the leading electrical & electronics monthly

ieema journal

VOLUME 12 • ISSUE NO. 4 • DECEMBER 2020 • PGS. 82

ISSN 0970-2946 • Rs. 100/-

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TRAFOTECH

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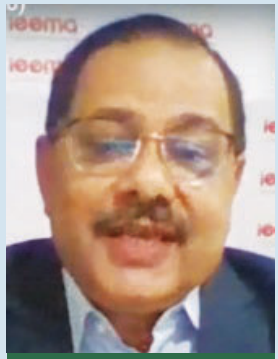

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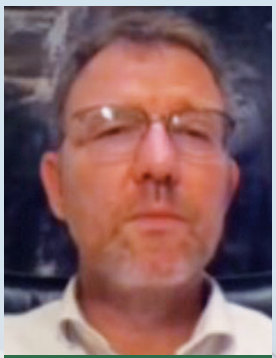

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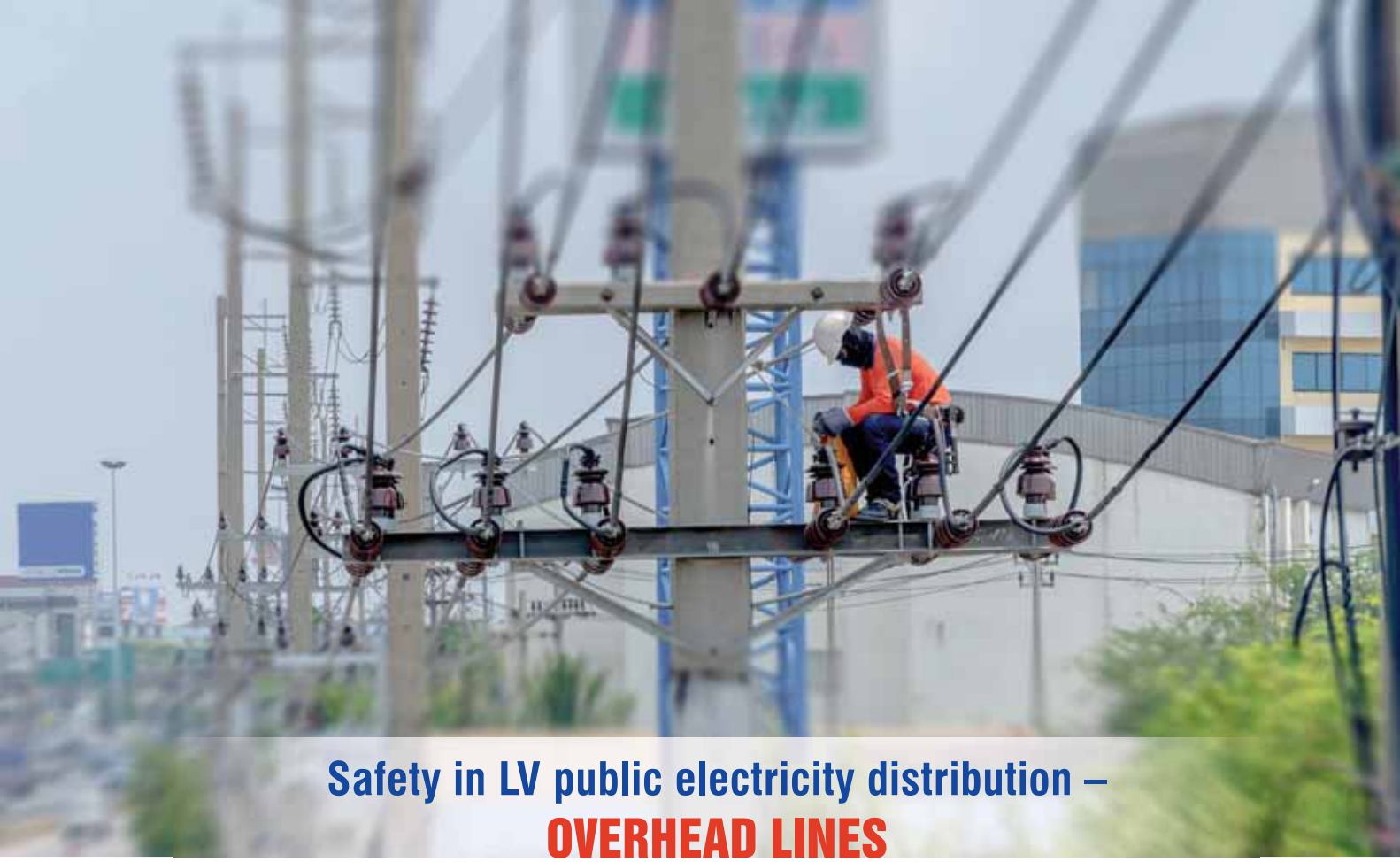
"Reforms must be implemented patiently and passionately."
Dr AK Verma, former Joint Secretary, Ministry of Power

