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MIS CONCEPTS AND THE RIGHT WAY OF EARTHING IN LOW VOLTAGE SYSTEM

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The word "earth" and "earthing" is misunderstood across India as an electrode in soil. Good earthing is understood as an earth electrode with a low resistance to soil. As a result, earth electrode in soil is always blamed as the reason for failures and incidents.

CEAR 2010 (or IER 1956) is misinterpreted as

1. Neutral of every transformer and DG require two separate and distinct connections to two separate earth electrodes in soil.
2. Body of every transformer and DG require two separate and distinct connections to two separate earth electrodes in soil.
3. Due to this misinterpretation every electrical apparatus is connected to earth electrode in soil, preferably 2 separate earth pits.

As we explained in the previous article, this misinterpretation is probably the biggest threat for electrical safety in India. Neither CEAR-2010 nor IS standards recommend "Neutral of every transformer and DG require connections to two earth electrodes in soil and Body of every transformer and DG require two more earth electrodes".

Few Myths and its Interpretations are

Separate Earth Pit

Myth: Standards and regulation recommend connection to two separate earth pit for transformer neutral, transformer body, DG neutral, DG body, UPS neutral, UPS body, Panel body, elevator, each and every electrical appliance. All earth electrodes under soil need interconnection under soil as a grid.

Fact: IS3043 / IS732 (or any other standards) recommend any of the above. The subject of earthing is about achieving safety during an earth fault by implementing various electrical safety rules. The most common rule is "protective equipotential bonding and automatic disconnection of supply"(also called as earthed equipotential bonding and automatic disconnection of supply).

Chemical earth pit improve the system

Myth: Chemical earth, digital earth, pipe in pipe, plate in pipe, NCE charge electrode, earth enhancing compound, chemical compound, granule backfill compound, carbon earth, gel earthing electrode and other attractive names are used to call earth electrodes. Some of them claim that they can absorb lightning, fault current and solve major electrical problems. They uniformly claim that they are capable of providing an earth pit resistance close to 1 ohm in any soil.

Fact: All the above claims are false. The compounds used are fly ash, bentonite, carbon flakes, graphite, cementor combination of these. They are called in attractive names. Except conductive cement, others seem to be creating problem to earth electrode in long run. (This is the reason bentonite materials are not allowed in RDSO for railway application).

Earth pit of 1 ohm is required for safety and operation of electronics.

Fact: Resistance of an earth pit in soil does not influence any LV electrical installation. There is no need of a1 ohm-resistance for an earth pit in an electrical system including DG or transformer.

Chemicals in a chemical earth pit produce low resistance.

Fact: Resistance of an electrode to soil is influenced by the (1) resistance of the metal electrode, (2) contact resistance to soil and (3) the resistivity of the surrounding soil. Out of these three, the main influencing factor is the soil resistivity surrounding the electrode over an area of few meters. Chemicals (such as salt) which influences the area surrounding the soil will leach in a short time and of no use after few months. Some compounds help in reducing the contact resistance between the electrode and soil, hence can be used in rocky areas to have some reduction in the resistance of an earth electrode. However, a value in the range of 1 ohm or 100 ohms does not influence the total LV system.

The best way of installing an earth electrode is to use with a chemical compound.

Fact: Best results are achieved by hammering the electrode in soil. However, this is not possible in rocky areas, hence an enhancing compound such as conductive concrete may help in getting better results.

Earth pit resistance influence the tripping time of an Over Current Protective Device.

Fact: Earth fault loop impedance (not earth pit resistance) influence the tripping time of an OCPD.

Lightning protection require an earth electrode of 10 ohms.

Fact: Type A electrodes can have an optional resistance of 10 ohm. However, the recommended practice for modern buildings are Type B earthing which is a ring earthing or a foundation earth electrode. For Type B earthing, 10 ohm resistance is not mandatory.

Earthing in high-rise buildings:

Myth: Type A, vertical rod electrodes are installed in basements inside the periphery of buildings, in order to dissipate lightning current to earth.

