Introduction

The electricity Act 2003

Cea (Measures Relating to Safety and Electric Supply) Regulations

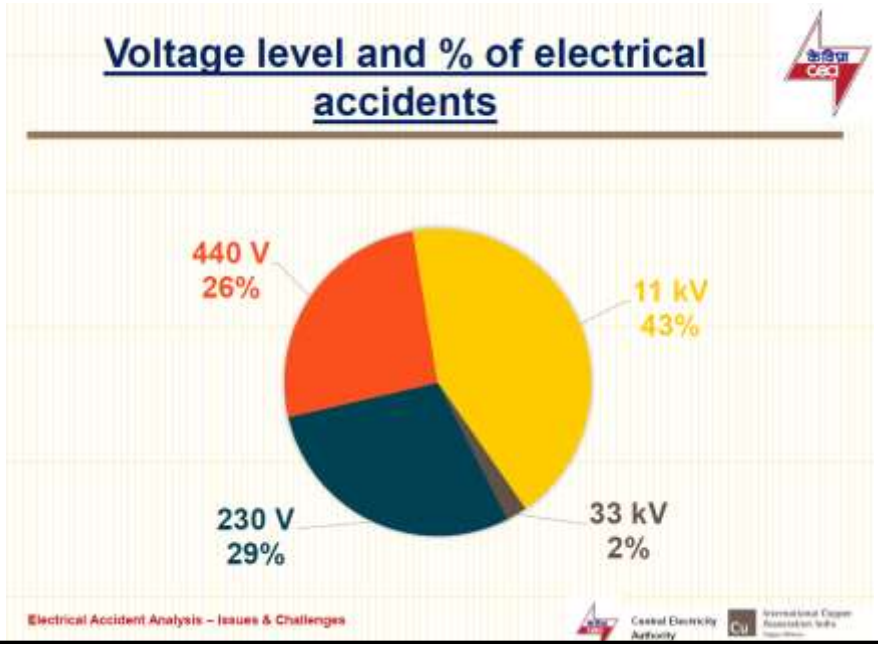
Code of Practice by Bureau of Indian Standards or National Electrical code of India

Product standards by Bureau of Indian Standards / IEC

IE rule 1956 has been replaced with CEA regulations

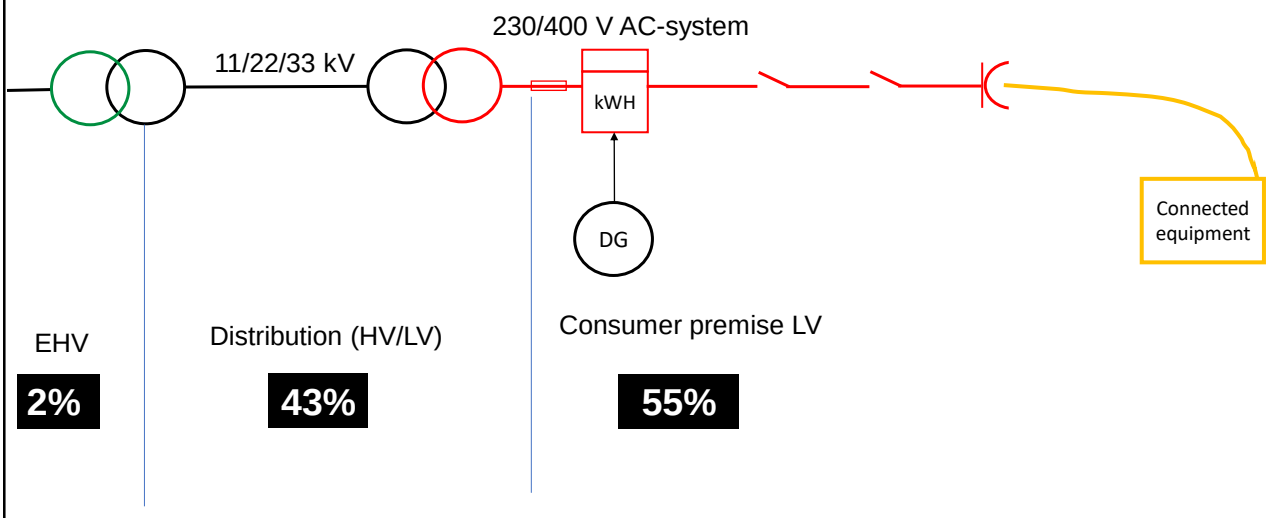
1

Accidents in Electrical System



2

Accidents in Electrical System



3

The electricity Act 2003

Section 53. (Provisions relating to safety and electricity supply):

The Authority may in consultation with the State Government, specifysuitable measures for –

(a) protecting the public (including the persons engaged in the generation, transmission or distribution or trading) from dangers arising from the generation, transmission or distribution or trading of electricity, or use of electricity supplied or installation, maintenance or use of any electric line or electrical plant;
(b) eliminating or reducing the risks of personal injury to any person, or damage to property of any person or interference with use of such property ;
(c) prohibiting the supply or transmission of electricity except by means of a system which conforms to the specification as may be specified;
(d) giving notice in the specified form to the Appropriate Commission and the Electrical Inspector, of accidents and failures of supplies or transmissions of electricity;
(e) keeping by a generating company or licensee the maps, plans and sections relating to supply or transmission of electricity;
(f) inspection of maps, plans and sections by any person authorised by it or by Electrical Inspector or by any person on payment of specified fee;
(g) specifying action to be taken in relation to any electric line or electrical plant, or any electrical appliance under the control of a consumer for the purpose of eliminating or reducing the risk of personal injury or damage to property or interference with its use.

4

Section 177. (Powers of Authority to make regulations): ---

(1) The Authority may, by notification, make regulations consistent with this Act and the rules generally to carry out the provisions of this Act.

(2) In particular and without prejudice to the generality of the power conferred in sub-section (1), such regulations may provide for all or any of the following matters, namely:--

a) the Grid Standards under section 34;
b) suitable measures relating to safety and electric supply under section 53;
c) the installation and operation of meters under section 55;
d) the rules of procedure for transaction of business under subsection (9) of section 70;
e) the technical standards for construction of electrical plants and electric lines and connectivity to the grid under clause (b) of section 73;
f) the form and manner in which and the time at which the State Government and licensees shall furnish statistics, returns or other information under section 74.
g) any other matter which is to be, or may be, specified;

(3) All regulations made by the Authority under this Act shall be subject to the conditions of previous publication.

5

Section 146 punishment and penalties for noncompliance

Electricity Act 2003
6.Sec 146:- Punishment for Non-Compliance orders or directions

Whoever fails to comply any order/direction/any rules/regulations made there under:

- Imprisonment for a term which may extend to 3 months
- Fine may extend to One Lakh rupees
- with both in respect of each offence
- In continuing failure, with additional F Rs.5,000/- for every day

6

Contents

Cea (Measures Relating to Safety and Electric Supply) Regulations, 2010	CEA (Measures Relating to Safety and Electric Supply) Regulations, 2022
Chapter I - Title, date of commencement and definitions (1-2)	Chapter I - Title, date of commencement and definitions (1-2)
Chapter II - Designating persons, Electrical Safety Officer & requirement of training of O&M staff etc (3-11)	Chapter II - Designating persons, Electrical Safety Officer & requirement of training of O&M staff etc (3-13)
Chapter III - General safety requirements (12-32)	Chapter III - General safety requirements (14-34)
Chapter IV - General conditions relating to supply and use of electricity (33-39)	Chapter IV - General conditions relating to supply and use of electricity (35-41)
Chapter V - Safety provisions for electrical installations of voltage not exceeding 650Volts (40 - 42)	Chapter V - Safety provisions for electrical installations of voltage not exceeding 1000 Volts (42 - 44)
Chapter VI - Safety provisions for electrical installations of voltage exceeding 650 volts (43-54)	Chapter VI - Safety provisions for electrical installations of voltage exceeding 1000 volts (45-56)
Chapter VII - Safety requirements for O/H lines, U/G Cables and Gen/Stns (55-77)	Chapter VII - Safety requirements for O/H lines, U/G Cables and Gen/Stns (57-80)
Chapter VIII Safety requirements for Electric Traction (78-92)	Chapter VIII Safety requirements for Electric Traction (81-95)
Chapter IX Additional Safety requirements for mines and oil fields (93-115)	Chapter IX Additional Safety requirements for mines and oil fields (96-118)

