydrogen, Oxygen, Nitrogen)	IS 9434 IS 10593	1 µl/L to 9000 µl/L
		Breakdown voltage	IS 6792	1 kV to 100 kV
		Tan Delta (Dielectric Dissipation Factor)	IS 6262	0.0002 to 10
		Resistivity (Specific Resistance)	IS 6103	10^7 Ωcm to 10^{15} Ωcm
		Appearance	IS 335	Qualitative (Free from suspended particles)
		Density	IS 1448 (Part 16)	0.80 g/cm^3 to 1.00 g/cm^3

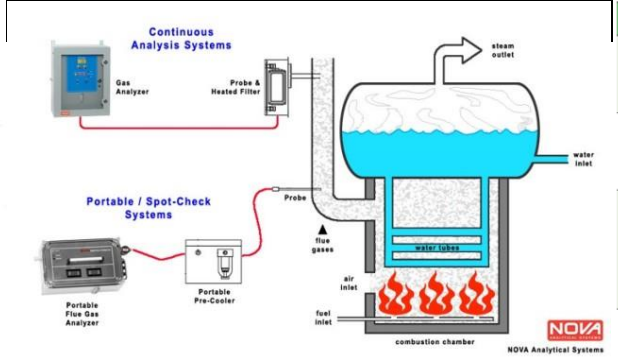
Naveen Jangra
Convenor

N. Venkateswaran
Program Director



BDV test





FAULT	KEY GAS	RESULTS
Arcing	Acetylene	Large amounts of acetylene and hydrogen or minor quantities of methane and ethylene can be produced.
Corona	Hydrogen	Low energy discharges generate hydrogen and methane as well as minor quantities of ethane and ethylene.
Overheated Oil	Ethylene and Methane	Overheating will produce ethylene and methane (300 degrees F) or hydrogen and methane (1,112 degrees F). Traces of acetylene may be formed if the fault is severe or involves electrical contacts.
Overheated Cellulose	Carbon Monoxide	If cellulose is overheated, carbon monoxide is generated.

DGA



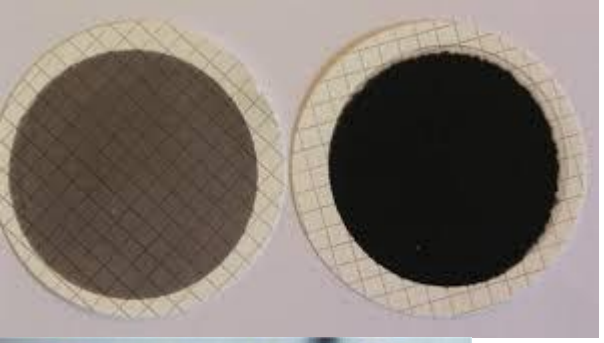
Flash point test



Interfacial tension test



Acidity test

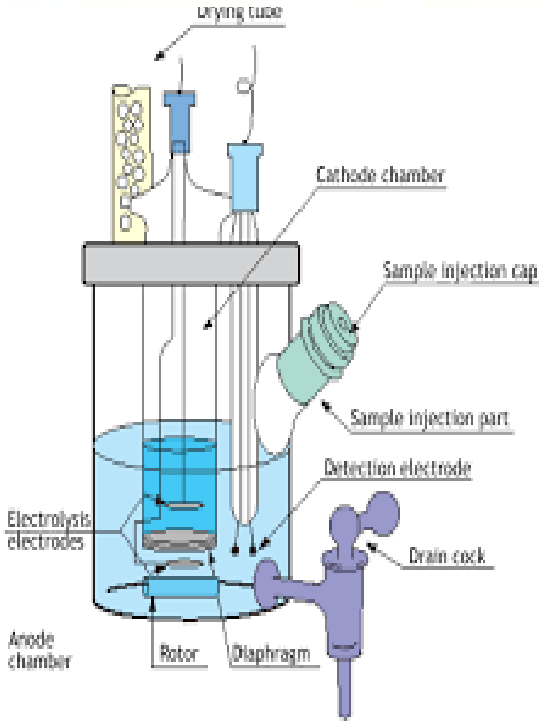


Sludge/ sediment test



Water content test

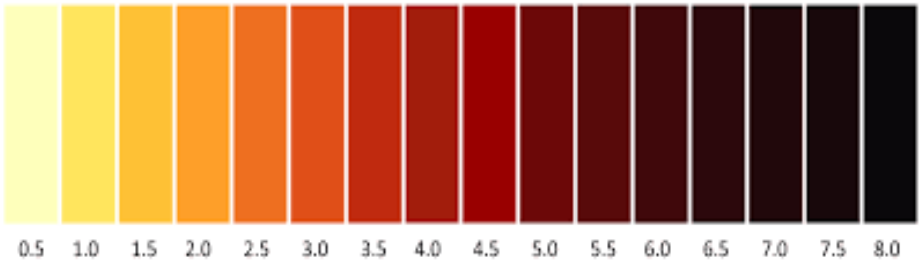




Resistivity test



Appearance/ colour test



Tan delta test



TRANSFORMER OIL RESULTS ANALYSIS

Oil Color	Acid (NN)	IFT	Oil Status	Transformer Condition
Water White	0.03-0.10	30-45	Excellent	Good
Yellow Tint	0.05-0.10	27-30	Good	Sludge dissolved in oil
Yellow Solution	0.11-0.15	24-27	Marginal	Acid coating insulation, sludge ready to deposit in transformer
Orange	0.16-0.40	18-24	Bad	Sludge in radiators, core & coil
Reddish-Brown	0.41-0.65	14-18	Very Bad	Sludge hardening & layering, insulation is shinking & weakening
Brown	0.66-1.5	9-14	Extremely Bad	Radiators blocked with bad sludge, increased operating temperture
Black	Over 1.5	Below 9	High Risk	Transformer failure is likely

Dissolved gas analysis

Generation of gases is due to arcing, Partial discharges, Low energy sparking, Severe overloading, and Overheating of insulation.
Testing is done as per ANSI/ IEEE C 57. 104.

Gas	Normal limit, <	#Action limit, >	Potential fault
Hydrogen	150	1000	Corona, arcing
Methane	25	80	Sparking
Acetylene	15	70	Arcing
Ethylene	20	150	Severe overheating
Ethane	10	35	Local overheating
CO	500	1000	Severe overheating
CO2	10000	15000	Severe overheating
Total combustibles	720	4630	

removal of transformer from service should be considered

Furan test

By analyzing furanic compounds in Insulation oil.
Test method : ASTM D5837

The furan and furfural derivatives for investigation are breakdown products of cellulose.
Determining their quantities can therefore help draw conclusions on the condition of the paper insulation, drawn into the transformer without requiring the transformer to be switched off.
This is usually done in transformers aging above 15 years. Furan indicates the compounds of carbon and hydrogen. **When the furan count is above 2500ppb, it means the transformer is about to fail.**
in general, the following limits are used :
Furfural: 2.0 ppm (typical limit) or 5.0 ppm (high limit)
5-Methylfurfural: 1.0 ppm (typical limit) or 3.0 ppm (high limit)
2-Furylfuran: 0.5 ppm (typical limit) or 1.5 ppm (high limit)

If the furan test results exceed the limits, then it is important to investigate the cause of the problem and take corrective action to prevent transformer failure. This may involve:

- Increasing the frequency of transformer oil testing
- Performing additional diagnostic tests
- Taking steps to repair or replace the transformer insulation

To prevent high furan levels in transformer oil :

- Avoiding overloading the transformer
- Operating the transformer at low temperatures
- Using high-quality transformer oil
- Keeping the transformer oil clean and free of contaminants
- Regularly testing the transformer oil for moisture and other impurities

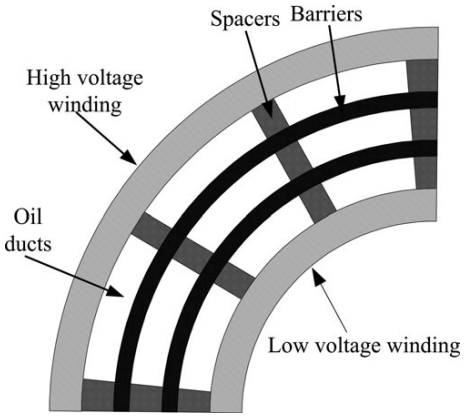
Degree of polymerization test

The degree of polymerization test is conducted on **cellulosic paper insulation**. The average number of monomer (cellulose molecule, $C_6 H_{10} O_5$) in the cellulose molecule is known as degree of polymerisation of paper.

Analysis of paper insulation for its DP value requires removal of a few strips of paper from suspect sites. **This procedure can conveniently be carried out during transformer repairs.**

Furaldehyde Content (PPM)	DP Value	Significance
‹0.1	700 - 1,200	Healthy
0.1 - 1	450 - 700	Moderate Deterioration
1 - 10	250 - 450	Extensive Deterioration
›10	‹250	End of Life



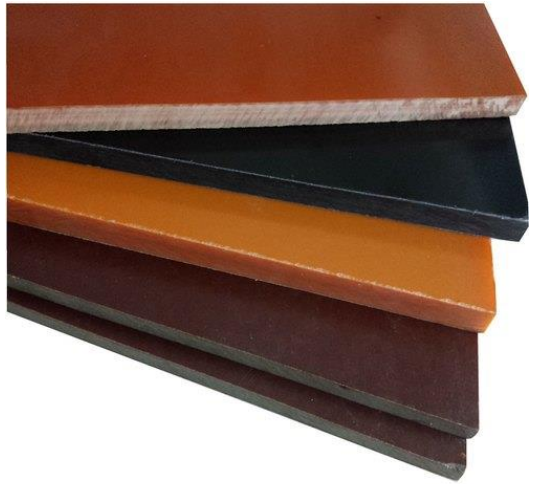


Electrical bus bar is a conductor or a group of conductors used for collecting electric power from the incoming feeders and distributes them to the outgoing feeders. It is available in rectangular (most common), cross-sectional, round and other shapes & made of copper/ aluminium.

The bus bar system consists the isolator and the circuit breaker. Upon occurrence of a fault, the circuit breaker trips to isolate the faulty section of the busbar from the circuit.



Bakelite sheet is a hard, dense material made by applying heat and pressure to layers of paper or glass cloth impregnated with phenolic resin. It is electrically nonconductivity and has heat-resistant properties. It has a bulk resistivity of the ~9X10 11 Ωcm and surface resistivity of the ~3X10 12 Ωcm.
Thickness = 10 to 50 mm, cost Rs 250/ per kg.

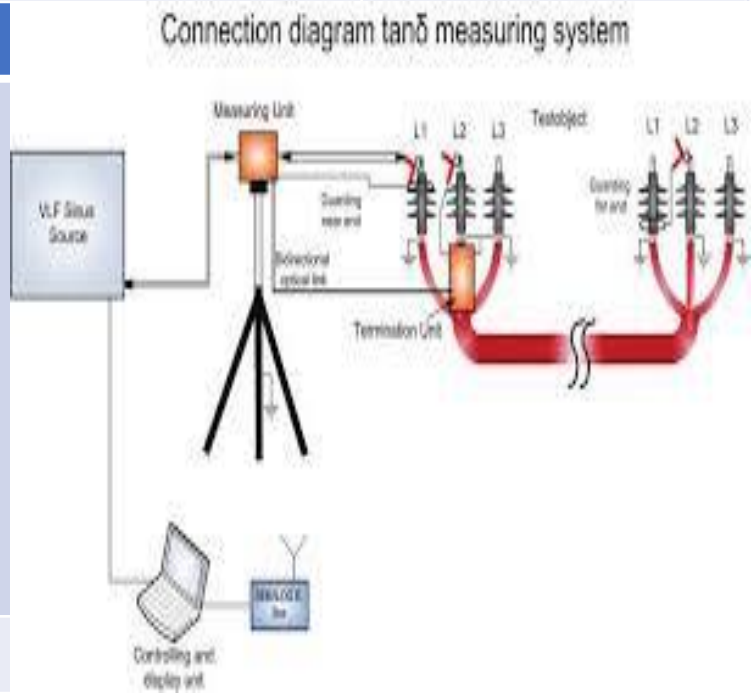




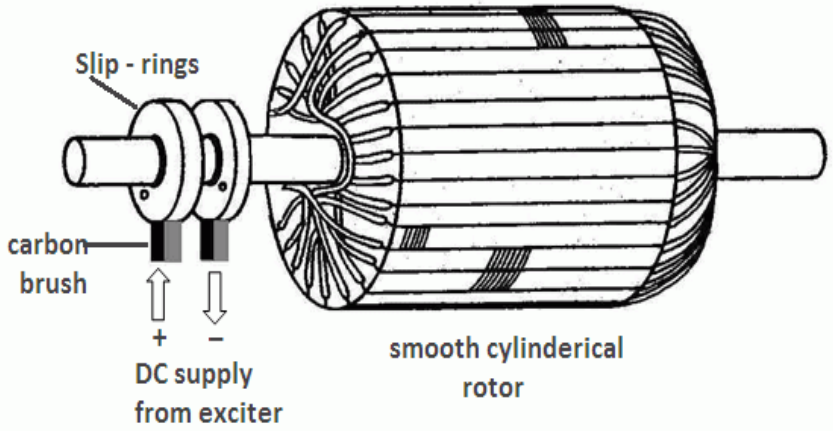
Power transformer & bus duct

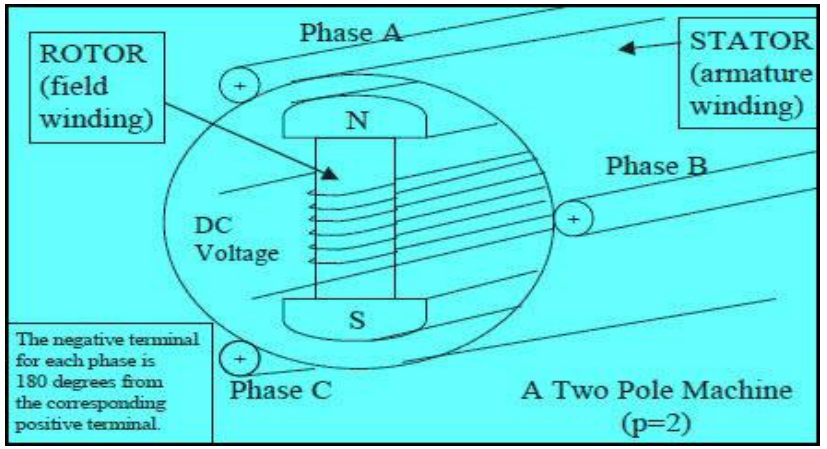
Onstream inspection item	Frequency
• Oil leakage & Oil level (transformer, conservator), Condition of silica gel, Working of oil/ winding temperature meters, Load	Weekly
Visually – yard upkeep & foundation	Quarterly
• Transformer oil test @ IS : 1866, On load tap changer (OLTC) oil test @ IS : 1866	Yearly
• Annunciations for abnormality, Insulator/ bushing for cracks (outdoor units)	Turn around
• **Dissolved Gas Analysis (DGA)** of transformer oil	3 years

Shutdown inspection item	
• Primary/ secondary terminal condition • Operation of protection & annunciation system • Insulation resistance test of primary & secondary windings • Earth resistance & earth continuity • Condition of explosion vent diaphragm • WTI & OTI calibration • Cooling fans auto start interlock check • Checking of buchholz relay operation • On load tap changer (OLTC) M&I as per OEM recommendations	
Tan delta test of transformer	**Every 3 years**











In a synchronous generator, the rotor rotates and produces an electric field in the stator due to electromagnetic induction.