Fact: This is a violation of standard IS/IEC 62305-3. The standard explains, "Type A arrangement comprises horizontal or vertical earth electrodes installed outside the structure to be protected connected to each down conductor or foundation earth electrodes not forming a closed loop".

Grounding & earthing:

Myth: Grounding is for transformer neutral and earthing is for metal objects in an installation.

Fact: Both terms are the same. "Grounding" is used in USA and "Earthing" is used in IEC/ISO standards. In India the correct wording is "Earthing".

Erroneous Practice of Earthing in Oil Industry

The following specifications are used in oil industry for low voltage installations. *(courtesy of this information: various tender documents in public domain)*

The resistance value of an earthing system to general mass of the earth should not exceed.

- 4 ohms for electrical systems and metallic structures;
- 7 ohms for storage tanks;
- 1 ohm for main earth grid, and bonding connections between joints in pipelines and associated facilities;
- 2 ohms for each electrode to the general mass of the earth.

The neutral of the transformer shall be earthed with two distinct earth pits separately. Connections will be made to the pit directly and then pits will be connected to each other to form a grid. This grid shall be distinct and shall not be connected to any other earth grid.

The neutral of the diesel generator shall be connected to two distinct earth pits separately. Connections shall be made to the pit directly and then pits will be connected to each other to form a grid. This grid shall be distinct and shall not be connected to any other earth grid.

The resistance value of an earthing system to the general mass of earth shall be as follows:

- For the electrical system and equipment, a value that ensures the operation of the protective device in the electrical circuit but not in excess of 4 ohms. However, for generating stations and large sub-stations this value shall not be more than 1 ohm;
- For lightning protection, the value of 4 ohms as earth resistance shall be desirable, but in no case it shall be more than 10 ohms.

Fact: The above specifications used in OIL INDUSTRY are in violation to all available national/international standards. The concept of "equipotential bonding" is often treated as danger. Separate earth pits as per the above specification in oil industry is made out of lack of knowledge. Non-standard practices as above attribute to accidents and failure of equipment.

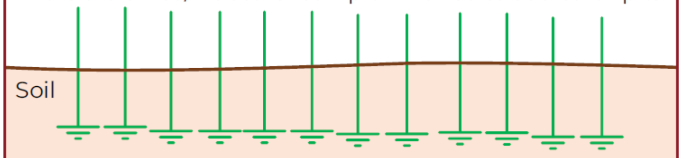
Confusion with Pipe & Plate with Salt and Charcoal

Two typical pictures of earth electrode installation in soil is included in IS 3043 (fig. 25 and 26). Often these pictures are misinterpreted and used as the meaning of "earthing". Due to the misinterpretation, there is a tendency to connect every electrical apparatus in a building to earth electrode in soil (as per the picture in IS3043) and neglect protective earthing and protective equipotential bonding measures. Users are requested to read complete clause 23 of IS3043:2018 to understand earthing in Low Voltage system. (explained in further clause in this article under right way of earthing). To satisfy some safety measure a connection to an earth electrode in soil is necessary, in that case an installation as per the typical figure in IS3043 could be used. However using SALT and Charcoal if installed along with earth electrode will greatly reduce the life of electrode due to accelerated corrosion.

Practices of Earthing

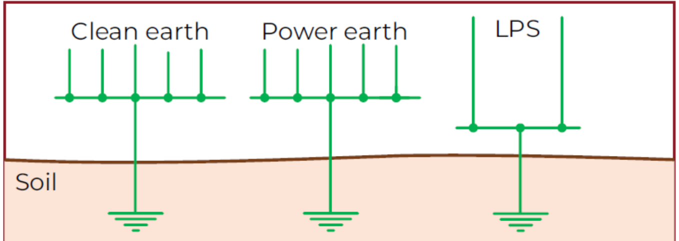
An electrical system may work without a fault for years. Good earthing practices are to ensure that the installation is safe during fault. However wrong practices create accidents during fault.

Separate earth electrodes in soil.
There are office/industrial complex with 50 to 300 earth pits.