7

Contents

Cea (Measures Relating to Safety and Electric Supply) Regulations, 2010	CEA (Measures Relating to Safety and Electric Supply) Regulations, 2022
Chapter XVII Miscellaneous (116) Schedules Amendment 1: 2015: Reg 5, 5A, 32,42,43,44 and safety requirements for Mines Amendment 2: 2018 Reg 5, Self Certification Procedure Amendment 3 (2019): Electrical Vehicle Charging Stations	Chapter X Additional Safety requirements for Generating Stations (119-121) Chapter XI Additional Safety Provisions for Electric Vehicle Charging Stations (122-128) Chapter XII Additional safety requirements for HVDC (129-131) Chapter XIII Additional safety requirements for GIS (132-133) Chapter XIII Additional safety requirements for solar installations (134-139) Chapter XV Additional safety requirements for wind energy installations (140) Chapter XVII Miscellaneous (141) Schedules
116 regulations and schedules + 3 amendments	141 regulations (all amendments are included)

8

Regulation 2: Definitions

(92) "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 voltmeter meeting Indian Standards;

Voltage Level	Voltage level (r.m.s.) value (Un) (under normal condition)
Low Voltage (LV)	$U_n \leq 1$ kV and ≤ 1500 VDC
Medium Voltage (MV)	1 kV $< U_n \leq 33$ kV
High Voltage (HV)	$33 < U_n \leq 150$ kV
Extra High Voltage (EHV)	150 kV$< U_n$

9

Definition of Voltages: overview

Note: Voltage is also called as Tension

IS 17036:2018 (subject: DISTRIBUTION SYSTEM SUPPLY VOLTAGE QUALITY)

High Voltage (HV): Voltage whose nominal root mean square (r.m.s.) value is 33 < Un ≤ 150 kV.
Medium Voltage (MV): Voltage whose nominal r.m.s. value is 1 kV < Un ≤ 33 kV.
Low Voltage (LV): Voltage whose nominal r.m.s. value is Un ≤ 1 kV.

IEV definitions:
low voltage (LV): a set of voltage levels used for the distribution of electricity and whose upper limit is generally accepted to be 1 000 V for alternating current.
low voltage (2) **(LV (2))**: the lowest of two or more voltages in an apparatus or installation (e.g. low-voltage winding of a transformer)
high voltage (2) **(HV (2))**: the highest of two or more voltages in an apparatus or installation (e.g. high-voltage winding of a transformer)

IEC 61000-3-6 (subject: EMC: Limits – Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems)
- low voltage (LV) refers to Un ≤ 1 kV;
- medium voltage (MV) refers to 1 kV < Un ≤ 35 kV;
- high voltage (HV) refers to 35 kV < Un ≤ 230 kV;
- extra high voltage (EHV) refers to 230 kV < Un.

IEC 61140 (subject: Protection against electric shock – Common aspects for installations and equipment)
- extra low voltage (ELV) refers to Un ≤ 50VAC and ≤ 120VAC ;
- low voltage (LV) refers to Un ≤ 1000VAC and ≤ 1500VAC
- high voltage (HV) refers to Un ≥ 1000VAC and ≥ 1500VAC.

10

Definition of Voltages: overview

IS12360
No name, only voltage bands

IEC 60038: IEC standard voltages
<1 kV, 1 to 35 kV, , 35 to 230 kV, >230 kV
Provide information on voltages used in various countries. No definition for LV,MV, HV etc

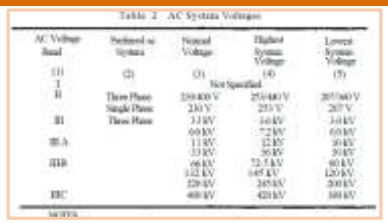


Table 2 - AC System Voltages

AC Voltage Band	Preferred or System	Nominal Voltage	Highest System Voltage	Lowest System Voltage
(1)	(2)	(3)	(4)	(5)
		Not Specified		
I	Three Phase	230/400 V	250/440 V	207/360 V
	Single Phase	230 V	253 V	207 V
II	Three Phase	3.3 kV	3.6 kV	3.0 kV
		6.6 kV	7.2 kV	6.0 kV
III A		11 kV	12 kV	10 kV
		22 kV	24 kV	20 kV
III B		66 kV	72.5 kV	60 kV
		132 kV	145 kV	120 kV
		220 kV	245 kV	200 kV
III C		400 kV	420 kV	380 kV

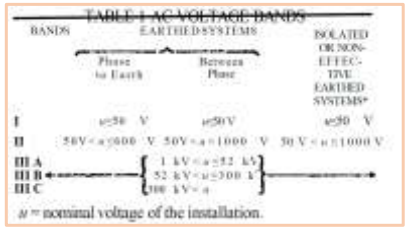


TABLE I AC VOLTAGE BANDS

BANDS	EARTHED SYSTEMS: Phase to Earth	EARTHED SYSTEMS: Between Phase	ISOLATED OR NON-EFFECTIVE EARTHED SYSTEMS*
I	$u \leq 50$ V	$u \leq 50$ V	$u \leq 50$ V
II	50 V < $u \leq$ 600 V	50 V < $u \leq$ 1000 V	50 V < $u \leq$ 1000 V
III A	1 kV < $u \leq$ 52 kV		
III B	52 kV < $u \leq$ 300 kV		
III C	300 kV < u		

u = nominal voltage of the installation.

The electricity act: 2003
"high voltage line" means an electric line or cable of a nominal voltage as may be specified by the Authority from time to time; (But CEA didn't mention this anywhere)

IE rule – 1956 (replaced with CEA regulation 2010, but the below definition is removed in CEA regulation 2010)
"**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;

Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2010 mentioned as Control, auxiliary low voltage (upto 1.1 kV) power and medium voltage (above 1.1 kV and upto 66kV) power cables shall be laid in separate trays;

Conclusion: There is no clear definition for Low voltage / high voltage etc, other than in IS 17036:2018 and IEC 61000-3-6

11

Definition of Voltages used in states


DERC (Supply Code and Performance Standards) Regulations, 2017

CHAPTER - II

SYSTEM, SAFETY, STANDARDS AND CATEGORIZATION OF SUPPLY

4. System of Supply:-

(1) The declared frequency of the alternating current (AC) shall be 50 Hz. The Licensee shall maintain the frequency within the frequency band as may be notified by the Authority from time to time.

(2) The voltage levels for supply shall be as under:-

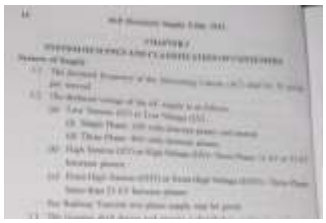
(i) Low Tension (LT)

(a) Single Phase: 230 volts between phase and neutral.
(b) Three Phase: 400 volts between phases.

(ii) High Tension (HT) - Three Phase: 11 kV between phases

(iii) Extra High Tension (EHT) - Three Phase: 33kV or 66kV between phases.

DERC
Low Tension(LT): Single phase 230 v between L and N
Three Phase: 400 volt between Lines
High Tension (HT) – Three phase 11 kV between phases
Extra high tension (EHT) - Three phase 33 kV or 66 kV between Phases



MP electricity supply code
Low Tension(LT): Single phase 230 v between L and N
Three Phase: 400 volt between Lines
High Tension (HT) – Three phase 11 kV or 33 kV between phases
Extra high tension (EHT) - Three phase more than 33 kV between Phases

12

Definition of Voltages used in states

KERALA ELECTRICITY SUPPLY CODE, 2014

Voltage levels for LT, HT and EHT supply.- (1) Voltage levels specified for low tension (LT), high tension (HT) and extra high tension (EHT) supply are the following:-

(a) Low Tension (LT) supply,-
- (i) Single phase 240 Volts between phase and neutral;
- (ii) Three phase 415 Volts between phases;

(b) High Tension (HT) supply,-
- (i) Three phase 11,000 Volts (11kV) between phases;
- (ii) Three phase 22,000 volts (22 kV) between phases;
- (iii) Three phase 33,000 Volts (33kV) between phases;

(c) Extra High Tension (EHT) supply,-
- (i) Three phase 66,000 volts (66 kV) between phases;
- (ii) Three phase 110,000 Volts (110 kV) between phases;
- (iii) Three phase 220,000 Volts (220kV) between phases;
- (iv) Three phase 400,000 Volts (400kV) between phases.