Shutdown inspection item

- Insulation resistance
- DC resistance of stator, rotor & exciter #
- Air gap between stator & rotor #
- Manual/ automatic synchronization & changeover
- Alignment
- Space heater, tripping, annunciator, interlock devices
- Internal damages, dis-coloration, open/ short connections, loose connections #
- Condition of commutator, brushes & collector ring
- Foundation, foundation bolts

during major overhaul

Motor (HT & LT)

Onstream inspection item	Frequency
Ventilation, Vibration, Abnormal noise, Load (Amps), Safety guards	Monthly
Lubrication	Quarterly

Shutdown inspection item
Mechanical freeness of rotating shaft
Insulation resistance & Polarization index test
Winding resistance
Earth resistance & continuity
Operation of space heaters, interlocks/ trips, annunciation circuits
Availability of protective devices/ circuits
Oil level
Internal damage, discoloration, loose connections#
Stator to rotor air gap measurement#
Condition of supporting legs, pedestal, base plate
Foundation & foundation bolts

during major overhaul

Relays & meters

Onstream inspection item	Frequency
Plugging of un-used cable entries	Half yearly
Illumination level	Yearly

Shutdown inspection item	Frequency
• Simulation test for relay circuit operation	Turn around
• Relay operation by primary injection (for fault condition simulation)	Turn around
• Correctness of relay setting	Turn around
• Changeover circuit operation	Turn around
• Checking/ calibration of meters	Yearly
• Electromechanical Relay testing	Yearly
• Numerical relay testing	Every 5 years

Relay and protection testing

Relays are electrically operated switches that open and close the circuits by receiving electrical signals from outside sources. Main types of relays are electromechanical, solid-state, and reed.

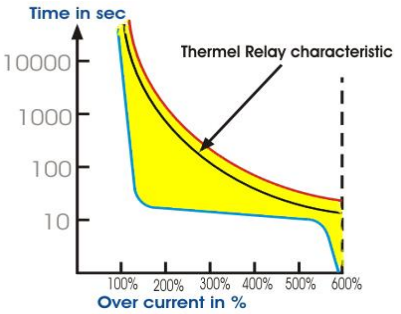




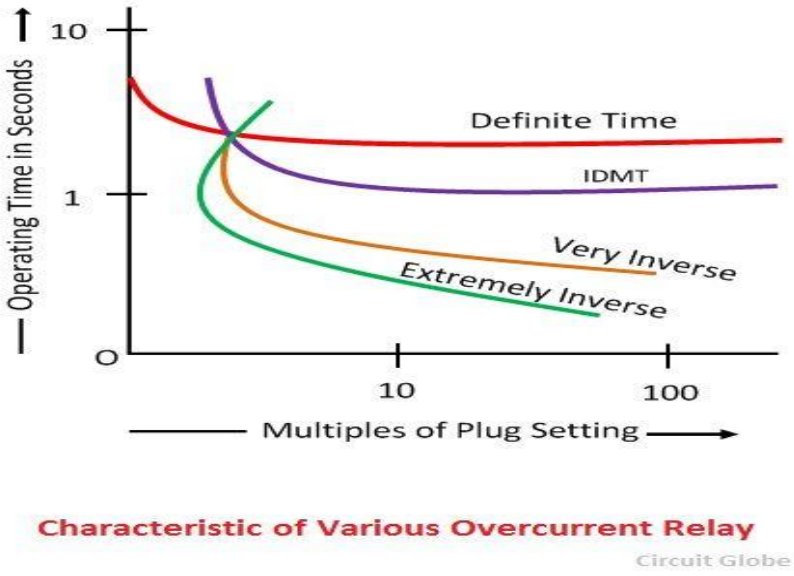








	1.05 x Ir	1.2 x Ir	1.5 x Ir	7.2 x Ir
Class	Time to trip from a cold start			
10A	>2hr	<2hr	<2min	2s< to <10s
10	>2hr	<2hr	<4min	2s< to <10s
20	>2hr	<2hr	<8min	2s< to <20s
30	>2hr	<2hr	<12min	2s< to <30s



Characteristic of Various Overcurrent Relay

Circuit Globe

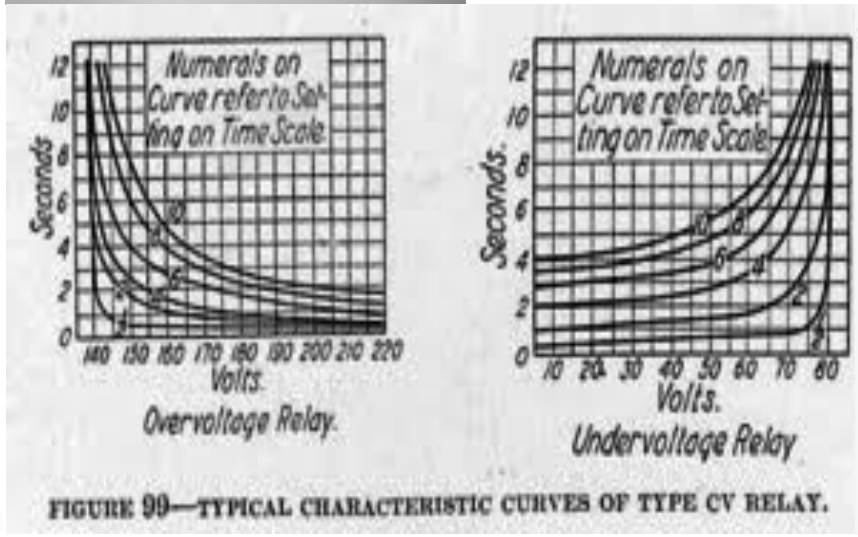
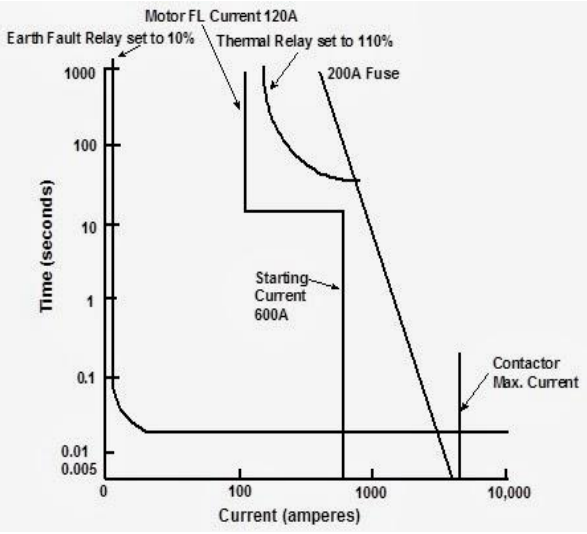


FIGURE 99—TYPICAL CHARACTERISTIC CURVES OF TYPE CV RELAY.





The trip relays of ACB provide protection for voltage, frequency, unbalance, over current, short-circuit, ground fault.

Battery

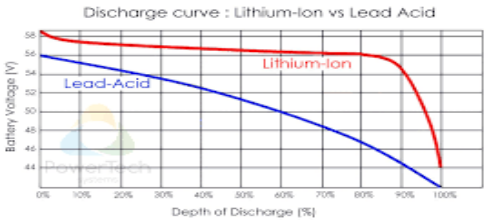
Onstream inspection item	Frequency
• General cleanliness of battery & battery room • Functioning of ventilation, Spillage of electrolyte	Weekly/ Daily (for critical - emergency/ switchgear applications)
• Electrolyte level, Cell voltage & specific gravity (lead acid batteries), Availability/ condition of PPE, Condition of acid proof flooring • No electrical fitting on top of battery bank • Availability of tap water in battery room • Condition of battery stand	Monthly/ Weekly (for critical- - emergency/ switchgear applications)
Battery load test	**Yearly**



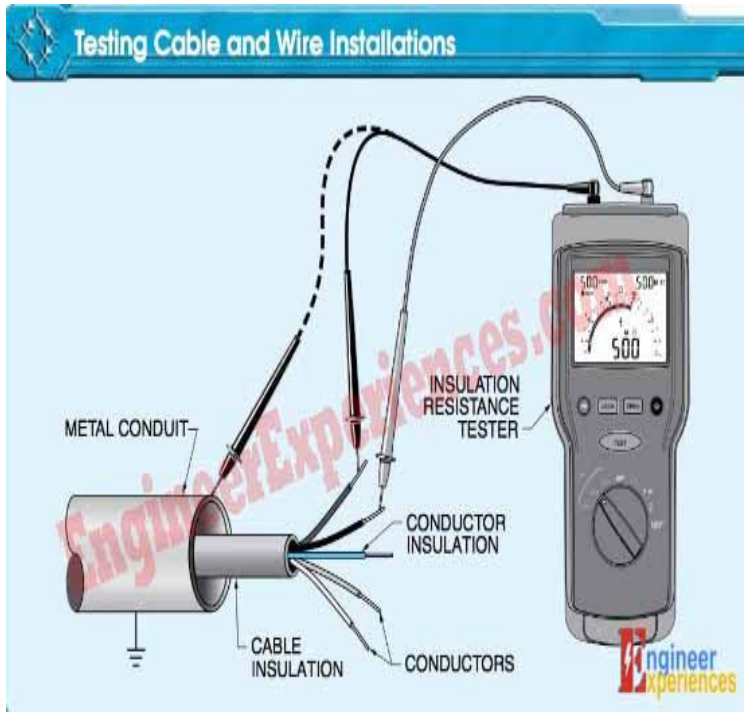
Capacity test/ load test/ discharge test is a dynamic test in which half the rated Cold cranking amps (CCA) of the battery is discharged for 15 seconds & battery voltage reading is recorded.

CCA is the amps a battery can support for 30 seconds at a temperature of 0 deg F (- 17.7 deg C) until the battery voltage drops to unusable levels.





Insulation resistance test

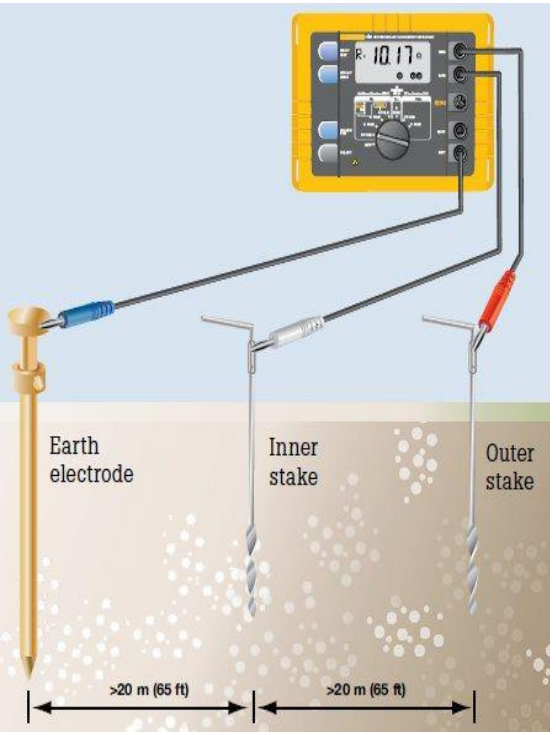


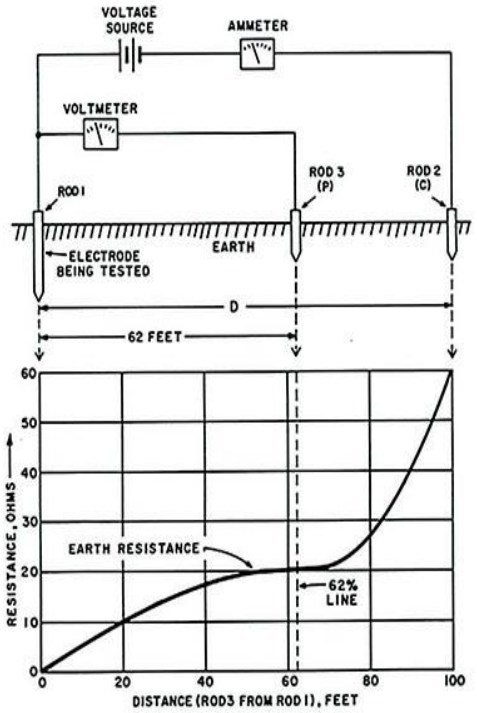
Test is performed through an insulation tester by applying 500 V for low/ medium voltage cables & 2500 V for high voltage cables between the conductors and between each conductor and ground and measuring the resulting leakage current for a period of 1 minute.
The minimum acceptable value for **low & medium voltage cables** is **1 mega ohm** & for **high voltage cables** is **1 mega ohm/ KV**.
When cable installations are tested, they should be disconnected from panels and machinery to keep them isolated.
Conductors with damaged insulation must be replaced.

CEA Regulation 33

- For equipment up to 650 V, application of 500 V dc for 1 minute ; minimum value = 1 Mega ohm or as specified in IS.
- For equipment above 650 V & up to 33 KV, application of 2500 V dc for 1 minute ; minimum value = 5 Mega ohm or as specified in IS.

Earth test





Earth test / earth resistance test is a method of testing the resistance of mass of earth around the electrode to flow of nuisance current.

As per IE Rules, **earth test is to be carried out at least once in 2 years during dry day of the dry season. As per OISD STD 137, the periodicity of earth test for locations is twice a year (once after monsoon) & for ROs is once a year.**

The fall-of-potential test method is used to measure the ability of an earth ground system or an individual electrode to dissipate energy from a site. The earth electrode of interest must be disconnected from the various equipments connected to it. The E terminal of earth tester or megger is then connected to the earth electrode. Then, two SS rods are placed in the soil in a direct line – away from the earth electrode, for the 3-pole fall of potential test. Spacing of 20 m is normally sufficient. The farther rod is connected through copper wire to terminal C of the megger & the nearer rod is connected to terminal P of megger. Reading is then obtained & reverified by shifting the inner rod by 10% distance nearer & farther from the earth electrode under test.

Allowable earth resistance value

- Electrical system : 4 ohms
- Generating station : 1 ohm
- Storage tank : 7 ohms
- Lightning protection system : 10 ohms
- Grid : 1 ohm
- Earth electrode : 2 ohms

Thermography

Standard : ASTM E 1934
Maintenance Testing Specifications for Electric Power Distribution Equipment and Systems – International Electric Testing Association (NETA) the Delta T Criteria for Electrical System is as follows:

Priority	Delta T between similar components under similar load	Delta T over ambient air temperature	Recommended Action
4	1 to 3 Deg. C	1 to 10 Deg. C	Possible deficiency; warrants investigation.
3	4 to 15 Deg. C	11 to 20 Deg. C	Indicates probable deficiency; repair as time permits.
2	----------	21 to 40 Deg. C	Monitor until corrective measures can be accomplished
1	> 15 Deg. C	> 40 Deg. C	Major discrepancy; repair immediately

A thermal camera capture and create an image of an object by using infrared radiation emitted from the object in a process that is called thermal imaging. The created image represents the temperature of the object.