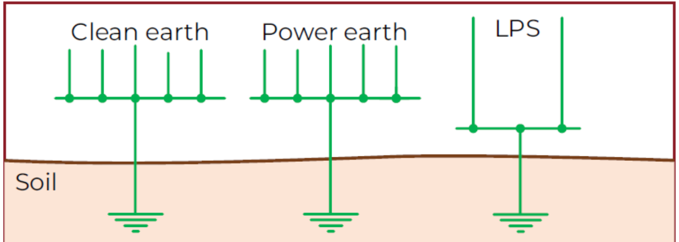
Separate earth electrode for each & every appliance (neutral, body, UPS, elevator, isolation transformer, electronic system system, etc.)

WRONG CONCEPT (01): Typical Indian practice. This wrong practice lead to accidents, deterioration of insulation, reduced life, malfunctioning of electronics.



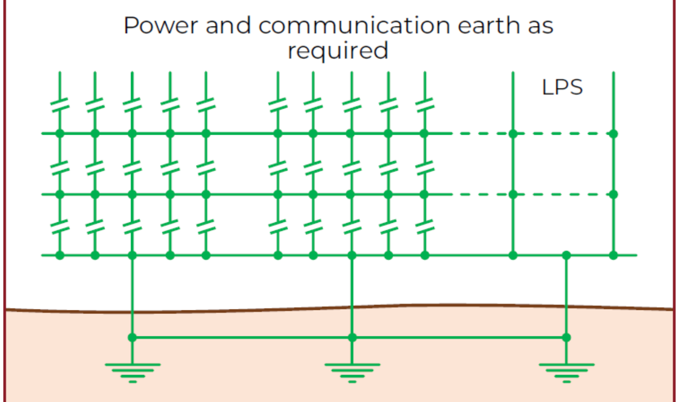
Independent (separate) earth electrodes in soil. Separate for instrumentation, Separate for electrical, Separate for LPS

WRONG CONCEPT (02): Independent earth electrodes resulting accidents, deterioration of insulation, reduced life, malfunctioning of electronics.



All earth electrodes in soil interconnected as a grid under soil. Separate for electronics, Separate for electrical, Separate for LPS

WRONG CONCEPT (03): Separate earth electrodes connected as a grid under soil, resulting accidents, deterioration of insulation, reduced life, malfunctioning of electronics, additional problems due to circulating currents.



Multiple bonded earthing system

GOOD PRACTICE: Safe, Maximum life for electrical and electronic system (do not forget to avoid circulating currents and current loops).

Earthing in Low Voltage System: Purpose and Methods

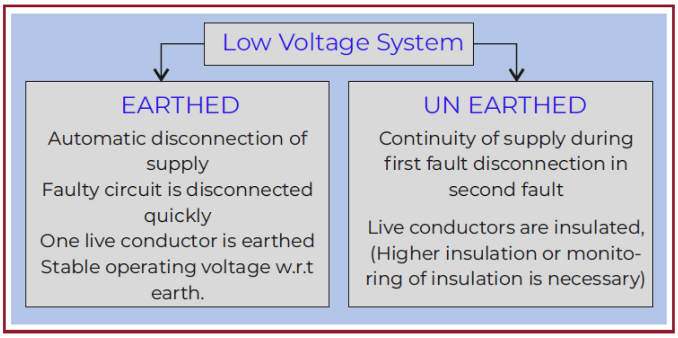
The purpose of earthing is to have a balanced voltage of an electrical network called as system earthing and to ensure safety in the installation during an earth fault called as equipment earthing

System Earthing for a Source of Power Supply

In order to have balanced voltage on an electrical network, one of the current carrying conductor is earthed. In a 3 phase 4 wire system, star point of the transformer is earthed (Neutral). In a three phase three wire system, one of the phase conductor is earthed directly or through a neutral earthing transformer. There are several methods such as low impedance earthing, high impedance earthing, earthing through NGR, etc. depending upon the requirement and application. System earthing is called as System grounding in USA. The definition of system earthing is "functional earthing and protective earthing of a point or points in an electric power system".