"**low tension (LT)**" means a voltage that does not exceed 1000volts under normal conditions subject to the percentage variation as may be specified by the Central Electricity Authority from time to time;
"high tension (HT)" means a voltage higher than 1000 volts and which does not exceed 33,000 volts under normal conditions subject to the percentage variation as may be specified by the Central Electricity Authority from time to time;
"extra high tension (EHT)" means a voltage exceeding 33000 volts under normal conditions subject to the percentage variation as may be specified by the Central Electricity Authority from time to time;

13

Definition of Voltages used in states

Tamil Nadu Electricity Regulatory Commission's Codes and Regulations (2015)

25. System of Supply: The Licensee's declared voltage of supply will be generally as follows :

(a) Low Tension Supply	i. Single phase 240 volts, 50 Hz A.C between phase and neutral. ii. Three-phase 415 volts 50 Hz A.C between phases.
(b) High Tension Supply	Three-phase 50 Hz A.C, 11,000 volts, or 22,000 volts and 33,000 volts between phases.
(c) Extra High Tension Supply	Alternating current - 50 Hertz Three- phase 66,000 volts, 110,000 volts and 230,000 volts between phases.

KARNATAKA ELECTRICITY DISTRIBUTION CODE (KEDC) (2015)

"Low Tension (LT) Supply" means voltages of 650 volts and below;
"High Tension Supply (HT)" means the nominal Voltage greater than 650 V and lesser than 66 kV;
Extra high Tension – No definition, but mentioned as "Transmission System" means the System consisting of extra high voltage lines/UG Cables and stations, having design/nominal voltage of 66 KV and above

MAHARASHTRA ELECTRICITY REGULATORY COMMISSION (Electricity Supply Code and Other Conditions of Supply) Regulations, 2005

"High Tension" or "HT" means all voltages defined as "high" or "extra high" voltage under clause (av) of sub-rule (1) of Rule 2 of the Indian Electricity Rules, (means above 650 volt)
"Low Tension" or "LT" means all voltages other than those defined as "high" or "extra high" voltage under clause (av) of sub-rule (1) of Rule 2 of the Indian Electricity Rules, 1956 (means up to 650 volt)

14

Definition of Voltages used in states

Proposal considered in NEC

Definitions of Voltage to be added under terminology fundamental definitions e.g
3.1.21: Voltage: nomenclature of commonly used short names of voltages

3.1.21.1 ELV (Extra Low Voltage): A system with a nominal voltage Un ≤ 50VAC or ≤ 120VDC ;
3.1.21.2 LV (Low Voltage / Low Tension): A system with a nominal voltage Un ≤ 1000VAC and ≤ 1500VDC
3.1.21.3 MV (Medium Voltage): A system with a nominal r.m.s. voltage is 1 kV < Un ≤ 33 kV
3.1.21.4 HV (High Voltage / High Tension): A system with a nominal r.m.s. voltage is 33 < Un ≤ 150 kV.
3.1.21.5 EHV (Extra High voltage): A system with a nominal r.m.s voltage is > 150 kV.

Note 1: The above nomenclatures are adopted from IS 17036:2018 & IS732:2019 for the purpose of this code.
Note 2: Electricity regulatory commissions of state governments use different definitions, which are not considered in this code.

15

Draft 2022 Regulation 2: Definitions

(92) "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 voltmeter meeting Indian Standards;

Voltage Level	Voltage level (r.m.s.) value (Un) (under normal condition)
Low Voltage (LV)	$U_n \leq 1$ kV and ≤1500 VDC
Medium Voltage (MV)	1 kV < $U_n \leq 33$ kV
High Voltage (HV)	33 < $U_n \leq 150$ kV
Extra High Voltage (EHV)	150 kV< U_n

650V is changed to 1000 VAC
Note: 650 still appears in regulation 37, 45 & 115

16

Change in numbering

Two additional regulation in chapter 3 changed (added two) in the serial number

6 Chartered Electrical Safety Engineer (regulation 5 A of amendment 1)

9. Safety measures for operation and maintenance of Load Despatch Centres

One additional regulation (74) changed (added one) in the serial number

75. Anti Climbing Devices-Barbed wires conforming to relevant IS for a vertical distance of 30 to 40 cm, at a height of 3.5 to 4 meters from ground level or clamps with protruding spikes at a height of 3 to 4 meter shall be provided on the pole/tower of above 11 kV line.

17

Draft 2022 Regulation 2: Definitions

Regulation 33: Testing of consumer's installation.- (1)

(a) Upon receipt of an application for a new or additional supply of electricity and before commencement of supply or recommencement of supply after the supply has been disconnected for a period of six months, the supplier (electrical power supplying company) shall either test the installation himself or accept the test results submitted by the consumer when same has been duly signed by the licensed electrical contractor/ chartered electrical safety engineer.

Provided that recommended testing and verifications as per IS 732 / National electrical code wherever applicable shall be carried out.

(b) The testing equipment shall be calibrated through a Government authorized or NABL accredited laboratory at periodical interval as recommended by NABL.

(2) The supplier shall maintain a record of test results obtained at each supply point to a consumer, in a Schedule--III.

Note: format in schedule III is not sufficient, better to use formats inIS732 / NEC

(3) If as a result of such inspection and test, the supplier is satisfied that the installation is likely to be dangerous, he shall serve on the applicant a notice in writing requiring him to make such modifications as are necessary to render the installation safe and may refuse to connect or reconnect the supply until the required modifications have been completed.

18

Uniform international standard for LV safety (wiring)

IEC 60364

NEC (NFPA 70) :USA
BS 7671: UK
VDE 0100: German

IS732: 2019 & NEC of India (SP30)

DESIGN, ERECTION & TESTING

NFPA 70& IEC 60364. Document by NEMA& UL
https://www.nema.org/docs/default-source/standards-document-library/nec-iec60364.pdf?sfvrsn=e2829491_2

19

Misuse of regulations and standards in India (e.g. Large metro rail project)

Chennai Metro Rail Project - Phase 2, Corridor 5 — Part-2 Section VII
TENDER No. CP16-MMC-DPT — Employer's Requirements

3.10 EARTHING SYSTEM

3.10.1 General

This section specifies the manufacture, supply, installation, testing & commissioning of the Earthing System. It covers the Earthing System requirements for AC power system except for the traction power system. The Contractor shall be responsible for preparation of the working drawings, manufacture, supply, delivery and installation, functional testing and handover of a working earthing and bonding system. Construction of earth mat as well as the test links including the risers from the test link, etc. and all works related to earthing is in the scope of this contract.