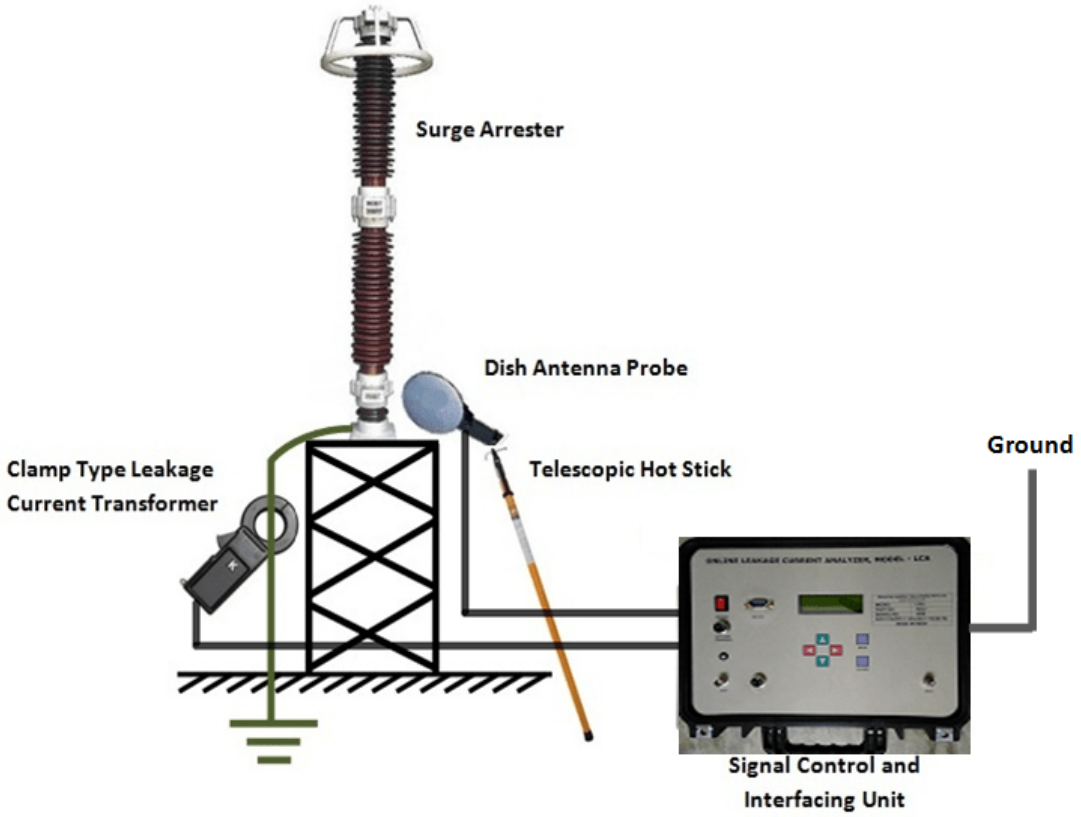


Lightning protection

Onstream inspection item	Frequency
• Visual checks for damages (LA, down conductors, insulator, supporting structures, earth electrodes) • Cleanliness of insulators • Earth resistance & continuity	Yearly
3rd harmonic current test of LA	**Every 3 years**

The fundamental frequency is 50 Hz. Third Harmonic means 3 times 50 Hz i.e. 150 Hz. Monitoring the Third Harmonic Resistive Component (THRC) of Lightning/Surge Arrester's leakage current becomes important as THRC is directly related to the extent of degradation of the Arresters' ZnO blocks.

Resistive leakage current is only 10-20% of total leakage current under normal operating condition, the rest being the capacitive component. Resistive Component of Leakage Current is an indication for health monitoring of Lightening Arrestor.











The circuit breaker automatically detaches the circuit at the ON-load situation to protect the circuit from damage caused by excess current from an **overload or short circuit.**

MCBs are **time-delay tripping electromagnetic devices**. Typically, these devices are designed to operate at less than **2.5 milliseconds when there are short circuit faults and between 2 seconds to 2 minutes in case of overloads.**

2, 3- or 4-pole isolators are typically found on many types of appliances and circuits.

Protective & safety appliances

Onstream inspection item	Frequency
Hand gloves, safety suits, breathing apparatus, rubber shoes, insulating mats, safety belts, ladders, earthing devices, helmets, voltage detectors, multimeters, tong testers, insulation tester, earth tester, googles, face shields, ELCBs/ RCCBs as per IS 4770 or as per manufacturer recommendations	Half yearly / before putting in use, whichever is earlier





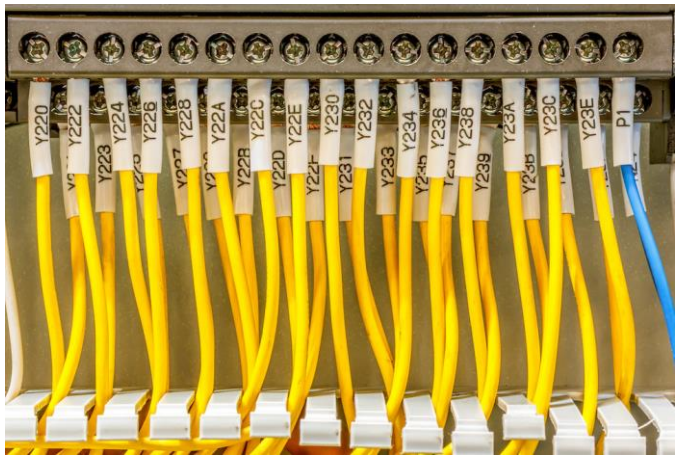


Cable & conduit wiring

Onstream inspection item	Frequency
• Availability of cable route & cable joint markers • Condition of cable jointing/ termination & clamping arrangement • Availability of identification tags • Mechanical protection to under ground & overhead cables	Yearly
• Damage to cables, conduits, wires & cable clamps/ supports • Water tightness of conduit system (for critical HV cables) • Corrosion of conduits/ JBs	Turn around (shutdown inspection)
• Underground cables are protected by sand & bricks & are not exposed • Condition of armour, pipe sleeve & mechanical protection	Random









Cable duct, trench, tray supports

Onstream inspection item	Frequency
Cable congestion in pipes > 50% (for new installation)	
• Damage to cable trench (cover, duct, tray support, walkway grating) • Sealing of cable trunks/ ducts • Corrosion of metal tray supports	yearly