COVID-19 Stay Safe



Safety in LV public electricity distribution – OVERHEAD LINES

Accidents in Low Voltage public electricity distribution is a common phenomenon. In this article we try to evaluate the probable cause of such accidents and solutions. Readers are requested to go through the previous articles to have a better understanding.

Accidents are mainly due to broken lines falling on ground and insulation failures creating accessible metal parts in LIVE condition. Non disconnection of supply during these faults attribute to the incident. A major challenge is to create a low impedance fault to ensure efficient disconnection of protective device.

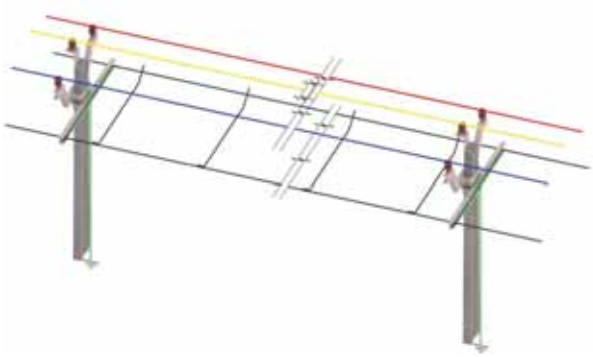
Majority of the public electricity distribution is carried out as a TT system with source and consumer end earthed to electrically independent earth electrodes. There is no earth wire (between the consumer premise and source) in most LV public distribution lines. Globally standardization of system earthing started during 1960's. TT system came into existence during 1960's. National safety regulations were created at a time when TT system was not existing. Reason for following TT system by the utilities in LV public distribution are unknown.

National safety regulation plays an important role in this subject. An evaluation of regulations on Measures Relating to Safety and Electric Supply Regulation 2010 and Technical Standards for Construction of Electrical Plants and Electric Lines Regulations, 2010 are necessary to find out the national legal requirement. The above two are the main regulations which are to be complied in order to achieve desired safety in public electricity distribution.

Regulation: Central Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2010	
Chapter VII: Safety requirements for overhead lines, underground cables and generating stations (Regulation 72. Earthing)	
Regulation	Interpretation

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 three points in every km. with the spacing between the points being as nearly equidistant as possible or each support and the metallic fitting attached thereto shall be efficiently earthed.	The regulation require an earth conductor in distribution lines (providing a continuous earth wire) This means a 4th conductor in HV lines as TN-S, 5th conductor as a separate earth conductor in LV TN-S or 4th conductor as a combined PEN conductor in LV TN-C-S. Metal supports in each pole need to be connected (earthed) to this earth wire. This earth wire is also earthed (to an earth electrode in soil) at three points every km. This continuous earth wire if installed as per the interpretation will be an efficient low impedance earth return path, resulting in higher earth fault current.

Regulation 73. Safety and protective devices	
Regulation	Interpretation
Every overhead line which is not being suspended from a dead bearer wire, not being covered with insulating material and not being a trolley-wire, is erected over any part of a street or other public place or in any factory or mine or on any consumer's premises shall be protected with earth guarding for rendering the line electrically harmless in case it breaks.	Uninsulated overhead conductors in populated areas such as public places and factories shall be protected with guarding to ensure safety if it breaks. "The broken wire shall not fall down"



Pole with guarding, continuous earth wire and connection to earth electrode in soil

CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2010.