3.10.2 Standards

Relevant Codes and Standards

S. No.	Code/Standards	Description
1	IS 3043	Code of Practice for Earthing. BS 7430: Code of Practice for Earthing
2	BS 7671	Requirements for Electrical Installations
3	ANSI/IEEE Std 80-2000	IEEE Guide for Safety in AC Substation Grounding
4	IEEE Std 81 81-2012	IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System
5	IEEE 1100	Recommended Practice for Powering and Grounding of Sensitive Electronic equipment
6	IEC 62561	Parts 1-7 Lightning Protection System Component
7	UL 467	Grounding and Bonding Equipment
8	ISO 1461 2009	Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods
9	IEEE837	Qualifying Permanent connections used in Substation Grounding
10	NBC-2016	National Building code -2016
11	IEC 60364	Electrical Installations of Buildings

3.10.3 Technical and Installation Requirements - Earthing and Bonding

3.10.4 General Requirements

3.10.4.1 All metal works associated with an electrical installation but not forming part of live

Section VII – Outline Construction Specification — SS3-169 — March 2021
Sub-Section-3-Electrical Works

3.10.2 Standards

Relevant Codes and Standards

S. No.	Code/Standards	Description
1	IS 3043	Code of Practice for Earthing. BS 7430: Code of Practice for Earthing.
2	BS 7671	Requirements for Electrical Installations
3	ANSI/IEEE Std 80-2000	IEEE Guide for Safety in AC Substation Grounding
4	IEEE Std 81 81-2012	IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System
5	IEEE 1100	Recommended Practice for Powering and Grounding of Sensitive Electronic equipment
6	IEC 62561	Parts 1-7 Lightning Protection System Component
7	UL 467	Grounding and Bonding Equipment
8	ISO 1461 2009	Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods
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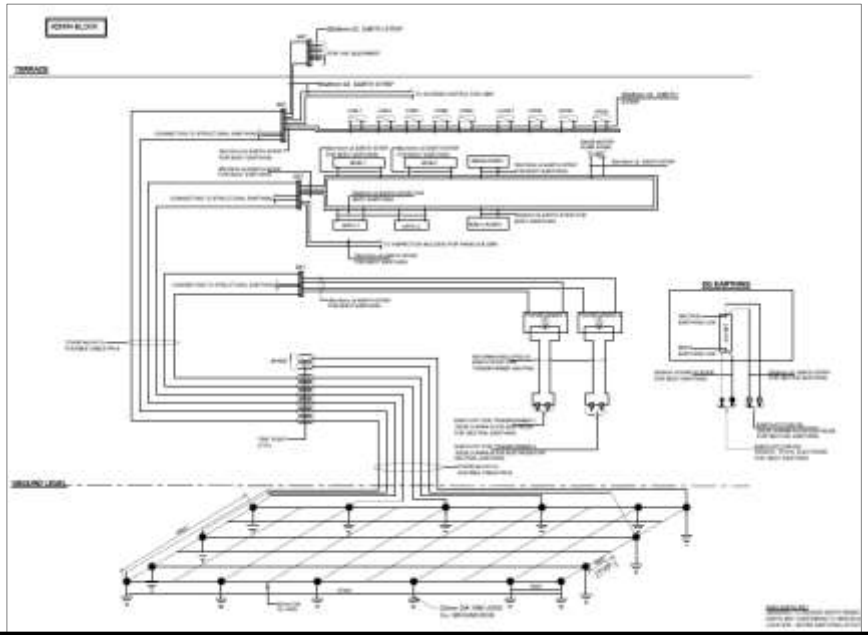
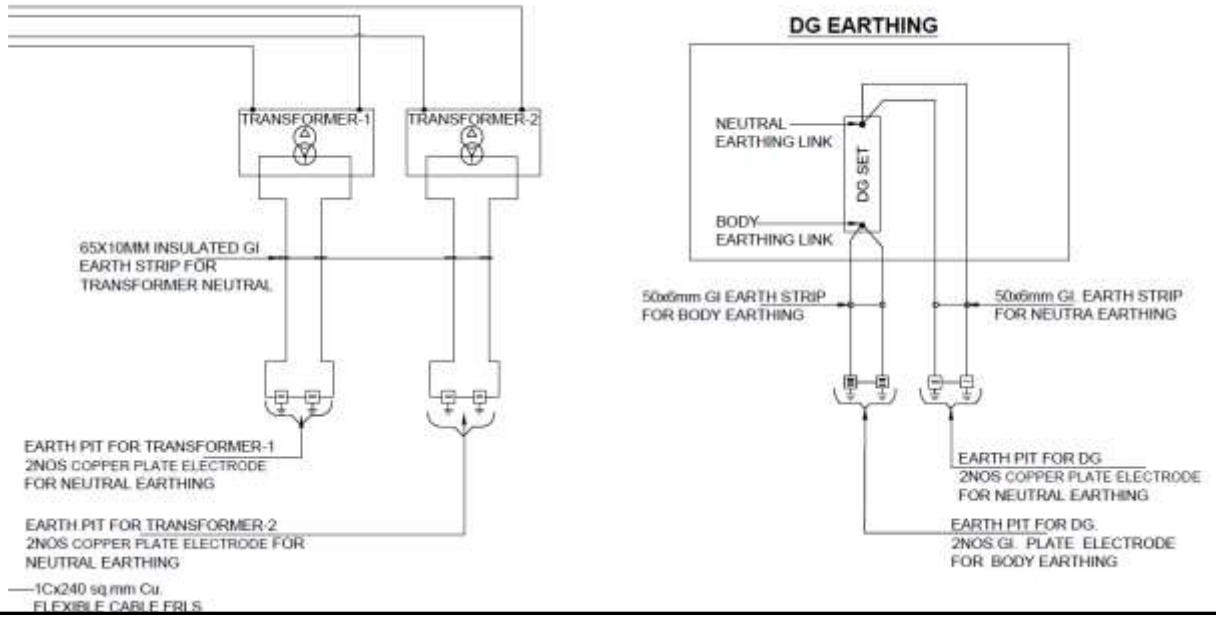
20

Misuse of regulations and standards in India (e.g. Large metro rail project)



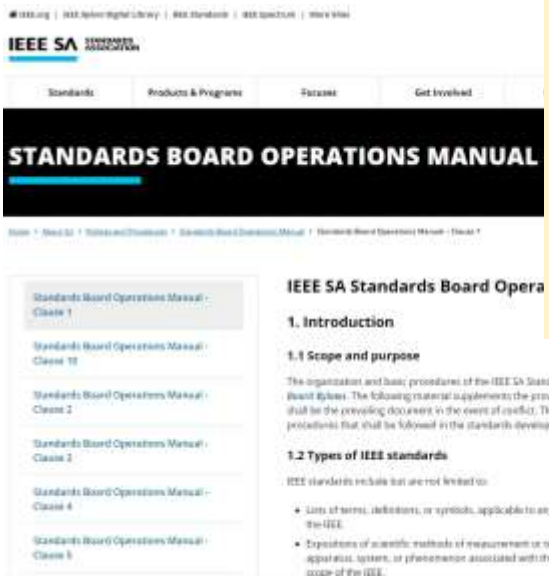
21

Misuse of regulations and standards in India (e.g. Large metro rail project)



22

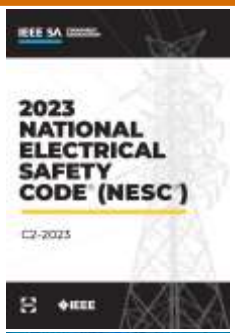
Information from IEEE website

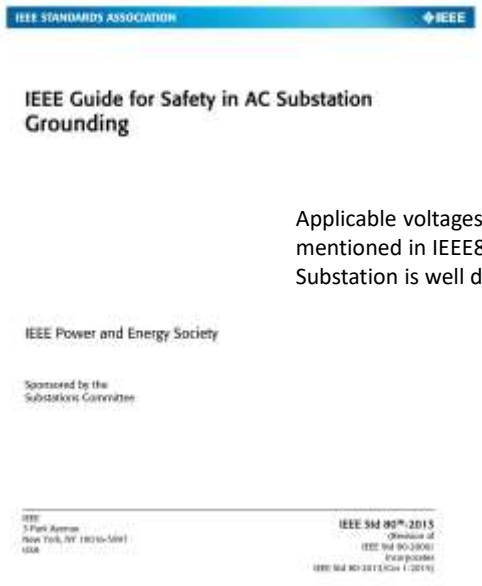


IEEE standards are classified as:

- *Standards*: documents with mandatory requirements.
- *Recommended practices*: documents in which procedures and positions preferred by the IEEE are presented.
- *Guides*: documents in which alternative approaches to good practice are suggested but no clear-cut recommendations are made.
- *Trial-Use documents*: publications in effect for not more than three years.