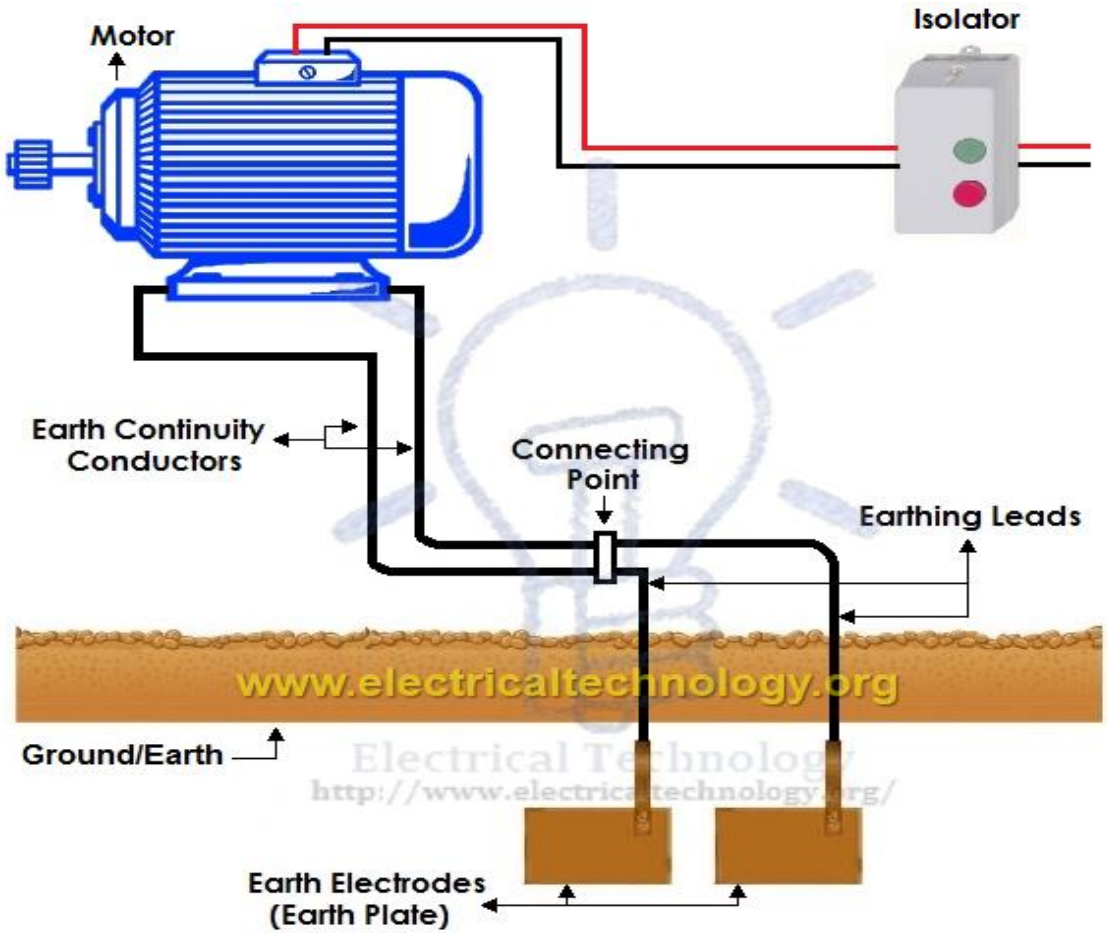




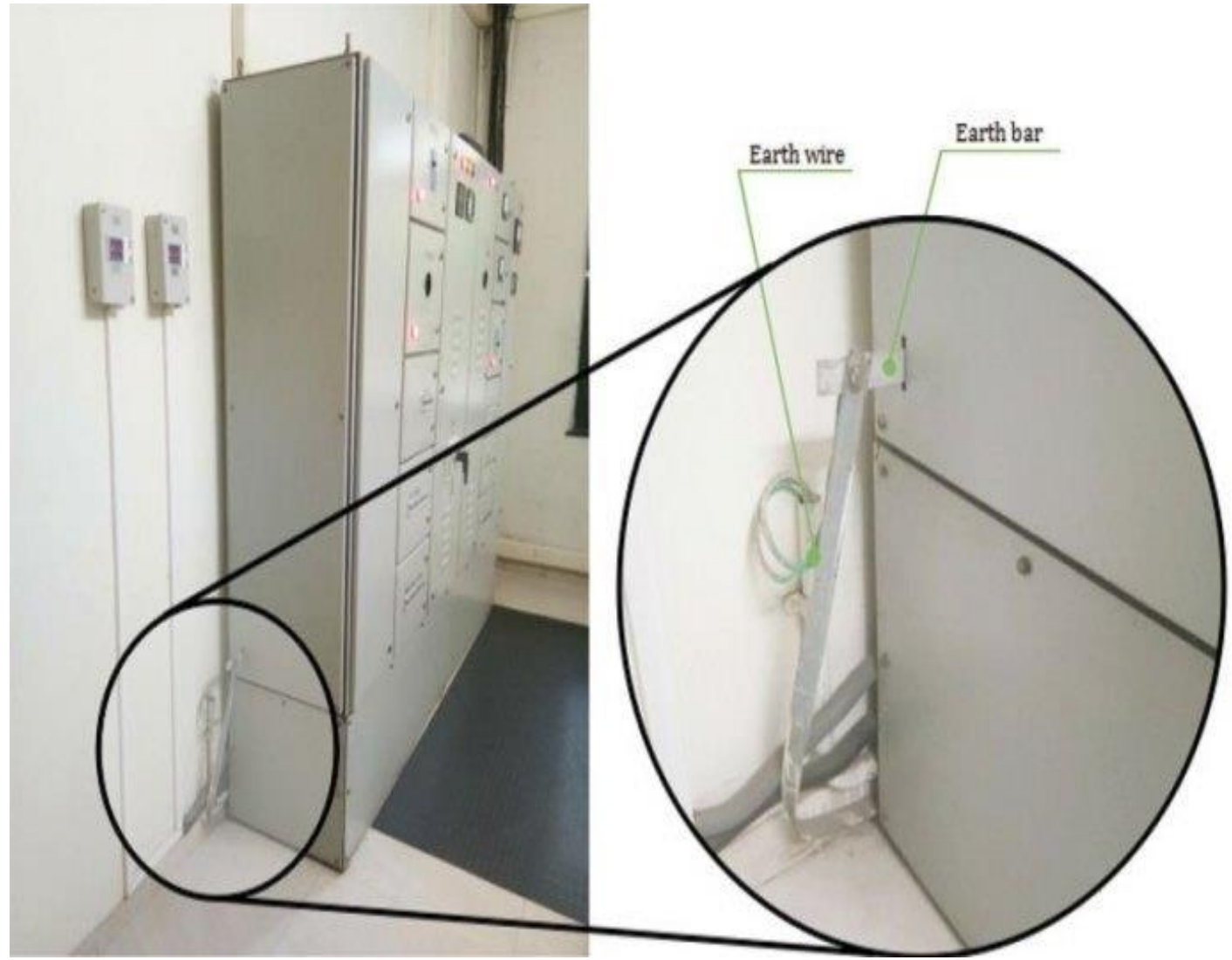





E/P NO.14
EQUIP. NE. 400 KVA.DG
TYPE. N- E/P
G.RES.0.1 P.RES.0.8
T.DATE 28.11.23 D.DATE 27.05.24
71



Earthing of Single Motor From Two Places




PIF
LP 4/4

Common Mistakes







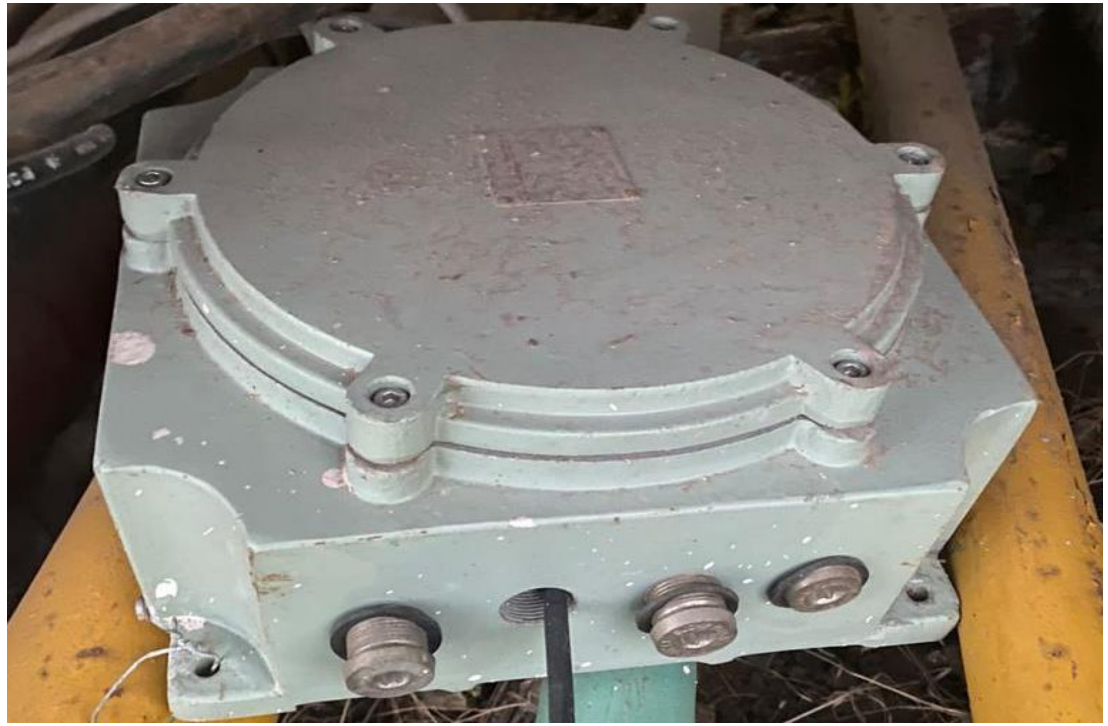




Common Mistakes

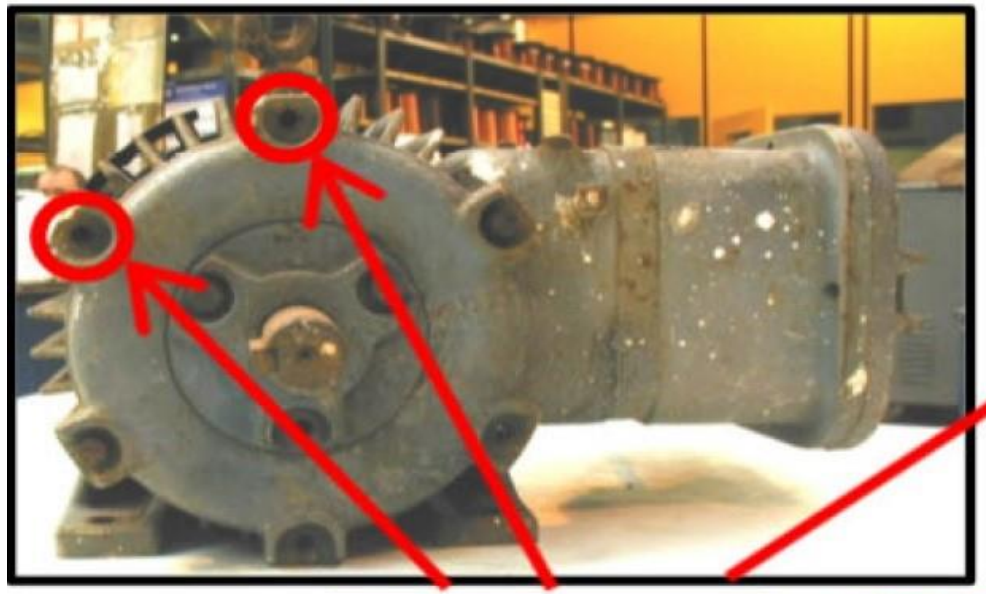


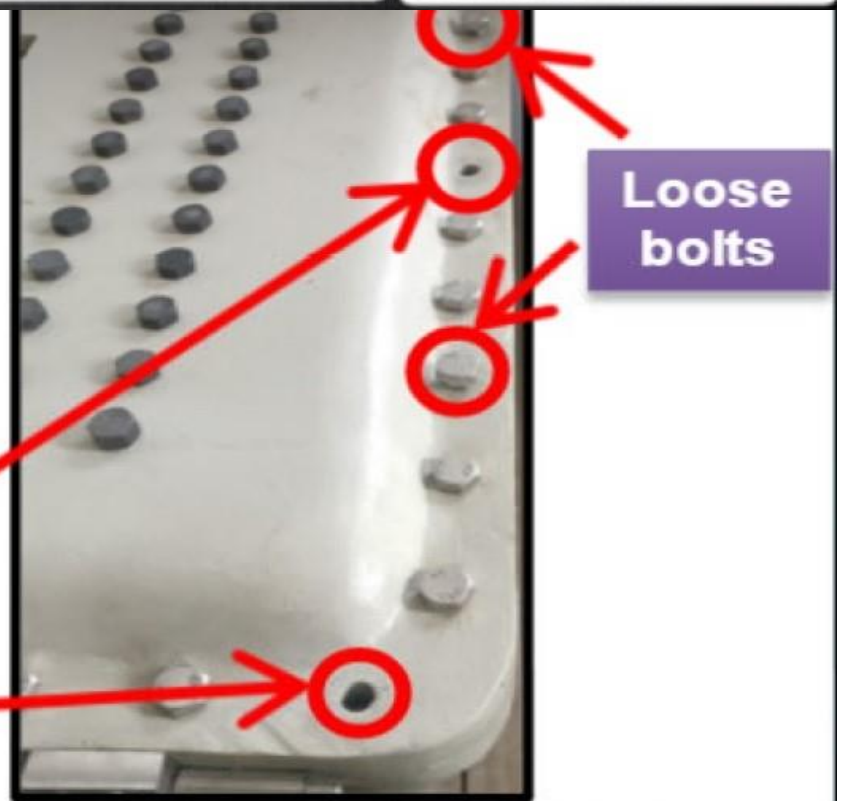




Common Mistakes







Missing bolts



Certified Cable gland

Non-certified Cable gland



Missing blanking plug

Inner core

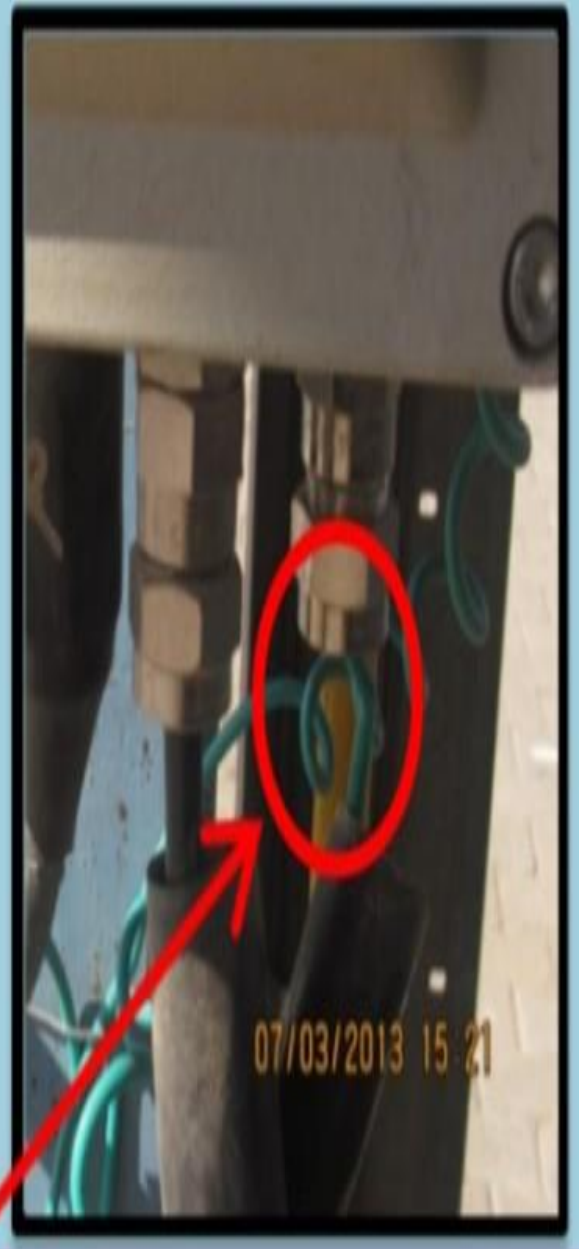


Inner Sealing ring

Sealing ring



Cable size too small for sealing ring



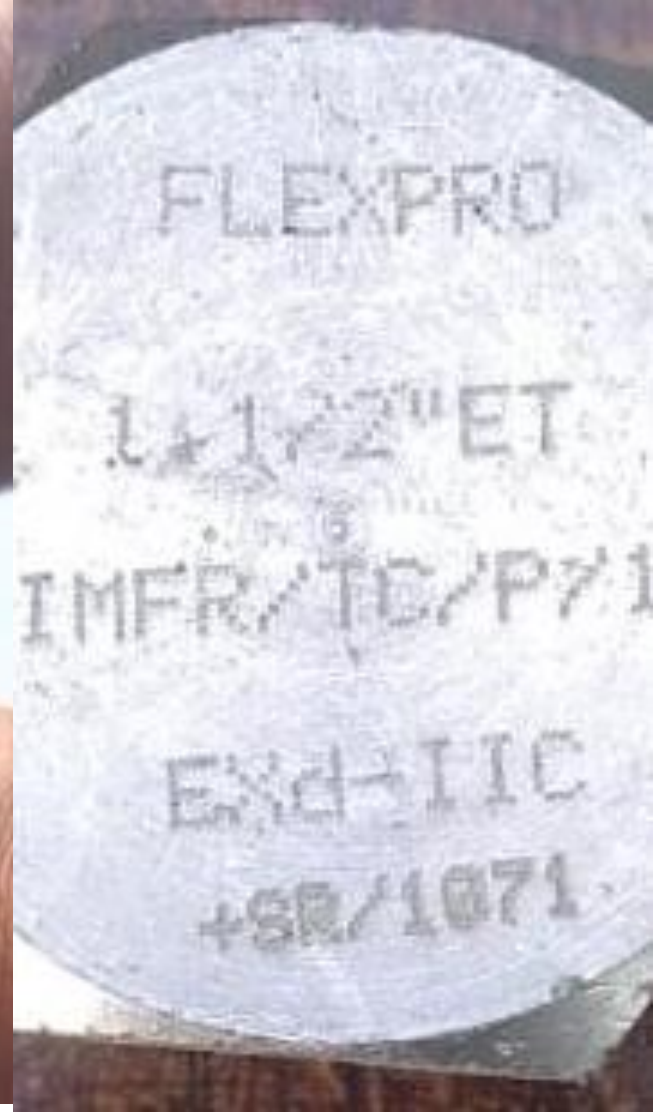
Cable size too small for Cable gland

Flameproof Enclosure / Equipment

Q- Have we prepared any preventive maintenance schedule for FLP enclosures / equipment?

- Check Before Use
- Regular inspection for any damage
- Check after any change or maintenance works for following
  - Missing bolts on the covers.
  - Open unused entries or use of PVC bushes in place of metallic certified stopper plugs,
  - Loose fitting of cable glands and insufficient compression of cable with rubber grommets.
  - Under / Over Size Cables
  - Improper layout of external cables resulting in entry of water inside the enclosure
- Maintain Data




FLEXPRO
1 1/2"ET
EXd IIC

This content is only for academic/education purpose. This should not be copied or reproduced anywhere by other than author.

Statutory Requirements

Regulations & Standards

- The Petroleum Rules, 2002.
- The Electricity Act, 2003 & The Electricity Rules, 2005.
- The Central Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2010 & Amendment Regulations, 2015/ 2018.
- The Central Electricity Authority (Safety Requirements for Construction, Operation and Maintenance of Electrical Plants and Electric Lines) Regulations, 2011.

Hazardous area classification

Need :

Hazardous areas are classified solely for the purpose of ensuring the safe and proper specification and installation of electrical/ electronic equipment located within them.

The Petroleum Rules, 2002

103. Hazardous area.—where—

(i) **petroleum having flash point below 65°C or any inflammable gas or vapour in a concentration capable of ignitions is likely to be present;**

(ii) petroleum or any inflammable liquid having flash point above 65°C is likely to be refined, blended, handled or stored at above its flash point.

104. Classification of hazardous area.—

Zone	Frequency of occurence	Duration of explosive gas atmosphere
Zone 0	An area in which an explosive gas atmosphere is present continuously or for long periods	Explosive atmosphere for more than 1000h/yr
Zone 1	An area in which an explosive gas atmosphere is likely to occur in normal operation	Explosive atmosphere for more than 10, but less than 1000 h/yr
Zone 2	An area in which an explosive gas atmosphere is not likely to occur in normal operation and, if it occurs, will only exist for a short time	Explosive atmosphere for less than 10h/yr, but still sufficiently likely as to require controls over ignition sources

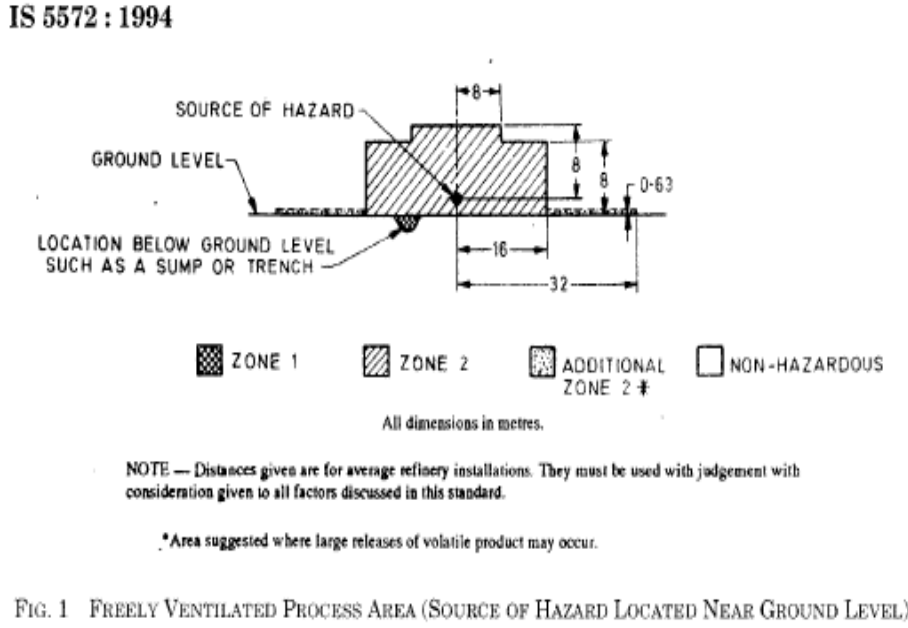


FIG. 1 FREELY VENTILATED PROCESS AREA (SOURCE OF HAZARD LOCATED NEAR GROUND LEVEL)

For **heavier-than-air gases and vapours** the classified **hazardous area shall extend vertically 8 m above the source of hazard and horizontally 16 m in all direction** from the source of hazard.

Beyond 8 m from the source of the hazard in the horizontal plane the vertical extent of the Zone 2 area may be reduced to 8 m above ground level. If there is a possibility of large release of volatile products, the **Zone 2 area may be further extended horizontally beyond 16 m up to 32 m with a height of 0.63 m.**

Any trench of pit below ground level and located within the area defined above should be classified as Zone 1 area.

Choice of electrical apparatus is based on

1. Zone
2. Gas group classification
3. Temperature classification
4. Environmental condition

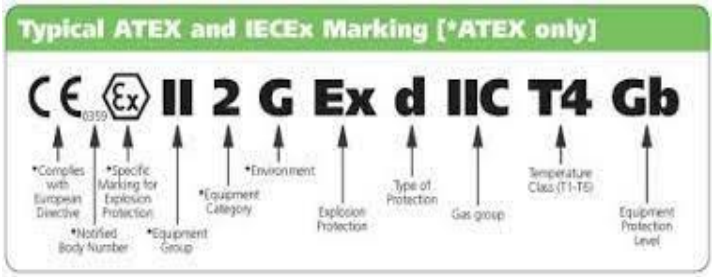
Zone 0	Zone 1	Zone 2
Category 1 : Ex	Category 2 : Ex	Category 3 : Ex
'ia' intrinsically safe	'd' - Flameproof enclosure	Electrical Type 'n'
s - Special protection	'p' – Pressurised Exp	
	'q' - Powder filling	
	'o' - Oil immersion	
	'e' - Increased safety	
	'ib' - Intrinsic safety	
	'm' - Encapsulation	
	's' - Special protection	



Industry	Gas Group	Substance	MIE	Selection of equipment
Mining Industry Group I	I	Methane	200µJ	Equipment only suitable for mines unless it is additional approved for surface: Marked I/IIC
Surface Industry Group II	IIA	Propane	180 µJ and higher	II; IIA; IIB and IIC certified equipment may be used in an IIA area.
	IIB	Ethylene	60 µJ -180 µJ	II; IIB and IIC certified equipment may be used in an IIB area.
	IIC	Hydrogen	20 µJ – 60 µJ	Only II & IIC certified equipment is allowed to be used in an IIC area.

Temperature Classification	Maximum Surface Temperature, °C	Ignition Temperature of gas or vapour, °C
T1	450	>450
T2	300	>300
T3	200	>200
T4	135	>135
T5	100	>100
T6	85	>85

Ingress Protection Classification			
First Number		Second Number	
IP	Protection Provided	IP	Protection Provided
0	No Protection	0	No Protection
1	Protected against solid objects up to 50mm e.g. accidental touch by hands	1	Protected against vertically falling drops of water e.g. condensation
2	Protected against solid objects up to 12mm e.g. fingers	2	Protected against direct sprays of water up to 15 degrees from the vertical
3	Protected against solid objects over 2.5mm e.g. tools	3	Protected against direct sprays of water up to 60 degrees from the vertical
4	Protected against solid objects over 1mm e.g. wires	4	Protected against water sprayed from all directions - limited ingress permitted
5	Protected against dust - limited ingress (no harmful deposit)	5	Protected against low pressure jets of water from all directions - limited ingress permitted
6	Totally protected against dust	6	Protected against strong jets of water e.g. for use on ship decks - limited ingress permitted
		7	Protected against the affects of immersion between 15cm and 1m
www.ControlAndInstrumentation.com		8	Protected against long periods of immersion under pressure



113. Repair and test work. –

(**1)No flame-proof or intrinsically safe apparatus shall be opened and no work likely to impair the safety characteristics of such apparatus or electric wiring connected thereto shall be carried out until all electrical supply has been cut off from the said apparatus or wiring.** The power supply shall not be restored thereto until the work has been completed and the safety characteristics provided in connection with the apparatus and wiring have been fully restored.