Chapter V - Technical Standards For Construction Of Electric Lines

Part - B: Electric Lines (33 kV and below)

Regulation 99. Earthing of Poles

	Regulation	Interpretation
1	All metallic supports shall be permanently and effectively earthed. The earthing arrangement shall conform to relevant IS.	General in nature
2	Metal cross arms and insulator pins for PCC and PSCC poles shall be bonded together and normally earthed at every pole for 33 kV or 22 kV or 11 kV lines and at every 5th pole for lines below 500 volts.	All metal parts interconnected and earthed at every pole. Additional connection to earth electrodes is also necessary. Every pole for 11,22 and 33 kV & every 5th pole for LV.
3	The support on each side of a road crossing, railway crossing, or river crossing shall be earthed	Both sides require connection to earth electrode
4	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. 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.	How to make an earth electrode is explained.
5	All steel poles on which switches, transformers, fuses etc. are mounted shall be earthed.	
6	All poles above 650 volts, irrespective of inhabited areas, shall be earthed. For poles below 650 V guarding with continuous earth-wire shall be provided invariably, connected to earth at three equidistant points in one km.	continuous earth wire invariably below 650 volts.

Regulation 101. Protective Guard	
Regulation	Interpretation
Guard wire shall be used where an overhead line crosses or is in proximity to any telecommunication line or any other overhead line and in populated localities. Every guard wire shall be connected to earth wherever its electrical continuity is broken. The minimum factor of safety for stay wires, guard and bearer wires shall not be less than 2.5 based on ultimate strength of the wire.	Guarding is necessary for crossings, populated areas.

In order to comply the above regulations,

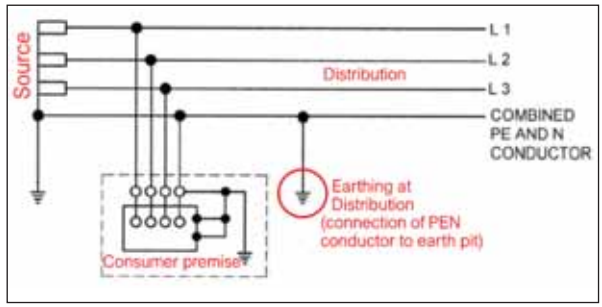
1. An overhead distribution line requires a continuous earth wire (along with phase conductors).
2. Measures (such as guarding) is necessary to ensure that the broken line is not falling in soil (e.g. in populated areas).
3. An additional connection from the interconnected conductive parts, continuous earth wire to an earthzelectrode in soil is necessary in the pole (up to 650 volts, every 5th pole or 3 times in 1 km. Above 650 volts, every pole).

Overhead distribution lines maintained, satisfying the above measures ensure low impedance fault return path, resulting in higher fault current and easy disconnection by the protective device. In case of less fault current (due to higher impedance of fault return path), protective devices such as fuses, MCB's, MCCB's will not operate.

Further analysis of the subject from IS3043 is as below.

IS3043: 2019. Clause 4: Statutory Provisions For Earthing	
IS 3043	Interpretation
Where the neutral and protective conductors of electricity supply system of Electrical supply undertaking are combined, it is in protective multiply earthed (PME) system, also called TN-C-S system. The PEN conductor, which is referred to as a combined neutral and earth (CNE) conductor, is earthed at the source and extremities of the distribution mains and point in between. The PME is the most common system adopted by Electrical supply undertakings. Multiple earthing of the CNE conductor ensures that if the conductor becomes open circuit for any reason (probably cut or snapped), exposed-conductor parts remain connected to earth; under such conditions the supply voltage between the installation line and neutral conductor is substantially reduced and consumer will experience unacceptable voltage variations.	The 4th conductor in LV distribution (combined PEN) can be used as continuous earth conductor.