23

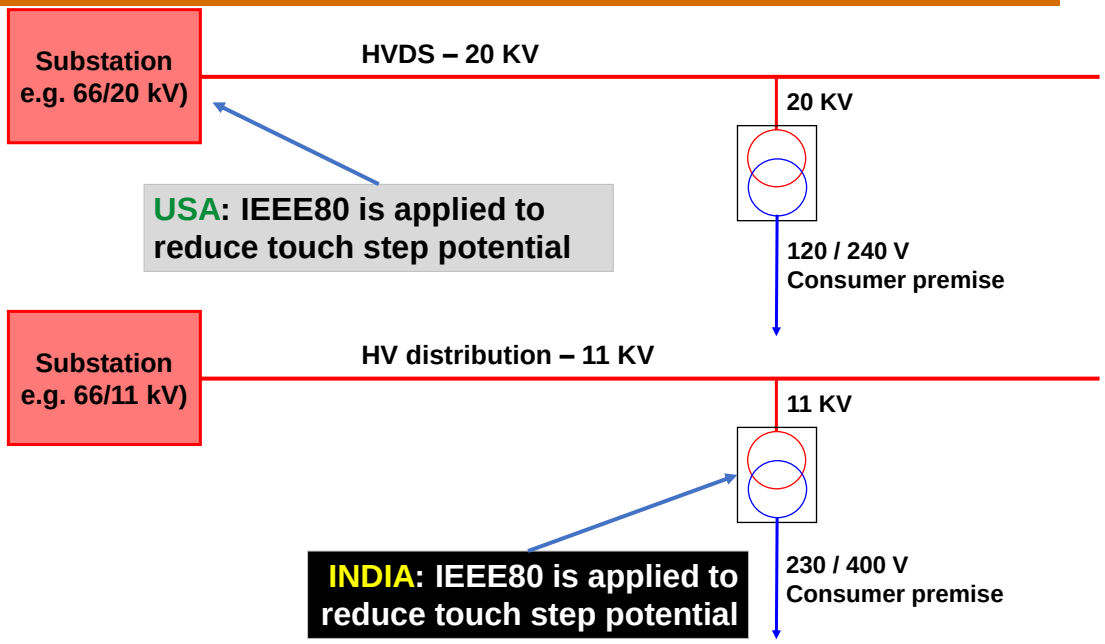




Applicable voltages are not mentioned in IEEE80.
Substation is well defined in USA

24

Methods followed to ensure safety by Utility & Industries



25

IEEE 80 calculations for LOW voltage application in all Metros across INDIA

MAIN EARTHMAT CALCULATION

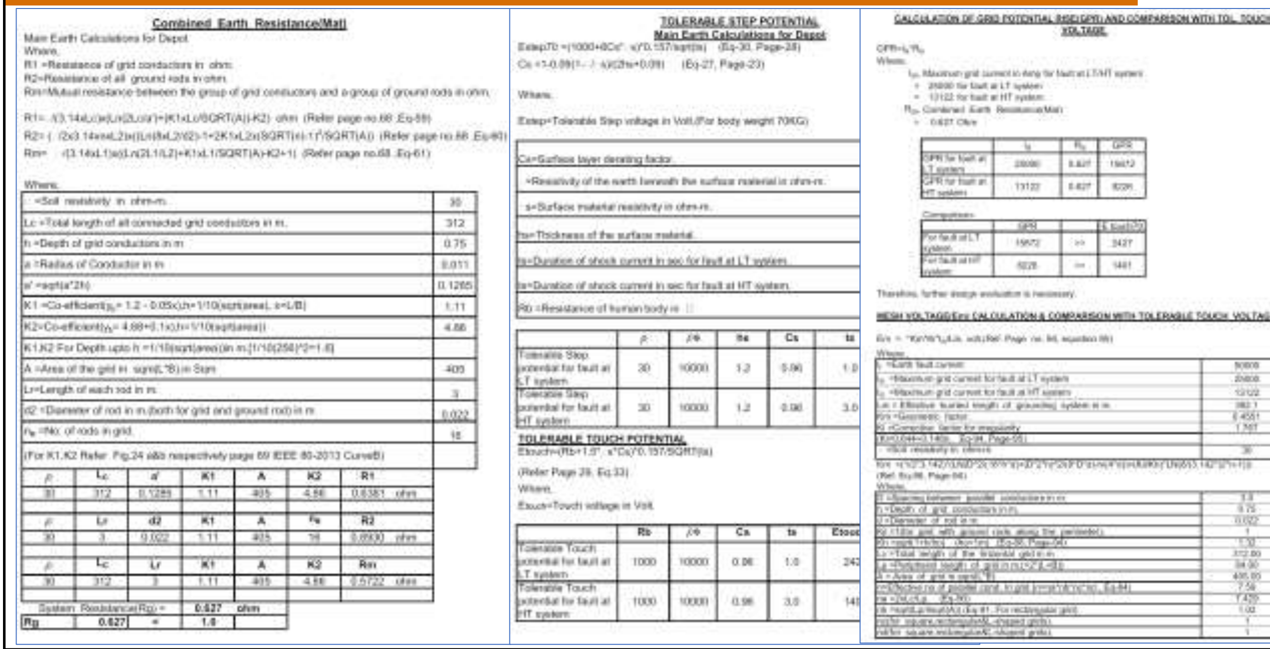
Main Earth Calculations for Depot

The earthing calculations have been done on the basis IEEE guide for safety in AC substation grounding (IEEE std 80-2013)
The earthing calculations have been done on the basis of following data :

1	System Voltage	0.415	KV	
2	System LT fault current	50000	A	
3	System HT fault current	26244	A	Assum
4	Decrement factor(Df)	1		
5	Current division factor(Sf)	0.5		
6	Maximum grid current for fault at LT system(I_G=I*Df*Sf)	25000	A	
7	Maximum grid current for fault at HT system(I_G=I*Df*Sf)	13122	A	
8	Fault duration (ts), for fault at LT system	1	Sec	
9	Fault duration (ts), for fault at HT system	3	Sec	
10	Soil resistivity( )	30	ohm-m	
11	Thickness of ballast surface material(dry concrete)(hs)	1.20	mtr	Assumed
12	Resistivity of ballast surface material(dry concrete(s)	10000	ohm-m	Assumed
13	Size of Yard Length (M)	27.0	mtr	
	Size of Yard Breadth (M)	15.0	mtr	
14	Area of Yard for earthing(L*B)	405	Sqm	
15	No of ground conductor selected	16	Nos	
16	Spacing between parallel conductor(D)	3	mtr	
17	Lc =Total length of the hrizontal grid in m			
	Lc=L*(B/D+1)+B*(L/D+1)	312	mtr	
18	Lp =Peripheral length of grid in m			
	Lp =2*(L+B)	84	mtr	
19	Lr =Length of each ground rod	3	mtr	
20	L_R =Total length of all ground rod			
	L_R=Lr*No of grid, Rod	48	mtr	

26

IEEE 80 calculations for LOW voltage application in all Metros across INDIA



Combined Earth Resistance(Mat)

Main Earth Calculations for Depot
Where,
R1 =Resistance of grid conductors in ohm.
R2=Resistance of all ground rods in ohm.
Rm=Mutual resistance between the group of grid conductors and a group of ground rods in ohm.