(2) Notwithstanding anything contained in this rule, **use of** soldering apparatus or other means involving flame, fire or heat or use of **industrial type apparatus in a zone "1" area shall be permitted for the purposes of effecting repairs and testing and alterations, provided that the area in which such apparatus or wiring has been installed, has first been made safe and certified by a competent person after testing with an approved gas-testing apparatus to be safe and free from inflammable vapours**, gases or liquids and is maintained in such conditions, so long as the work is in progress.







Vehicle Electrical installation. –

If electric light or instrument or any other electrically operated equipment is employed on any vehicle including a trailer used in the transportation by road of petroleum other than petroleum Class C-

(i) the pressure of the electric circuit shall not exceed 24 volts.

(ii) electrical wiring shall-

(a) be heavily insulated and be adequate for maximum loads to be carried.

(b) be provided with suitable over-current protection in the form of fuses or automatic circuit breakers and installed so as to be protected from physical damage and contact with possible product spill either by location or by being encased in metal conduit or other oil resistant protective covering,&

(c) have all junction boxes sealed;

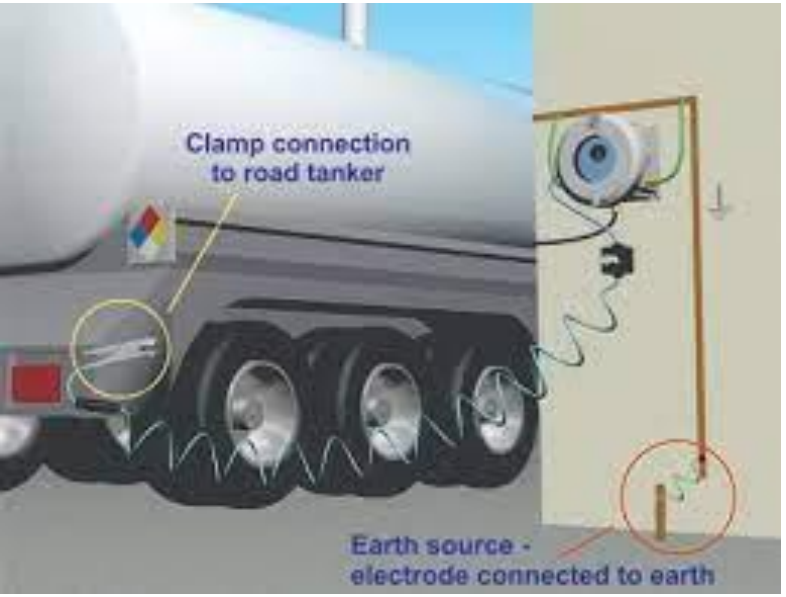








Precautions against static charges. –
(1) All petroleum pipelines entering any tank vehicle loading or unloading area shall be electrically continuous and be efficiently earthed.
(2) An earth boss with a flexible cable having robust clamping device shall be provided adjacent to the loading point.
(3) Sound and electrically continuous hoses or metal pipes shall only be used for loading or unloading of a tank vehicle. Where stand pipes or metallic loading arms are provided, swivel joints shall be electrically continuous.







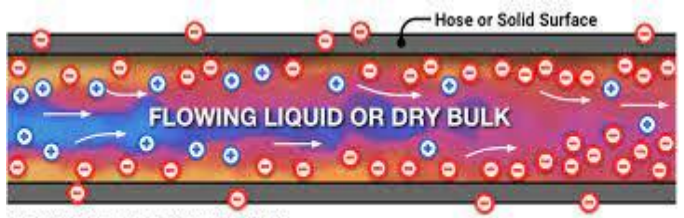
(4) The tank, filling pipe and the chassis of the tank vehicle shall, during loading of a tank vehicle, be efficiently bonded and connected with the earth boss referred to in sub-rule (2) by means of a flexible metal wire or tape.
(5) The bonding and earthing connections shall not be broken until loading of the tank vehicle has been completed and the filling and dip pipes thereof have been securely closed.
(6) Dip rod, if used, shall be lowered into the tank or compartment before loading of petroleum starts; such a rod shall not be completely raised above the liquid level during or within one minute of the completion of such loading.

(7) No tank vehicle shall be loaded at a rate exceeding one metre per second at the delivery end of the filling pipe until the filling pipe is completely submerged in petroleum and thereafter the loading rate may be gradually increased but it shall at no time exceed six metres per second at the delivery end of the filling pipe:

(8) No tank or compartment of any tank vehicle which has last carried petroleum Class A, shall be filled with petroleum of any other class if the interior thereof has any floating non-conducting loose object or water. No tank vehicle shall be subjected to splash loading.

Precautions against electrical hazards and hazard of a running engine. –No mechanically propelled vehicle for the petroleum shall be loaded or unloaded until its engine has been stopped and battery is isolated from the electrical circuit. The engine shall not be restarted and the battery shall not be connected to the electrical circuit until tanks and valves have been securely closed:





FLOW ELECTRIFICATION

Friction is created when the flowing material rubs against a static surface. An electarastic charge is generated and builds up from that friction.

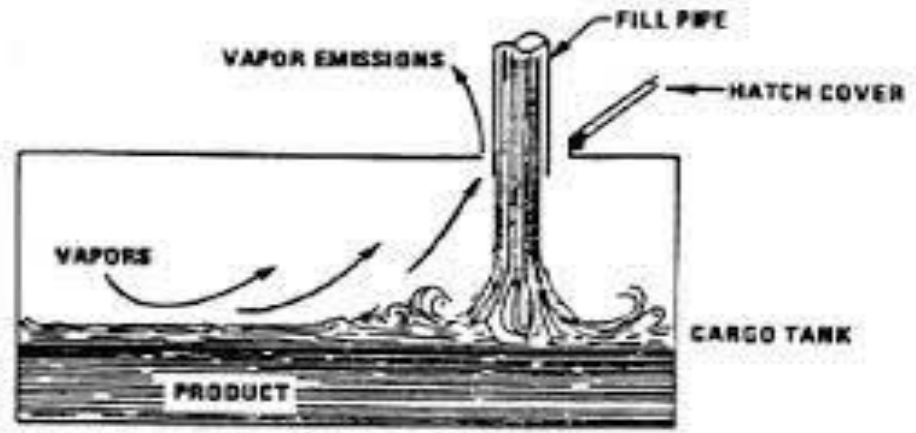


Figure 5.2-2. Splash loading method.

Earthing and bounding (Rule 108)

Electric system and equipment should be earthed with the resistance of 4 ohms or a value that ensure the safe operation of the protective device in the circuit whichever is lower.

All non-current carrying metallic parts of electric apparatus or another metallic object should be earthed with the resistance of 10 ohms.

All joints in pipelines, valve, plants, storage tanks, associated facilities and equipment for petroleum shall be electrically bonded with the resistance value between each joint not exceeding 1 ohm.

Rule 110

Electrified railway system (overhead line and live contact rails) are not allowed within a refinery or an installation. They should be terminated outside the area where tank wagons are loaded or unloaded. **Both the rails of spur lines shall be insulated from a railway siding which is used for the loading or unloading of tank wagons.**







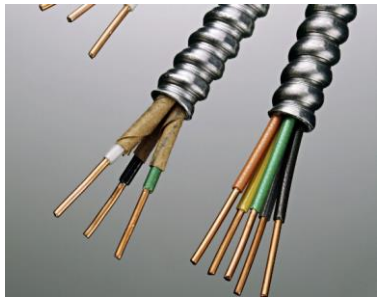


Fixed Electric Wiring (R. 107): PETROLEUM RULE 2002

It should be effectively sealed at all joints, mechanically protected, adequately supported and consisting of

- **approved armored cable** or
- **metal sheathed cable** or
- **insulated cable in a galvanized conduits with approved flame proof fitting** or
- **mineral insulated cable of an approved type with a flameproof gland at all joints** and details mentioned in the rule.















The Petroleum Rules, 2002
2. Definitions
(iii) ” Approved”,
(a) Where applied to a specification, means that **the specification** is authorized by the Chief Controller **including the following Oil Industry Safety Directorates Standards: OISD -105**, OISD-116, OISD- 117, OISD-118, OISD-141 and OISD –156;

Electrical isolation and energization permit:
Before issuing any work permit, it is essential that **the equipment / facility to be worked on is electrically safe and electrical power is isolated to the extent necessary for the safe conduct of the authorized work.**
Permit for electrical isolation and energization shall be in triplicate and in two sections with tear off facility.
Section-A shall be used for electrical isolation and Section-B for energization.

The original should be in color different than the other permits and copies should have the word "COPY" printed in large letters. **Original along with a copy shall be issued to the electrical section for electrical isolation / energization.** Electrical section authorized person on isolation / energization of the equipment / circuit shall return the original to the issuer keeping copy for record.

EXPLANATORY NOTES TO WORK PERMIT FORMS

Equipment / Area inspected:
Equipment or area where work is to be conducted, should be inspected to ensure that it is safe to carry out the work and assess other safety requirements / stipulations.

Sewers, Manholes, Closed Blow Down (CBD) etc. and Hot Surfaces covered:
Flammable gases may be released from nearby sewers. These are to be properly covered to prevent fires.

Equipment electrically isolated and tagged:
Before issuing a permit, it shall be ensured that electrical isolation has been done, switches are locked-out and cautionary tags duly signed with date and time are attached.

Running water hose / Portable extinguisher provided / Fire water system available:
Running water hose and portable fire extinguisher are required to flush / dilute in case of release of any hazardous chemical or to quench sparks and to put out small fires immediately. In order to meet any contingency, it should be ensured that the fire water system including firewater pumps, storage, network etc. is checked and kept ready for immediate use.

Gas / Oxygen deficiency test done:
Gas test includes measurement of: (i) Hydrocarbons by Explosive meter

Shield against sparks provided:
Hot works like welding, grinding etc generates sparks which can provide source of ignition to the surroundings. In order to protect operating area from the hazards of sparks generated, shields are to be provided to contain the sparks generated. The shield material should be non-flammable and should be kept wet with water.

Proper ventilation and lighting provided:

Where natural ventilation is not available, fans / air eductors are provided. These are also required for speedy dispersal of fumes generated by welding job. Only approved reduced voltage extension lights (not exceeding 24 volts) are to be allowed for work inside vessels from consideration of personal safety.

Portable equipment / Hose nozzles properly grounded:

As a precaution against static electricity generation, portable equipment / hose nozzles e.g. nozzle of a shot blasting gun, are to be grounded. Use of hydrocarbon lines for earthing should be avoided. 30 mili-amp circuit breaker shall be installed on electrical circuits / cables feeding power supply to portable equipment.

Standby personnel provided for fire watch from Process / Maintenance / Contractor / Fire Department:

Depending on the criticality of the job, work permit issuer shall decide the type of standby to be provided i.e. from which department, of which level, how many and also additional fire fighting support facilities etc.

ELECTRICAL WORK PERMIT – IS : 5216-Part 1

3.1 All work on major electrical installations shall be carried out under permit-to-work system, which is now well established, unless standing instructions are issued by the competent authority to follow other procedures.

The permit-to-work certificate from the person-in-charge of operation to the person-in-charge of the men selected to carry out any particular work ensures that the portion of the installation where the work is to be carried out is rendered dead and safe for working.

All work shall be carried out under the personal supervision of a competent person.

The permit is to be prepared in duplicate by the person-in-charge of operation on the basis of message, duly logged, from the person-in-charge of the work. The original permit will be issued to the person-in-charge of work and the duplicate will be retained in the permit book.

On completion of the work, the original shall be returned to the issuing officer duly discharged for cancellation.

All sheets in the permit books and the books themselves should be serially numbered.

APPENDIX A (Clause 3.6)
MODEL FORM OF PERMIT-TO-WORK

Name of the Organization ....
Department (issuing the permit) .....
Permit No. ..... Time. ..... Date. .....

1. I ..,.....certify that the following apparatus has been made dead, is isolated from all live conductors and has been connected to earth and the work mentioned in para (3) can now be carried out in accordance with the safety rules and regulations.
2. For the purpose of making the above apparatus dead, the following switches/ isolators / links/ fuses have been opened and the section so isolated has been earthed at each isolation point and danger notice plates tied thereon:
   Switches . . . . . Isolators . . . . . Links. . . . . Fuses . . . . . .
3. Work to be carried out (testing work, if any, to be specifically mentioned): ....

(NAME OF COMPANY)
(LOCATION)

Electrical Isolation / Energisation Permit

Section-A: Isolation Permit. Sl.No._____

Request for Isolation: Date:
_____Time:_____

Department / Section / Area issuing the permit
_____

Equipment number to be isolated:
_____

Name of the equipment / circuit to be isolated: _____

The above-mentioned equipment / circuit shall be de-energized and isolated from all live conductors to carry out the maintenance work by _____ section / for operational requirement.

_____ _____ _____
Issuer Name **Designation** **Signature**

Certificate of Isolation: Date:
_____Time:_____

Certified that Equipment / Circuit no. _____ of _____plant has been electrically isolated by switches / isolators / links / fuses (tick as applicable) and the danger tag is put on the supply panel. Actions in respect of electrical isolation have been recorded in the electrical shift logbook.

_____ _____ _____
Name of Authorized Person **Designation** **Signature**

Section-B: Energisation Permit.
Sl.No._____

Request for Energisation: Date:
_____Time:_____

Department / Section / Area issuing the permit_____

Equipment number to be energized: _____

Name of the equipment / circuit to be energized:_____

Work on the above mention equipment / circuit has been completed and all the applicable permits closed. This equipment / circuit may be energized.

_____ _____ _____
Issuer Name **Designation** **Signature**

Certificate of Energisation: Date:
_____Time:_____

Certified that Equipment / circuit no._____ of _____plant has been electrically energized and the danger tag removed from the supply panel. This is also recorded in the electrical shift logbook.

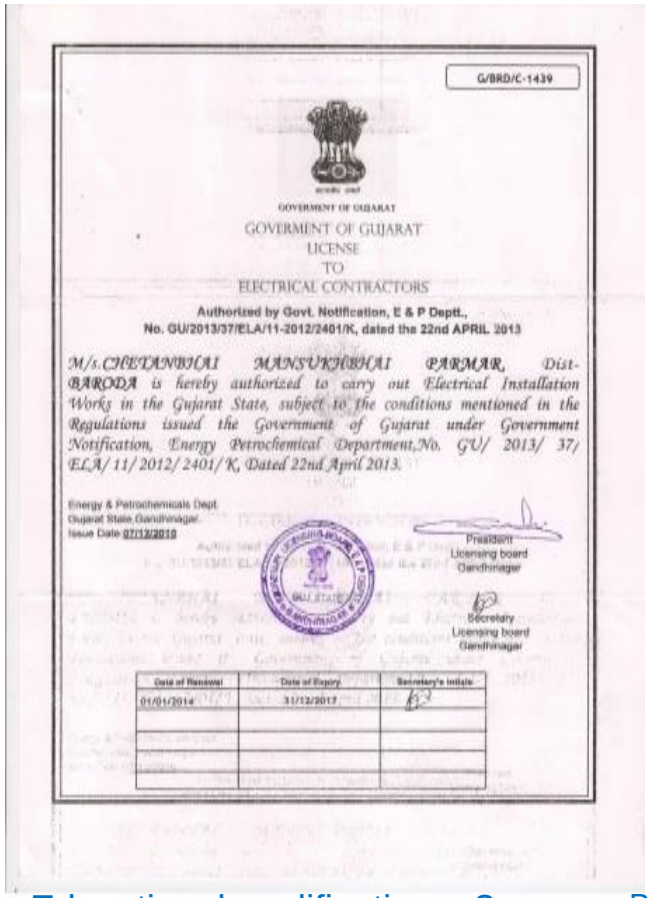
_____ _____ _____
Name of Authorized Person **Designation** **Signature**

This content is only for academic/education purpose. This should not be copied or reproduced anywhere by other than author.