Interpretation of TN-C-S system with PME as per IS3043 clause 4



TN-C-S System, neutral and protective functions combined in a single conductor in a part of the system

NOTES

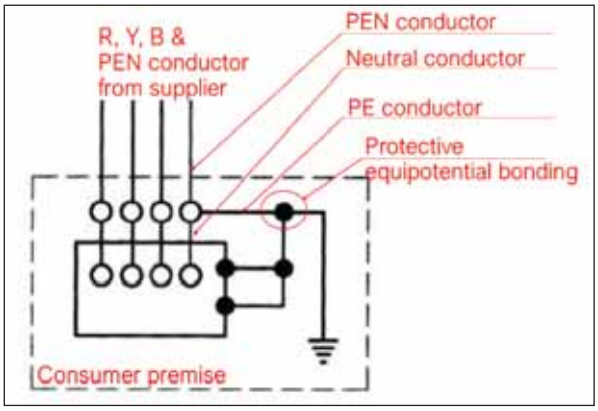
1 The usual form of a TN-C-S system is as shown, where the supply is TN-C and the arrangement in the installations in TN-S.

2 This type of distribution is known also as Protective Multiple Earthing and the PEN conductor is referred to as the combined neutral and earth (CNE) conductor.

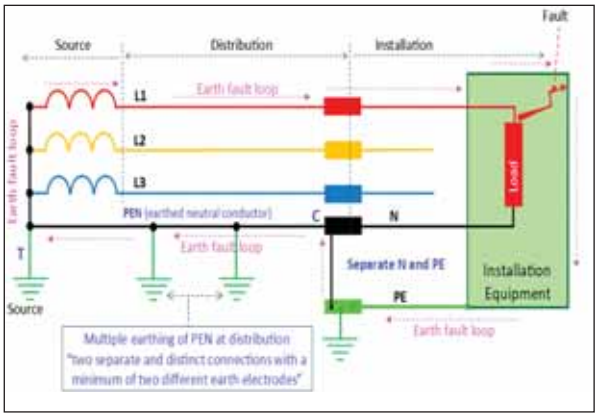
3 The supply system PEN conductor is earthed at several points and an earth electrode may be necessary at or near a consumer's installation.

4 All exposed conductive parts of an installation are connected to the PEN conductor via the main earthing terminal and the neutral terminal, these terminals being linked together.

Fig:15 from IS3043: TN-C-S system with PME



Explanations of fig 15 from IS3043.



Note: Illustration of TN-C-S with PME and its fault loop path during fault at consumer premise

Conditions to implement TN-C-S with PME (In countries where this system is followed)

1. Supplier shall provide the fault loop impedace and prospective fault current at "origin of installation". Based on which the type and rating of incoming protective device at the consumer premise is selected.
2. Supplier is supposed to install "OCPD" at outgong of the transformer in every feeder. Type and rating of these OCPD's are decided based on the fault loop impedance.
3. In case of Line snapping (break), the phase conductor is "supposed" to fall on earth conductor (PEN conductor). Thus snapping of phase conductor produces a fault of low impedance resulting in higher fault current and disconnection of the feeder by OCPD.
4. Additional safety can be implemened by "Shunt" protectie devices by measuring the Neutral current (returning back to Neutral terminal) . The challenges are

- Deciding the amount of neutral current in normal condition
- Deciding the amount of neutral current during fault
- Influence of harmonics in PEN conductor

Shunt operated protective devices are difficult in LV system due to single phase loads and harmonics. As a result, OCPD's shall be relied upon for disconnection.

From these regulations and standard, it is clear that

a. An earth conductor is mandatory along with line conductors in overhead distribution
b. Earth conductor shall interconnect all metallic parts (other than live conductors) in each pole.
c. The interconnected parts shall be connected to earth electrodes in soil at every pole for 11/22/33 kV system and at every 5th pole or (three equidistance points every km.) for LV system.
d. To ensure harmless installation, measures such as guarding to ensure "line conductors not falling to soil" and methods of disconnection of supply shall be implemented.
e. Guarding is necessary at every crossing and in populated areas.
f. A line not maintained as above violates the safety regulations resulting in accidents including loss of life and property. Majority of accidents are due to noncompliance to regulations.
g. The management of the utilities are responsible for the accidents happening from such non-compliant and unsafe lines. ■

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