R1= [illegible] ohm (Refer page no.68 ,Eq-59)
R2= [illegible] (Refer page no.68 ,Eq-60)
Rm= [illegible] (Refer page no.68 ,Eq-61)

Where,

=Soil resistivity in ohm-m.	30
Lc =Total length of all connected grid conductors in m.	312
h =Depth of grid conductors in m	0.75
a =Radius of Conductor in m	0.011
a' =sqrt(a*2h)	0.1285
K1 =Co-efficient[illegible]	1.11
K2=Co-efficient[illegible]	4.88
K1,K2 For Depth upto h =1/10(sqrt(area)(in m.)[1/10(258)^2=1.6]	
A =Area of the grid in sqm(L*B) in Sqm	405
Lr=Length of each rod in m	3
d2 =Diameter of rod in m (both for grid and ground rod) in m	0.022
n_R =No. of rods in grid.	18
(For K1,K2 Refer Fig.24 a&b respectively page 69 IEEE 80-2013 CurveB)	

ρ	Lc	a'	K1	A	K2	R1
30	312	0.1285	1.11	405	4.88	0.8381 ohm

ρ	Lr	d2	K1	A	n_R	R2
30	3	0.022	1.11	405	18	0.8930 ohm

ρ	Lc	Lr	K1	A	K2	Rm
30	312	3	1.11	405	4.88	0.5722 ohm

System Resistance(Rg) = 0.627 ohm

Rg	0.627	=	1.0	

TOLERABLE STEP POTENTIAL
Main Earth Calculations for Depot

Estep70 =(1000+6Cs* [illegible])*0.157/sqrt(ts) (Eq-30, Page-28)
Cs =1-0.09(1- [illegible])/(2hs+0.09) (Eq-27, Page-23)

Where,

Estep=Tolerable Step voltage in Volt.(For body weight 70KG)

Cs=Surface layer derating factor.
=Resistivity of the earth beneath the surface material in ohm-m.
s=Surface material resistivity in ohm-m.
hs=Thickness of the surface material.
ts=Duration of shock current in sec for fault at LT system.
ts=Duration of shock current in sec for fault at HT system.
Rb =Resistance of human body in

	ρ	ρs	hs	Cs	ts
Tolerable Step potential for fault at LT system	30	10000	1.2	0.96	1.0
Tolerable Step potential for fault at HT system	30	10000	1.2	0.96	3.0

TOLERABLE TOUCH POTENTIAL
Etouch=(Rb+1.5*s*Cs)*0.157/SQRT(ts)
(Refer Page 28, Eq.33)
Where,
Etouch=Touch voltage in Volt

	Rb	ρs	Cs	ts	Etouc
Tolerable Touch potential for fault at LT system	1000	10000	0.96	1.0	242
Tolerable Touch potential for fault at HT system	1000	10000	0.96	3.0	14[illegible]

CALCULATION OF GRID POTENTIAL RISE(GPR) AND COMPARISON WITH TOL. TOUCH VOLTAGE

GPR=I_G*R_G
Where,
I_G= Maximum grid current in Amp for fault at LT/HT system
= 25000 for fault at LT system
= 13122 for fault at HT system
R_G= Combined Earth Resistance(Mat)
= 0.627 Ohm

	I_G	R_G	GPR
GPR for fault at LT system	25000	0.627	15672
GPR for fault at HT system	13122	0.627	8228

Comparison

	GPR		E touch70
For fault at LT system	15672	>>	2427
For fault at HT system	8228	>>	1401

Therefore, further design evaluation is necessary.

MESH VOLTAGE(Em) CALCULATION & COMPARISON WITH TOLERABLE TOUCH VOLTAGE

Em = [illegible] (Ref. Page no. 94, equation 89)
Where,

I_f =Earth fault current	50000
I_G =Maximum grid current for fault at LT system	25000
I_G =Maximum grid current for fault at HT system	13122
Lm = Effective buried length of grounding system in m	382.1
Km =Geometric factor	0.4551
Ki =Correction factor for irregularity	1.757
(Ki=0.644+0.148n, Eq-94, Page-95)	
=Soil resistivity in ohm-m	30

Km = [illegible]
(Ref. Eq-86, Page-94)
Where,

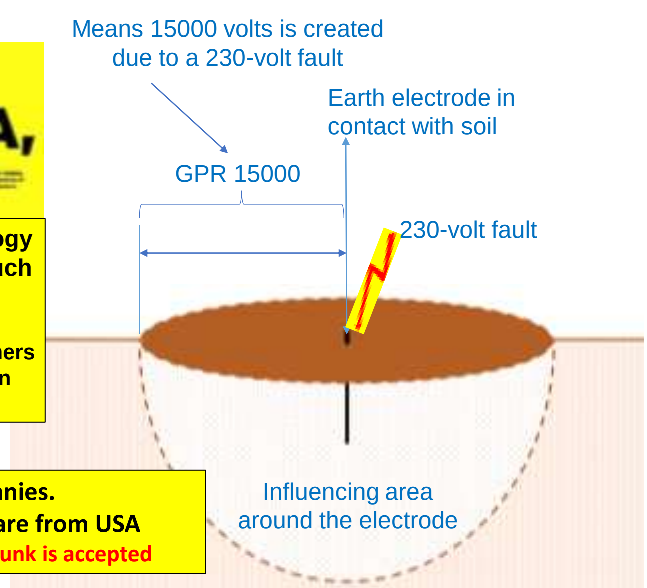
D =Spacing between parallel conductors in m	3.0
h =Depth of grid conductors in m	0.75
d =Diameter of rod in m	0.022
Kii =1(for grid with ground rods along the perimeter)	1
Kh =sqrt(1+h/ho) [illegible] (Eq-88, Page-94)	1.32
Lc =Total length of the horizontal grid in m	312.00
Lp =Peripheral length of grid in m [illegible]	84.00
A = Area of grid in sqm(L*B)	405.00
n=Effective no of parallel cond. in grid [illegible] Eq-84	7.56
na =2*Lc/Lp (Eq-90)	7.429
nb =sqrt(Lp/(4sqrt(A))) (Eq 91 , For rectangular grid)	1.02
nc(for square,rectangular&L-shaped grids)	1
nd(for square,rectangular&L-shaped grids)	1

IEEE 80 calculations for LOW voltage application in all Metros across INDIA

According to the theory applied in Chennai metro,

1. Fault Voltage is 230 volt
2. GPR is 15000 Volts
3. (60-times voltage is multiplied)

Use this technology for application such as voltage multiplying.
(STEPUP Transformers can be replaced in future)



This is Propaganda Business by IEEE 80 software companies.
Spoiling the knowledge of engineers by showing software from USA
Introducing nonscientific & foolish ideas to India, where any junk is accepted

Uniform international standard for LV safety (wiring)

IEC 60364

NEC (NFPA 70) :USA
BS 7671: UK
VDE 0100: German

IS732: 2019 & NEC of India (SP30)

DESIGN, ERECTION & TESTING

Another Propaganda business:
Large Industries use arc flash and thermography as per NFPA 70 (D or E),
But basics as per NFPA 70 (IS732) is UNKNOWN

Neglecting the Indian standards, which are often better than others, and running behind American, European and British standards is one serious factor spoiling our nationalism.
Companies often do it protect their business interest, but we don't understand why Indian consultants and contractors who doesn't have any connection with international interest do this. Some of them are proud to use American and British standards.
99% industrial and commercial LV installations, the word electrical safety exist only in paper, There is no actual safety at all. More than 75 % electrical safety written rules in IS standards are not known. A classic example is the test as per IS732:2019.

29

Regulation 38: Provisions for supply and use of electricity in multi-storeyed building more than 15 metres in height. -

(4) The owner or occupier of a multi-storeyed building shall ensure that electrical installations and works inside the building are carried out and maintained in such a manner as to prevent danger due to shock and fire hazards, and the installation is carried out in accordance with IS732 and National electrical code (SP30).

Provided that hospitals and medical establishments shall have safety measures as per National Electrical Code irrespective of height.

(6) (a) Only Fire Retardant Low Smoke and Low Halogen (FRLSH) power cables shall be used as per relevant IS.

Provided Halogen Free Flame Retardant (HFFR) as per IS 17048 power cables shall be used in airports, hospitals and hotels irrespective of height.

(6) (b) Distribution of electricity to the floors shall be done using bus bar trunking system.

Provided for airports, hospitals and hotels, distribution of electricity to the floors shall be done using bus bar trunking system irrespective of height.

(7) Lightning protection of the building shall be as per IS/IEC 62305.

Provided Lightning protection of Hotels/Airports shall be provided irrespective of height.

(8) Electrical Safety Verification of the installation shall be done as per IS 732.

(9) Meter shall not be installed in staircase.

(10) Electrical safety verification of the installation at the time of construction shall be done as per relevant IS.