THE INDIAN ELECTRICITY RULES

3. Authorisation-[(2) **No person shall be authorised under sub-rule (1) unless he is competent to perform the duties assigned to him and possesses either an appropriate certificate of competency or permit to work.]**

(3) **No person shall be deemed to be authorised under sub-rule (1) unless his name has been entered in a list maintained at the office or premises of the person authorizing him, and giving the purpose for which such person is authorised and the entry has been attested by the authorised person and the person authorising him.**



G/BRD/C-1439

GOVERMENT OF GUJARAT

GOVERMENT OF GUJARAT
LICENSE
TO
ELECTRICAL CONTRACTORS

Authorized by Govt. Notification, E & P Deptt.,
No. GU/2013/37/ELA/11-2012/2401/K, dated the 22nd APRIL 2013

M/s. CHETANBHAI MANSUKHBHAI PARMAR, Dist-BARODA is hereby authorized to carry out Electrical Installation Works in the Gujarat State, subject to the conditions mentioned in the Regulations issued the Government of Gujarat under Government Notification, Energy Petrochemical Department, No. GU/ 2013/ 37/ ELA/ 11/ 2012/ 2401/ K, Dated 22nd April 2013.

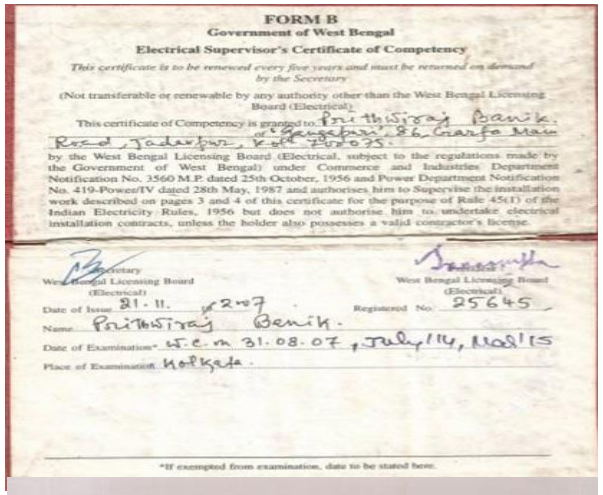
Energy & Petrochemicals Dept.
Gujarat State, Gandhinagar.
Issue Date 07/12/2010

President
Licensing board
Gandhinagar

Secretary
Licensing board
Gandhinagar

Date of Renewal	Date of Expiry	Secretary's initials
01/01/2014	31/12/2017	

Educational qualification = ?



FORM B
Government of West Bengal
Electrical Supervisor's Certificate of Competency

This certificate is to be renewed every five years and must be returned on demand by the Secretary

(Not transferable or renewable by any authority other than the West Bengal Licensing Board (Electrical))

This certificate of Competency is granted to Prithwiraj Banik of Gangapur, 86, Garfa Main Road, Jadavpur, Kol 700075.

by the West Bengal Licensing Board (Electrical, subject to the regulations made by the Government of West Bengal) under Commerce and Industries Department Notification No. 3560 M.P. dated 25th October, 1956 and Power Department Notification No. 419-Power/IV dated 28th May, 1987 and authorises him to Supervise the installation work described on pages 3 and 4 of this certificate for the purpose of Rule 45(1) of the Indian Electricity Rules, 1956 but does not authorise him to undertake electrical installation contracts, unless the holder also possesses a valid contractor's license.

Secretary
West Bengal Licensing Board
(Electrical)

West Bengal Licensing Board
(Electrical)

Date of Issue 21.11.2007

Registered No. 25645

Name Prithwiraj Banik.

Date of Examination* W.C.m 31.08.07, July/14, Mod/15

Place of Examination Kolkata.

*If exempted from examination, date to be stated here.



No.: G/GS-E-000528-DEE-2007

GOVERNMENT OF GUJARAT

CERTIFICATE OF COMPETENCY

(Authorised by Govt. Notification, I.M.P. Deptt., No. GU-40/IER-1067/2336-K, dated the 7th April, 1969 and further notification No. GU-71-88/IER/1067/2336K, dated 7th Sept. 1971)
& further amended from time to time.

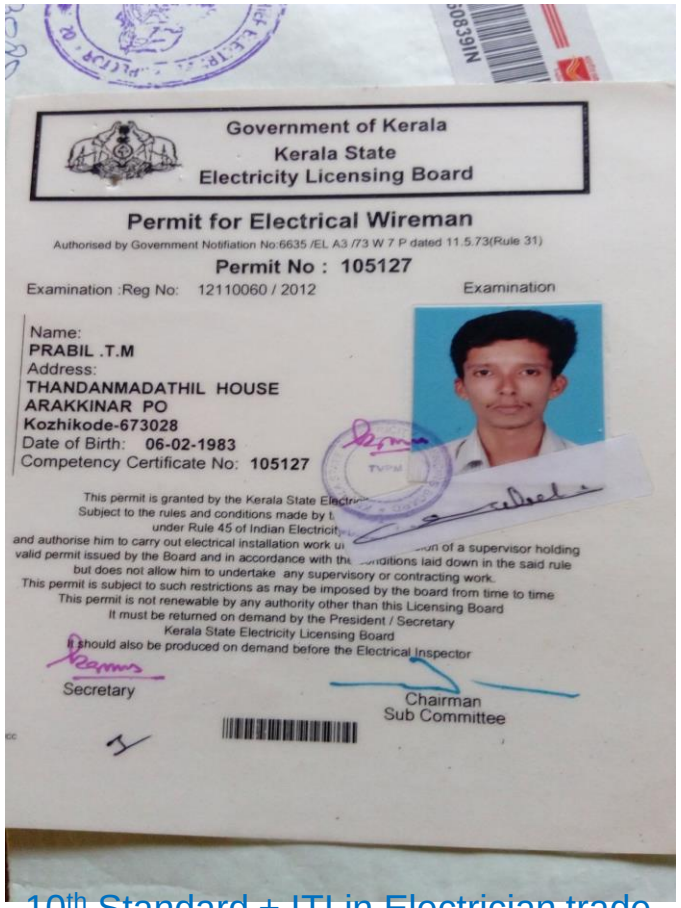
Shri/Kum/Smt. MODI SUCHIT HASMUKH
having satisfied the Licensing Board that his/her qualifications entitle him to exemption from taking the prescribed Examination for Electrical Supervisor is hereby granted this Certificate of Competency

Energy & Petrochemicals Dept.
Gujarat State, Gandhinagar
Issue Date :27/JUL/2007

President
Licensing Board
Gandhinagar.

Secretary
Licensing Board
Gandhinagar.

BE (Elect) + 5 yrs experience/ Diploma in Elect Engg + 10 years experience



Government of Kerala
Kerala State
Electricity Licensing Board

Permit for Electrical Wireman

Authorised by Government Notifiation No:6635 /EL A3 /73 W 7 P dated 11.5.73(Rule 31)

Permit No : 105127

Examination :Reg No: 12110060 / 2012

Examination

Name:
PRABIL .T.M
Address:
THANDANMADATHIL HOUSE
ARAKKINAR PO
Kozhikode-673028
Date of Birth: 06-02-1983
Competency Certificate No: 105127

This permit is granted by the Kerala State Electr...
Subject to the rules and conditions made by t...
under Rule 45 of Indian Electricity...
and authorise him to carry out electrical installation work u... of a supervisor holding valid permit issued by the Board and in accordance with the conditions laid down in the said rule but does not allow him to undertake any supervisory or contracting work.
This permit is subject to such restrictions as may be imposed by the board from time to time
This permit is not renewable by any authority other than this Licensing Board
It must be returned on demand by the President / Secretary
Kerala State Electricity Licensing Board
It should also be produced on demand before the Electrical Inspector

Secretary

Chairman
Sub Committee

10th Standard + ITI in Electrician trade

9[(6) In every registered factory, **where more than 250 KW of electrical load is connected**, **there shall be a person authorised by the management of the factory for ensuring the observance of the safety provisions laid under the Act and the rules made there under, who shall periodically inspect such installation, get them tested and keep a record thereof** and such records shall be made available to the Inspector 2[or any officer of a specified rank and class appointed to assist the Inspector], if and when required.]

Health, Safety & Environment Department, HO

Ref. HSE/HO/102 **20.7.2016**

Office Order

Central Electrical Authority on 13th April, 2015, amended some of the regulations of Central Electrical Authority (Measures relating to Safety and Electric Supply) Regulations, 2010.

With a view to ensure compliance of above, you are nominated as designate Electrical Safety Officer for respective electrical installations connected with more than 250 kW in the respective regions, in addition to your normal assignment.

You are designated as Electrical Safety Officer and shall carryout periodic tests as per the relevant standards and inspection of such installation for ensuring observance of safety measures specified under these regulation at intervals not exceeding one year and keep a record formats as per CEA guidelines and amendments issued from time to time. Ensure a register of recommended safety requirements are maintained by Location-in-Charge with compliance details thereafter and such records shall be made available by Location-in-Charge to the Electrical Inspector as and when required.

(B. S. Giridhar)
ED(H,S&E)

Shri R. Narula, (EC No. 28476)
Sr. Manager (H,S&E),
Western Region,
Mumbai

cc : ED(HR), HO
cc : GM, Director(M) Secretariat

As required by rule 45 of the Indian Electricity Rules, 1956, **no electrical installation work (including additions, alterations, repairs and adjustments to existing installations),**
except such replacement of lamps, fans, fuses, switches, low voltage domestic appliances and fittings
as in no way alter the capacity and the character of the installation, shall be carried out upon the premises on behalf of any consumer or owner for the purposes of supply of energy to such consumer or owner, **except by an electrical contractor licensed by the in this behalf and under the direct supervision of a person holding a certificate of competency issued or recognised by the State.**

1. HUMAN & ANIMAL LIFE NOT TO BE ENDANGERED
2. CLOSED SWITCHBOXES
3. ISOLATOR ACROSS TRANSFORMER
4. EARTHING TEST, INSULATION TEST
5. PROVISION OF PROTECTIVE RELAYS
6. BALANCING OF LOADS
7. ELCBs
8. GROUND CLEARANCE OF ABOVE GROUND CONDUCTORS – MV – 5.8/5.5m(across/ along), HV – 6.1/5.8 m (across/along), bare HV – 4.6 m, insulated HV – 4.0 m, above 11 KV – 5.2 m





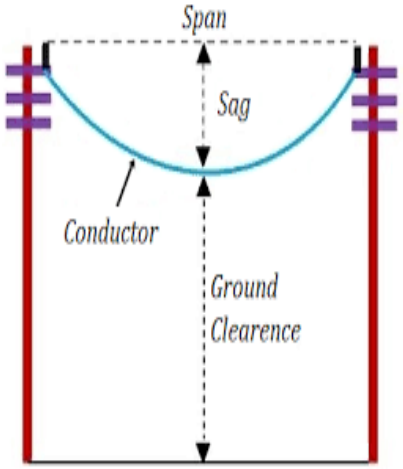
















9. DANGER NOTICE PLATES : IS 2551
10. AVAILABILITY OF SAFETY DEVICES - GLOVES / SHOES / BELTS / LADDERS / EARTHING DEVICES / HELMETS / LINE TESTERS / FIRST AID BOXES
11. FIRE BUCKETS, FIRST AID BOX, F/EXTINGUISHERS
12. SHOCK TREATMENT CHART
13. CLEARANCES – 1 m FRONT, 0.75 m REAR
14. RECORD OF TEST, TRIPPING, M&R – HV
15. ELECTRICAL WORK PERMIT SYSTEM
16. AUTHORIZED PERSON TO OPERATE

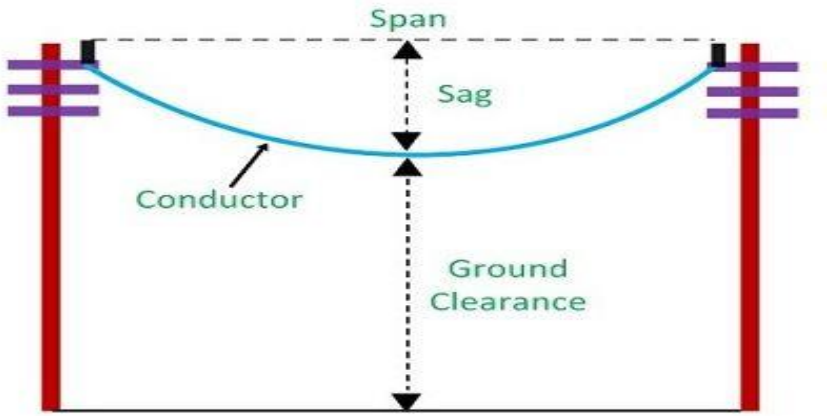








Requirements for high voltage installations





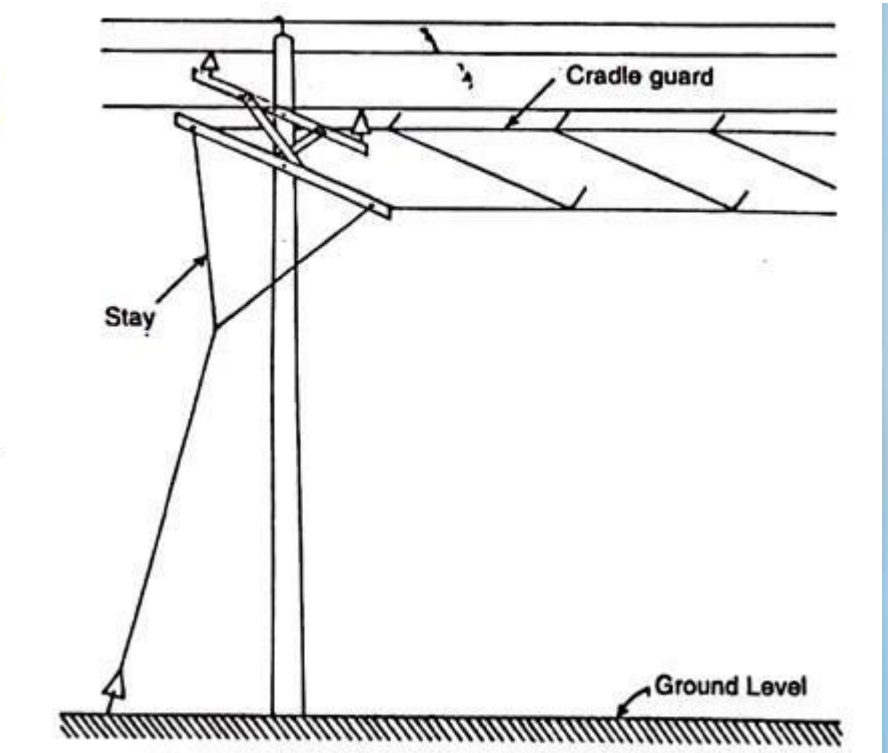


Fig. 283 : Use of cradle guard with distribution lines

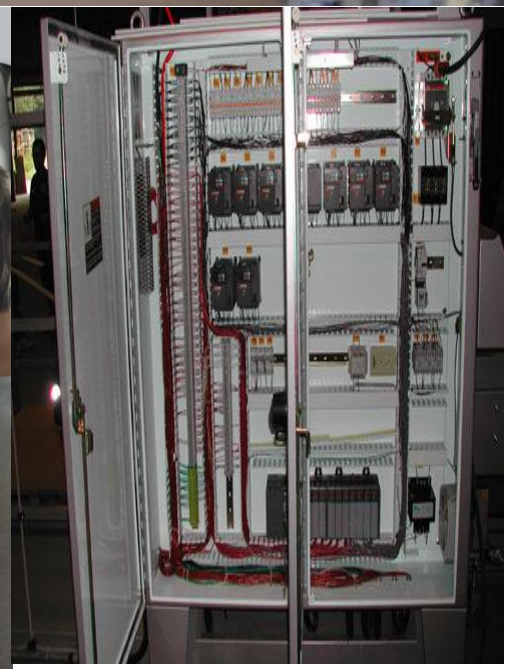
Anti-climbing device



Clearances at front, side & rear of electrical panels







Clearances at front : at least 1m

Clearances at side : at least 0.75 m up to a height of 1.8 m or less than 0.2 m

Clearances at rear : at least 0.75 m up to a height of 1.8 m or less than 0.2 m

This is to facilitate M&R.

61. Clearances from buildings of lines of voltage exceeding 650 V

(1) An overhead line shall not cross over an existing building as far as possible and no building shall be constructed under an existing overhead line.

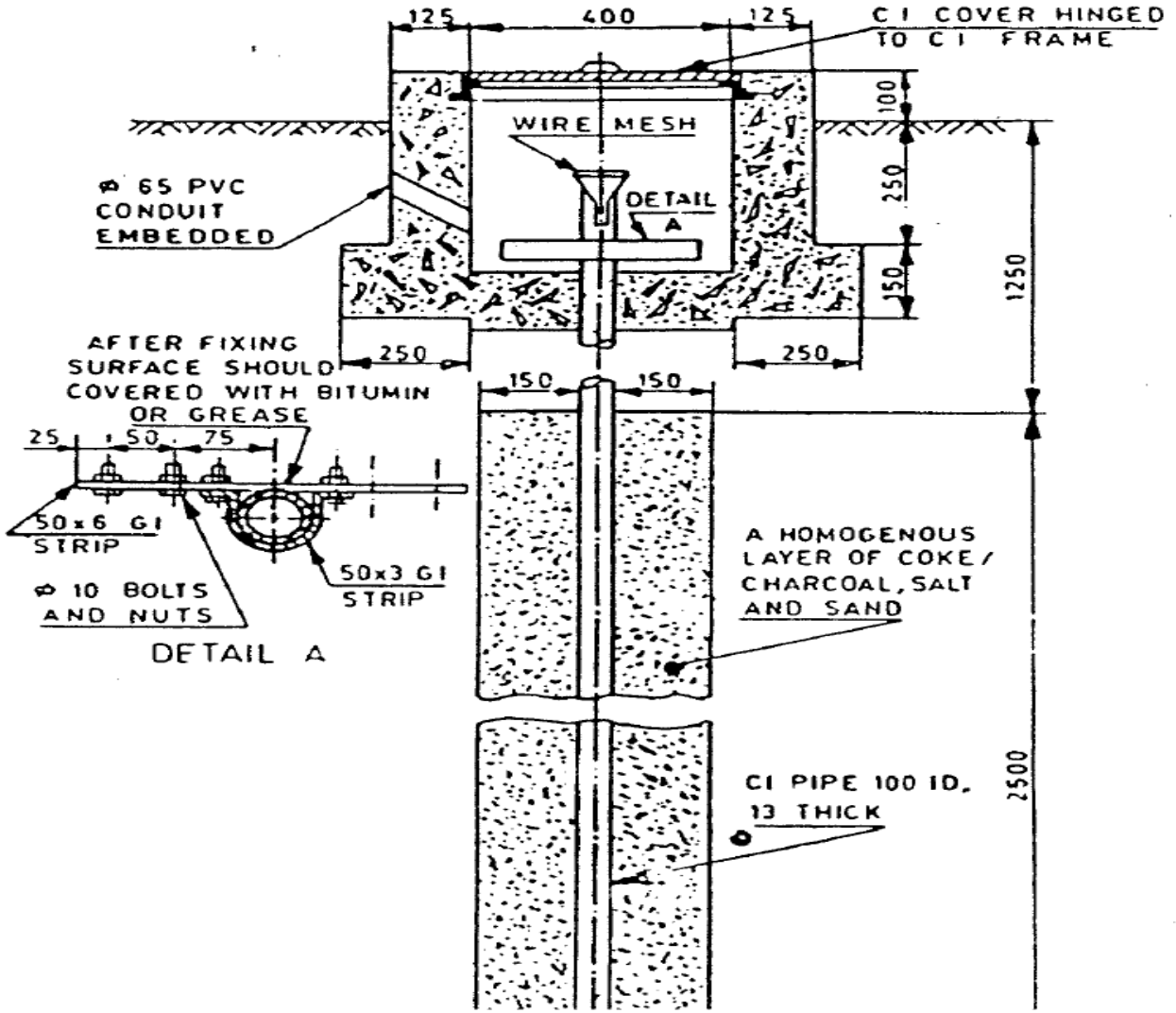
(2) Where an overhead line of voltage exceeding 650 V passes above or adjacent to any building or part of a building it shall have on the basis of maximum sag a vertical clearance above the highest part of the building immediately under such line of not less than-

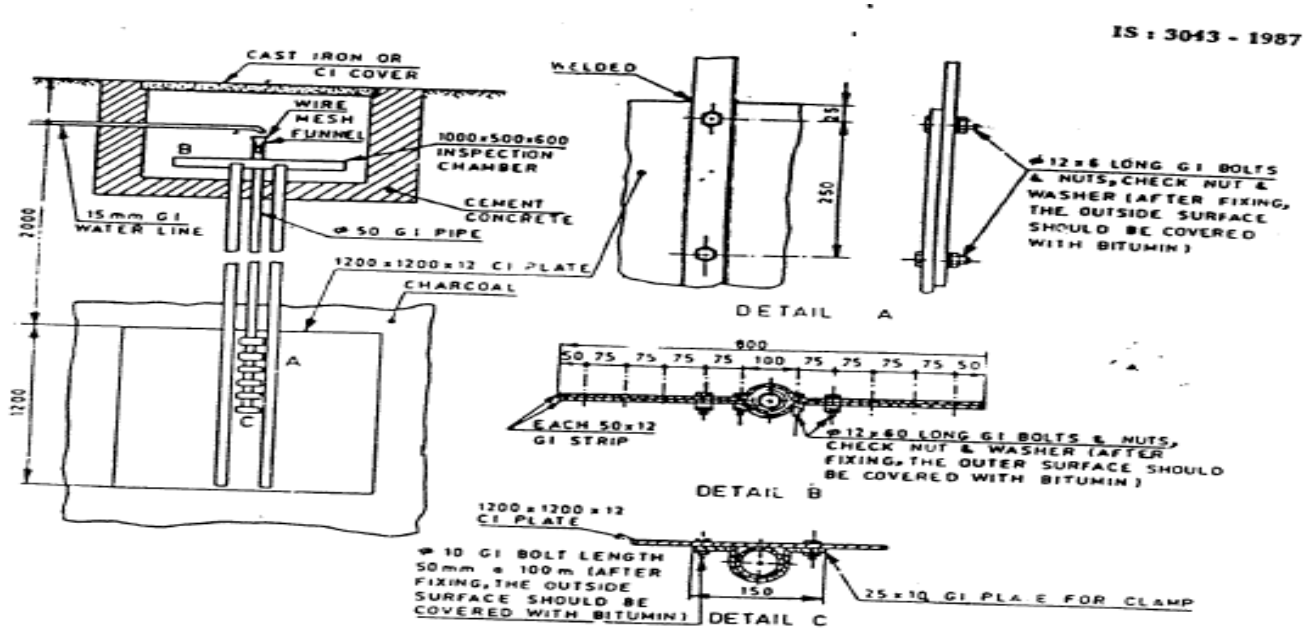
(i) for lines of voltages exceeding 650 Volts up to and including 33,000 Volts	3.7 m
(ii)for lines of voltages exceeding 33 kV	3.7 metres plus 0.30 metre for every additional 33,000 Volts or part thereof.

(3) The horizontal clearance between the nearest conductor and any part of such building shall, on the basis of maximum deflection due to wind pressure, be not less than-

(i) for lines of voltages exceeding *650 V* up to and including 11,000 Volts	1.2 metres
(ii) for lines of voltages exceeding 11,000 V and up to and including 33,000 V	2.0 metres
(iii) for lines of voltages exceeding 33 kV	2.0 metres plus 0.3 metre fore every additional 33kV or part thereof.

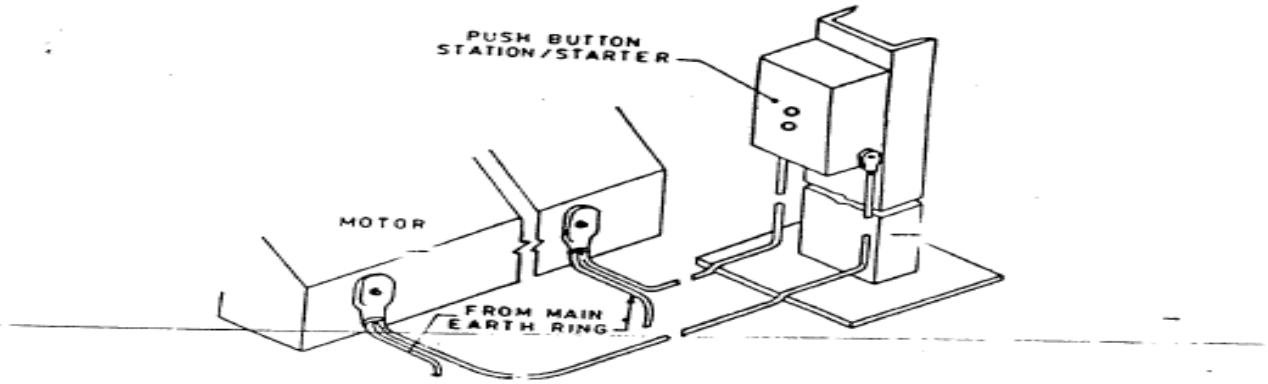
Earth pit as per IS 3043





All dimensions in millimetres.

FIG. 15 TYPICAL ARRANGEMENT OF PLATE ELECTRODE



16A Earthing Arrangement for Motors with Push Button Station/Starter Earth Connections to Starter Looped from Earth Connections of Motor



The Factories Act, The Factories (Amendment) Act

Section 7A. General duties of the occupier.-

(1) **Every occupier shall ensure, so far as is reasonably practicable**, the health, **safety** and welfare **of all workers while they are at work** in the factory.

(2) Without prejudice to the generality of the provisions of sub-section (1), the matters to which such duty extends, shall include-

- (a) the **provision and maintenance of plant and systems of work** in the factory **that are safe** and without risks to health;
- (b) the **arrangement in the factory for ensuring safety** and absence of risks to health **in connection with the use, handling, storage and transport** of articles and substances;
- (c) the **provision of such information, instruction, training and supervisions** as are **necessary to ensure** the health and **safety** of all workers at work;
- (d) the **maintenance of all places of work in the factory in a condition that is safe** and without risks to health and the provision and **maintenance of such means of access to, and egress from, such place as are safe** and without such risks;

(e) the **provision, maintenance or monitoring of such working environment in the factory for the workers that is safe,** without risks to health and adequate as regards facilities and arrangements for their welfare at work.

Section 36A. Precautions regarding the use of portable electric light.-

In any factory-

(a) **no portable electric light** or any other electric appliance **of voltage exceeding twenty-four volts shall be permitted** for use inside any chamber, tank, vat, pit, pipe, flue or other confined space unless adequate safety devices are provided; and

(b) **if any inflammable gas**, fume or dust **is likely to be present in such** chambers, **tank**, vat, pipe, flue or other confined space, no lamp or light other than that of **flame-proof construction shall be permitted to be used** therein.



- **The Safety Officer** / Fire Officer / **Officer authorized should make periodic check of the work sites and see that the work is being carried out as per conditions laid down in the work permit.** At any point of time, if he considers that the conditions are not safe for the work, **he may suspend the work** and inform the Work Permit Issuing Authority to restore the safe conditions so that work can be restarted.
- **Issuer should make periodic check of the work sites and see that the work is being carried out in safe manner** and as per conditions laid down in the work permit. **Work shall be suspended** in case the conditions are not safe.
- **Welding machine** should be **located in a non-hazardous and ventilated area and shall be properly earthed.** Before commencing the welding job, ensure that all the **cables and earthing connections are as per the standard welding codes / practices**. **It should be switched off immediately on completion of the job.**
- **After completion or stoppage of the job, the permit shall be closed. Receiver shall satisfy himself about the completion of the job** (thoroughly check the area for clearing of debris, removal of temporary electrical installations & machines etc.) **before closing the permit**. **Similarly issuer shall satisfy himself regarding completion of the job** and that the area has been cleaned **before closing the permit. The permit will be treated "Closed" only after signing by Issuer and the Receiver.**
- **Any person who is authorized to issue or receive the work permit shall be imparted training for a period of not less than one day covering various aspects of work permits system.** Further **all the person authorized to issue / receive or involved with the work permit shall be given a minimum of one day training once in two year on the work permit system and records maintained.**

Best Engineering Practices

Brief description of equipment	Recommended Hazard Code No.	Typical Industrial Operation	Protection Against hazard	Remarks
Thermo plastic material helmet	H-4	Contact with bare live electrical conductor	Electrical shock	No metal parts in helmet
Electric current carrying equipment	H-11	Work on live electrical equipment	Electric shock	Equipment code E-23 Natural rubber gloves
Electric grinder & hammer Gas/ electric cutting	H-1 H-6	Chipping, grinding of metals Oxy-acetylene cutting & welding, electric arc welding etc.	Impact Injurious radiant energy	Equipment code E-1 (Safety spectacles with side shields, safety lenses mounted in spectacle frames) ,E-2 (Cup type goggles, 2 separate cupped eye pieces, connected across the nose & holding safety lenses, provided with head band), E-5 (One piece eye protectors / mono goggles), E-6 (Face shields)
Electric grinder, short blasting machine	H-2	grinding, sand/ shot blasting	Dust	Equipment code E-4 (Dust goggles), E-5 (One piece eye protectors / mono goggles)










HEARING LOSS IS PERMANENT & IRREVERSIBLE.

The limit for continuous noise without protection is 90 dBA for exposures of 8 hrs/ day.

Sound level, dBA	90	95	100	105	110	115
Exposure time limit, hrs	8	4	2	1	$\frac{1}{2}$	$\frac{1}{4}$



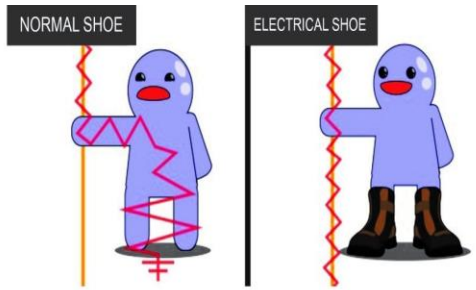
Material : PVC / PU/ Silicone; Type : Limited use
Protection : Reduce noise level by upto 20 dBA
Cost : Rs 15-20/ pp



Material : thermo plastic or metal headband; Type : Reusable
Protection : Reduce noise level by upto 23 dBA
Cost : Rs 350-450/ pp

Ear plugs & earmuffs can be used together to provide protection up to 23 dBA.

Electrical safety shoes where an employee's feet are exposed to electrical hazards.