30

Chapter V : Safety provisions for electrical installations and apparatus of voltage not exceeding 1000 Volts AC & 1500 V DC :

42. Test of insulation.- Where any electric supply line for use at voltages not exceeding 1000 V AC or 1500 V DC is new or has been disconnected from a system for the purpose of addition, alteration or repair, such electric supply line shall not be reconnected to the system until the supplier or the owner has applied the test as per IS 732-6.

31

Chapter V : Safety provisions for electrical installations and apparatus of voltage not exceeding 1000 Volts AC & 1500 V DC :

Existing	NEW DRAFT
41. Connection with earth: - The following conditions shall apply to the connection with earth of systems at voltage normally exceeding 125 V but not exceeding 650 V, namely: -	43. Connection with earth.- The following conditions shall apply to the connection with earth of systems at voltage normally exceeding 40 V but not exceeding 1000 V AC or 1500 V DC, namely:-
(i) neutral conductor of a 3-phase, 4-wire system and the middle conductor of a 2- phase, 3-wire system shall be earthed by not less than two separate and distinct connections with a minimum of two different earth electrodes or such large number as may be necessary to bring the earth resistance to a satisfactory value both at the generating station and at the sub-station.	(i) neutral conductor of a 3-phase, 4-wire system and the middle conductor of a 2-phase, 3-wire system shall be earthed as per IS:3043.
(ii) the earth electrodes so provided, shall be inter-connected to reduce earth resistance.	
(iii) neutral conductor shall also be earthed at one or more points along the distribution system or service line in addition to any connection with earth which may be at the consumer's premises.	(ii) neutral conductor shall also be earthed at one or more points along the distribution system or service line in addition to any connection with earth which shall be at the consumer's premises.

32

Chapter V : Safety provisions for electrical installations and apparatus of voltage not exceeding 1000 Volts AC & 1500 V DC :

Sub regulation iv to x are removed	(iv) in a direct current system, earthing and safety measures shall be as per IS 732.
	(v) every building shall have protective equipotential bonding by interconnecting exposed and extraneous conductive parts as per IS 3043 & IS 732.
	(vii) the frame of every generator, stationary motor, portable motor, and the metallic parts, not intended as conductors, of all transformers and any other apparatus used for regulating or controlling electricity, and all electricity consuming apparatus, of voltage exceeding 250 V but not exceeding 1000 V shall be earthed by the owner as specified in IS 3043 and IS 732.

33

Chapter V : Safety provisions for electrical installations and apparatus of voltage not exceeding 1000 Volts AC & 1500 V DC :

	(ix) All earthing systems shall, -
	(a) consist of equipotential bonding conductors capable of carrying the prospective earth fault current without exceeding the allowable temperature limits as per IS: 3043 in order to maintain all non-current carrying metal works reasonably at earth potential and to avoid dangerous contact potentials being developed on such metal works;
	(b) ~~maintain~~ Earth fault loop impedance shall be maintained sufficiently low to permit adequate fault current for the operation of protective device within the time stipulated in IS: 3043
	(x) all earthing systems belonging to the supplier shall in addition, be tested for resistance on dry day during the dry season at least once a year.

34

Chapter V : Safety provisions for electrical installations and apparatus of voltage not exceeding 1000 Volts AC & 1500 V DC :

	(xi) Earth fault loop impedance shall be tested to ensure the automatic disconnection of the protective device and a record of every earth test made and the result thereof shall be kept by the supplier for a period of not less than two years after the day of testing and shall be available to the Electrical Inspector when required.
	(xii) Earth fault loop impedance of each circuit shall be limited to a value determined by the type and current rating of the protective device used such that, on the occurrence of an earth fault, disconnection of the supply shall occur before the prospective touch voltage reaches a harmful value.
	(xiii) Where multiple sources are used in the same installation (e.g. Transformer and DG with changeover facility), fault loop impedance shall be tested for both the sources and automatic disconnection of supply shall be ensured.

35

Chapter V : Safety provisions for electrical installations and apparatus of voltage not exceeding 1000 Volts AC & 1500 V DC :

Existing	NEW DRAFT
42. Earth leakage protective device: -	**44. Residual Current Device.**
The supply of electricity to every electrical installation other than voltage not exceeding 250 V below __ kW and those installations of voltage not exceeding 250 V which do not attract provisions of section 54 of the Act, shall be controlled by an earth leakage protective device so as to disconnect the supply instantly on the occurrence of earth fault or leakage of current:	The use of electricity to every electrical installation, shall be controlled by a Residual Current Device as per IS 12640(part-1)/IEC 61008-1 or IS 12640(Part-2)/IEC 61009-1 or IEC 62423 whichever is applicable. whose rated residual operating current shall not exceed 30 milliampere so as to disconnect the supply instantly on the occurrence of earth fault or leakage current.
Provided that such earth leakage protective device shall not be required for overhead supply lines having protective devices which are effectively bonded to the neutral of supply transformers and conforming to regulation 73.	Provided further that such protective device shall not be required for ~~overhead~~ supply lines having protective devices which are effectively bonded to the neutral of supply transformers and conforming to regulation 76.

74. Earthing conductor

36

74. Earthing-

(1) Earthing of 33 kV and below overhead line supports

a. All metal supports and all reinforced and prestressed cement concrete supports of overhead lines and metallic fittings attached thereto, shall be either permanently and efficiently earthed by providing a continuous earth wire and securely fastening to each pole and connecting with earth ordinarily at every third support or each support and the metallic fitting attached thereto shall be permanently and effectively earthed.

b. Metal cross arms and insulator pins for Plain cement Concrete (PCC) and Pre-Stressed Cement Concrete (PSCC) poles shall be bonded together and normally earthed at every pole above 1000 V lines and at every 3rd pole for lines below 1000 volts.

c. Normally coil earthing shall be provided except for locations involving railways, telegraph line, power line crossings and special structures where pipe/rod type earthing shall be provided.:

d. Whenever the electric lines pass close to a well or a permanently moist place, an earth should be provided in the well or the marshy place and connected to the electric line pole.

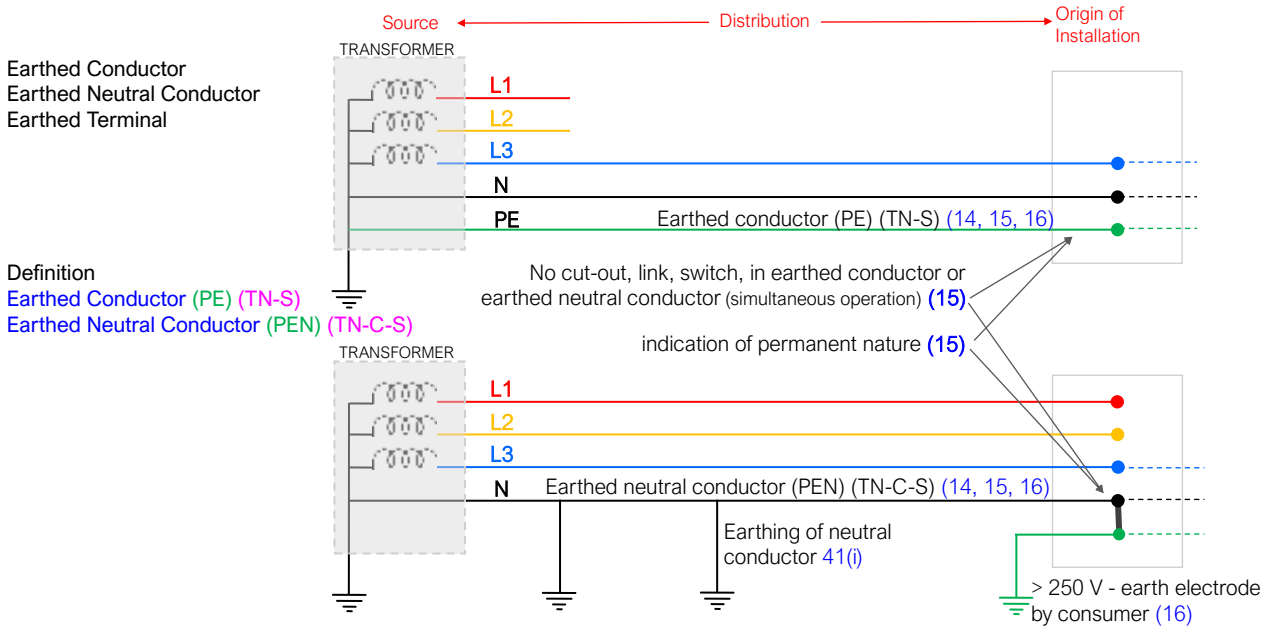
e. All steel poles on which switches, transformers, fuses etc. are mounted shall be earthed.

f. For poles below 1000 V guarding with continuous earth wire (messenger wire in case of aerial bunched cable) shall be provided and shall be connected to earth at three equidistant points in one km.

g. Each stay-wire shall be similarly earthed unless insulator has been placed in it at a height not less than 3.0 metres from the ground.