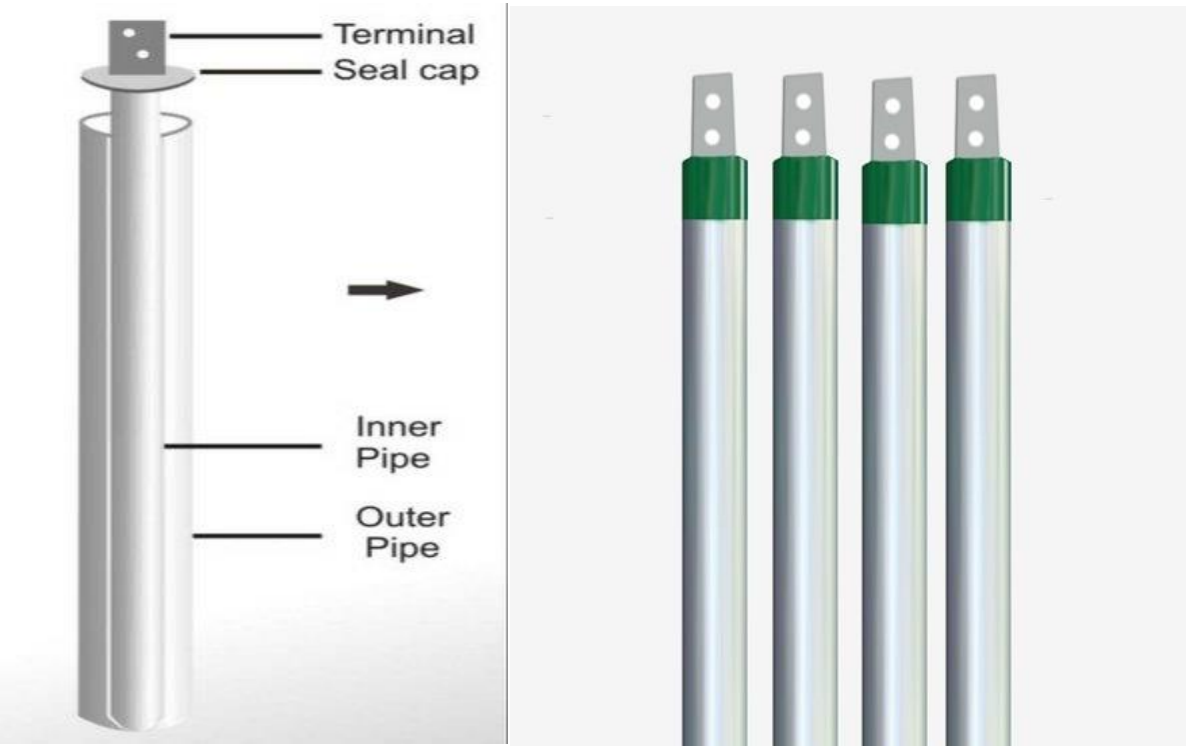




ARTICLE	: T TORP REDDING 03/B
ELECTRICAL-PROPERTY	:15 KV ELECTRICAL RESISTANCE
UPPER	: TANGO PRINTED FINISHED LEATHER
LINING MATERIAL	: BREATHABLE SPACER
TOE CAP	: COMPOSITE 200 JOULES
SOLE TECHNOLOGY	: DIRECT INJECTION
DENSITY	: DOUBLE DENSITY PU

Chemical Earthing System as Per IEEE 80 and IEC 62561 Standards

This type of earthing is maintenance free and offers long life up to 20-25 years. A copper bonded rod of 250 micron copper coating over mild steel is used as vertical conductor which enhances its conductivity and manufacturing strength since it is physically stronger than copper.



IS: 3043 – 1987 clause 8.5
Soil treatment to improve earth electrode contact resistance may be applied in special or difficult locations.
Earth electrodes packaged in material such as bentonite are preferable. Bentonite or similar material may be used to advantage in rocky terrain. Where holes are bored for the insertion of vertical electrodes or where strip electrodes are laid radially under shallow areas of low resistivity overlaying rock strata, bentonite packing will increase the contact efficiency with the general mass of ground.

EARTHING Guidelines

Earth pit – as per IS : 3043 – 1987.

Earth grid – 600 mm below grade; 1.5 m away from buildings.

Welded portion of earth strip – painted with black bituminous paint.

Minimum contact surface = width of earth strips.

GI strip connection to earth electrode – by SS / Cadmium plated bolts/ nuts.

1 ph equipments – single earthed; 3 ph equipments – double earthed.

OISD – STD – 244 : Earthing

Earthing for LA	2/4 Pole Structure, GO, Fence	Transformer Neutral	DG set Neutral	Body of DG Set / control panel for DG Set	Sub-station/ PMCC Room	Fire Pump House/ Admin Blocks	All structures Shed of Pump House / Fire Engine / Loading unloading Gantry / Air Compressor / Engg Store etc	Static Earth for Loading / unloading Gantry (TT) operations
2 No independent earth electrodes	2 Nos (All metal bodies connected)	2 No independent earth electrodes	2 Nos independent for each DG Set	2 no	4 no	2 no each	2 no for each structure	2 No earth pits for 8 bay gantry
50 mm x 6 mm GI strip	40 mm x 6 mm GI strip	50 mm x 6 mm GI strip	50 mm x 6 mm GI strip	40 mm x 6 mm GI strip	40 mm x 5 mm GI strip	25 mm x 6 mm GI strip	40 mm x 5 mm GI Strip	40 mm x 6 mm GI strip
Static Earth for Loading unloading Gantry (Tank Wagon) operations		rail track	3 Phase Motors / FLP lights in each shed	High Mast Tower (HMT)		Data Processing	Inspection Platform / Watch Tower / Weigh Bridge	Product Storage Tank
Min. 4 nos. earth pits for each (single/two spur) gantry		as per railway norms	2 no	2 No for each HMT		1 no for Metallic equipment body and 1 no for neutral of isolation-transformer	1 no each	Minimum 2 no for tanks up to 60 m perimeter; 3 no for tanks above 60 & up to 90 m perimeter & so on
40 mm x 6 mm GI strip, 10 Sq mm Copper flexible cable			10 mm (3/8") GI Wire Rope	50 mm x 6 mm GI strip		10 mm (3/8") GI Wire Rope	40 mm x 5 mm GI Strip	40 mm x 5 mm GI Strip

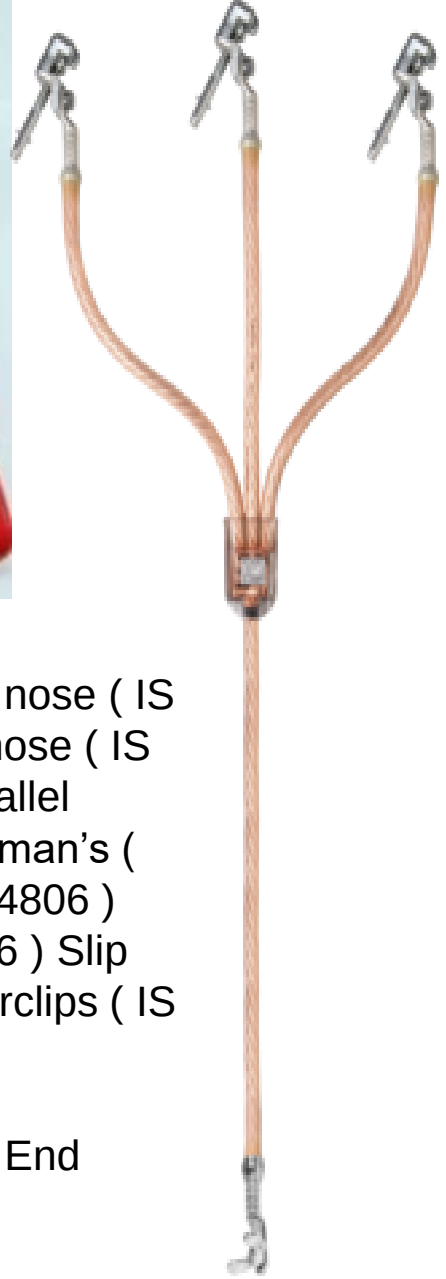

DANGER
440 - VOLTS
खतरा
ಅಪಾಯ
ಅಪಾಯಮು
ಅಪಾಯಂ
ಅಪಾಯಮ
सावधान


ELECTRIC SHOCK & it's MANAGEMENT
विद्युताघात एवं उसके प्रबंध नियम
EFFECTS
MANAGEMENT
1. EXPOSED LIVE WIRE
2. HIGH TENSION WIRE
PRECAUTIONS
LOW VOLTAGE
HIGH VOLTAGE
HOSPITAL


Jyot
Jyot


DO NOT OPERATE







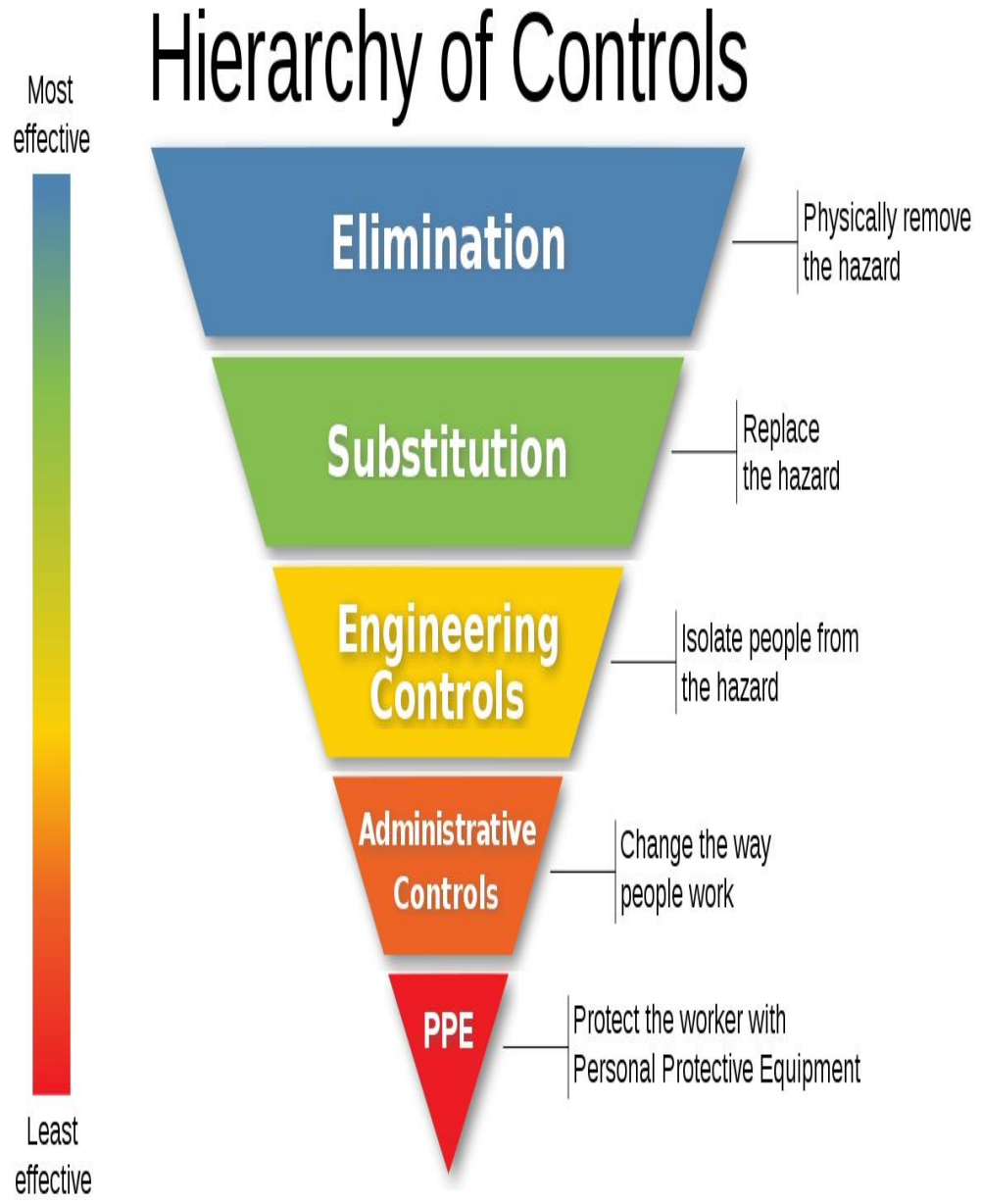
IS 2615 : 1988 (R2004)

Pliers : 4 Combination side cutting (IS 3650) Flat nose (IS 3552 and IS 8672) Round nose (IS 3568) Snipe nose (IS 5658) Duckbill (IS 4481) Pipe grip (IS 5995) Parallel action flat nose (IS 6086) Fencing (IS 5067) Lineman's (IS 6078) Battery terminal (IS 5006) Heat coil (IS 4806) Burner (IS 3569) Eyelet (IS 3529) Glass (IS 5066) Slip joint (IS 6118) Wire stripping (IS 5087) Internal circlips (IS 7989) External circhps (IS 7990)

Pincers (IS 4095)

Nippers 1) Diagonal cutting [IS 4378 (Part 1)] 2) End cutting [IS 4378 (Part 2)]

EN 131 : made of dielectric fiberglass and aluminium Protects against accidental shock of up to 30,000 V.



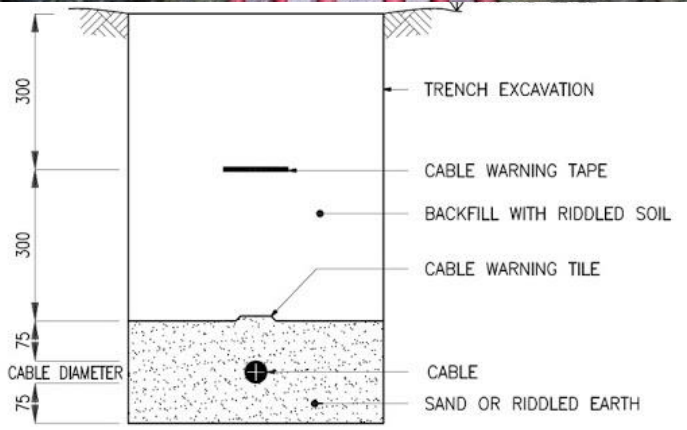
THE RISK CONTROL HIERARCHY AND ELECTRICAL SAFETY

1. **Elimination** -Removing all electrical energy exposure (LOTO).
2. **Substitution** –Lowering the electrical energy exposure (Maintaining safe distance from OH lines/ Undergrounding HV lines).
3. **Engineering Controls** –Reinventing ways to control electrical energy exposure (Use of line tester, insulated tools/ Guarding/ Earthing & bonding).
4. **Awareness** –Revealing and labeling all sources of electrical energy (Danger signs/ Caution boards).
5. **Administrative Controls** – Regulations that teach personnel safety around electrical energy (SOPs/ Work methods/ Work instructions/ Toolbox talk).
6. **Personal Protection** –Reducing risks of working on live voltage (Use of insulating rubber mats/ rubber hand gloves electrical/ electrician safety shoes/ arc flash protection suits).

Manual Cable Laying and Termination (Normal lifespan = 40 to 50 years)

1. Excavation permit, Safety belt, Safety helmet.
2. Careful excavation - for possible cables laid already.
3. While excavating near the Cables, the Cables shall be de-energized.
4. Barricading - to avoid fall into the excavated trenches.
5. Cable ends to be properly identified before start of work.
6. Check the presence of Voltage by line tester/test lamp for L.T. & by remote voltage indicator for HT.
7. Precaution while peeling off the Cable sheath - Wear canvas/leather hand gloves.
8. Ensure that the power supply is cut off before termination of the cable.
9. While conducting IR test – Ensure persons are away from the Cable terminals, Cable terminals at the farther end are safe & isolated from human approach/caution boards are put & earth cable is discharged.
10. Minimum trench width = 350 mm. Horizontal inter axial space between 02 cable = 200 mm. Minimum clearance between cable's axis and sides of trench = 150 mm. Depth for LT cable = 750 mm. Depth for 11/ 33 kV = 900/ 1200 mm respectively. Vertical clearance between 02 tiers = 300 mm.
11. Cable joining not permitted in hazardous areas.





This content is only for academic/education purpose. This should not be copied or reproduced anywhere by other than author.

Revisiting the Agenda

- Overview of electrical hazards
- Electrical installation
- Statutory Requirements
- Best Engineering Practices



Your Queries Please!!!

Thank you