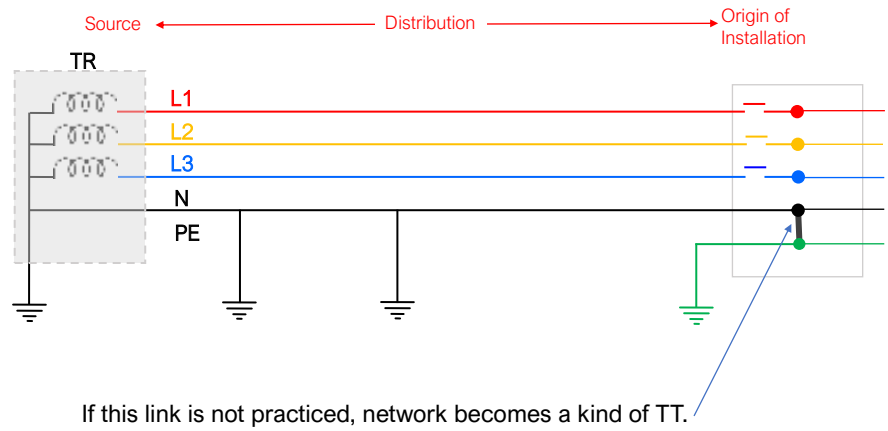
37

How to read these regulations: Earthed and earthed neutral conductor



38

Regulations very clearly specify the best safety measures available, but utilities don't follow it



If this link is not practiced, network becomes a kind of TT.
30 mA RCD at origin of installation is 100 % required for fault protection.

Installing earth electrodes such as pipes, plates, maintenance free electrodes, chemical electrodes, digital earthing etc at the consumer premise will not help in improving safety.

But a 30 mA RCD will improve safety.

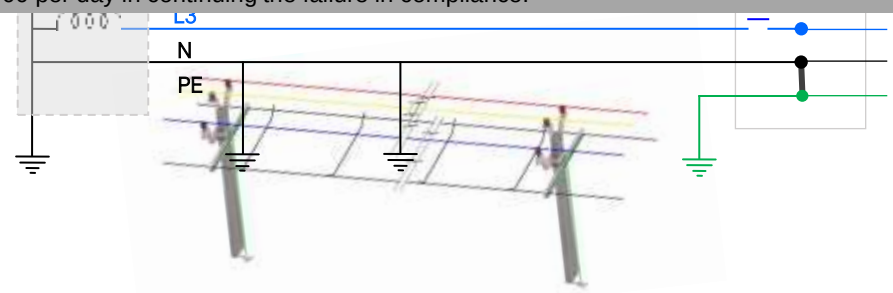
39

Regulations very clearly specify the best safety measures available, but utilities don't follow it

Affected consumers have the right to proceed punishment / penalty as per section 146 of The electricity Act 2003

This means the Managing Director or directors of the energy supply company shall be

- Imprisoned up to 3 months,
- Fine up to 1 lac per accident,
- Rs. 5000 per day in continuing the failure in compliance.



- Continuous earth wire is for easy fault return to source in case of fault in distribution / consumer premise. Fault current will be high and disconnection of fault is easy.
- Guarding is not provided in most cases.
- Generally, energy supply companies are caress less in implementing regulations

40

Same subject repeating ????? 46 (xiv) and 77

46. Use of electricity at voltage exceeding 1000 V

(xiv) Lightning protection;

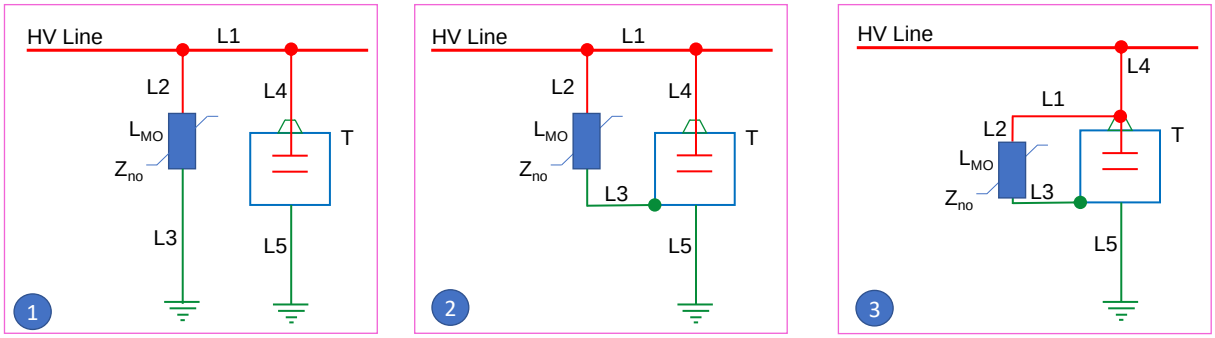
a) The surge arrester (SA) which responds to over-voltages without any time delay shall be installed for protection of 11 kV and above switchgear, transformers, associated equipment and lines.
b) Surge arresters as per requirement and conforming to relevant IS shall be provided
c) Surge arresters shall be connected to two independent earthing connections.
d) The earthing lead for surge arrester shall not pass through any iron or steel pipe and shall be taken as directly as possible from the surge arrester to a separate earth electrode or junction of the earth mat already provided for the sub-station.
Provided that a down rod shall be provided at the node where surge arrestor is connected with earth mat.
(3) All apparatus shall be protected against lightning as per IS/IEC 62305.

77. Protection against lightning.-
(1)The owner of every overhead line, sub-station or generating station which is exposed to lightning shall adopt efficient means for diverting to earth any electrical surges due to lightning which may result into injuries.
(2) The earthing lead for any lightning arrestor shall be as short as possible and shall not pass through any iron or steel pipe, but shall be taken as directly as possible from the lightning arrestor without touching any metal part to a separate vertical ground electrode or junction of the earth mat already provided for the substation of voltage exceeding 1000 V subject to the avoidance of bends wherever practicable.

41

IS 15086: Part 5: 2020 (IEC 60099-5)

Figure 12 – Examples of good and poor connection principles for distribution arresters



1. Poor. The connection leads are too long and in (1) the transformer and arrester do not have the same earthing point. The loop L1 + L2 + L3 + L4 + L5 + LMO is too long.
2. Good. Common earth of arrester and transformer, and the loop L1 + L2 + L3 + L4 + LMO is much shorter than the loop L1 + L2 + L3 + L4 + L5 + LMO in 1.
3. Very good. The arrester is earthed directly at the transformer tank. The loop L1 + L2 + L3 + LMO is short. In this way, the inductances are kept to a minimum.

42

To avoid repetition and to improve the regulation.

Remove content in regulation 46

77. Protection against lightning.-
(1)The owner of every overhead line, sub-station or generating station which is exposed to lightning shall adopt efficient means for diverting to earth any electrical surges due to lightning which may result into injuries.
~~(2) The earthing lead for any lightning arrestor shall be as short as possible and shall not pass through any iron or steel pipe, but shall be taken as directly as possible from the lightning arrestor without touching any metal part to a separate vertical ground electrode or junction of the earth mat already provided for the substation of voltage exceeding 1000 V subject to the avoidance of bends wherever practicable.~~

(2) Surge arresters shall be selected and erected as per IS 15086: Part 5: 2020 (IEC 60099-5)

THANK YOU

43