Earthed and Unearthed System

LV electrical system is of two categories with respect to earthing. Earthed systems are used in general application, where automatic disconnection is used as a safety measure. The disconnection time is fixed in the standards. Unearthed systems are used for specific application where continuity of supply is desired, e.g. application such as operation theatres in hospitals, supply for control, instrumentation and automation, supply for emergency services etc.



Right way of Earthing in an Installation (Consumer Premise)

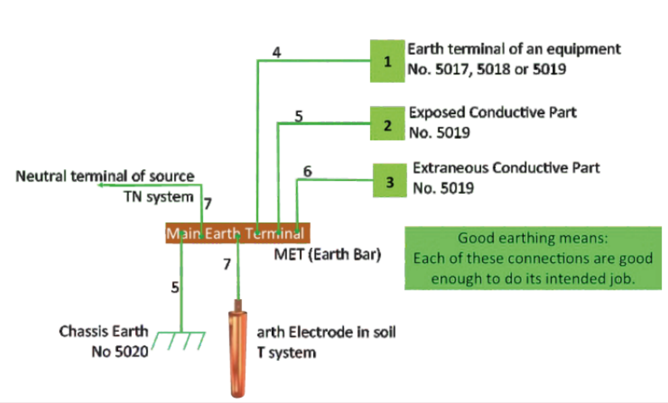
There are several rules established by IEC in order to achieve safety from electric shock, thermal effects of electricity (ignition of fire), over current, fault currents and voltage disturbances. This concept is used worldwide to have uniform protective measure. This concept has already been adopted in IS732:2019.

Out of the several established safety methods in IS732, one commonly used protection against shock from indirect contact (fault protection) is called as "automatic disconnection of supply". This safety measure is achieved by

1. Protective earthing of exposed conductive parts;
2. Protective equipotential bonding of extraneous conductive parts;
3. Automatic disconnection of supply by connection to the means of earthing;

Protective equipotential bonding is also used in other safety methods such as *"protection by equipotential bonding" and "protection by electrical separation".*

In the recommended safety measures in IS732 and IS3043, main and supplementary protective equipotential bonding is probably the first protective measure to be implemented in a building.



4. Protective or functional earthing
5. Protective Earthing
6. Protective Equipotential bonding
7. Means for automatic disconnection (protective earthing)

Fig: Earthing in a building

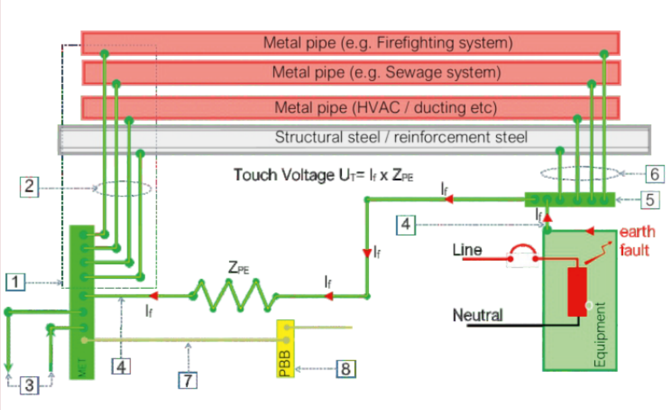
Earthing as per IS 732 & IS 3043 in a Consumer Installation

In a consumer premise (irrespective of the size and criticality of the building), earthing is done by creating equipotential bonding zones. At the point of commencement of supply (mains incoming) every exposed and extraneous conductive part entering the building is connected to the MET (MET is Main Earth Terminal in new standards and Earth Busbar in old standards). This is called as Main protective equipotential bonding. For medium to larger installations additional protective zones need to be created. These are called as supplementary protective equipotential bonding.

Main and Supplementary protective equipotential bonding shall be created in such as a way that the fault voltage inside a consumer premise (including commercial and industrial premise) is reduced to a level lesser than 50 Volt. NEC of India:2011 (SP 30) recommend a value less than 32 volt during a fault in a consumer premise.

In order to avoid confusion of "earthing", a simple definition is adopted in IS732 Earthing means

"Connection of the exposed conductive parts of an installation to the main earthing terminal of that installation"



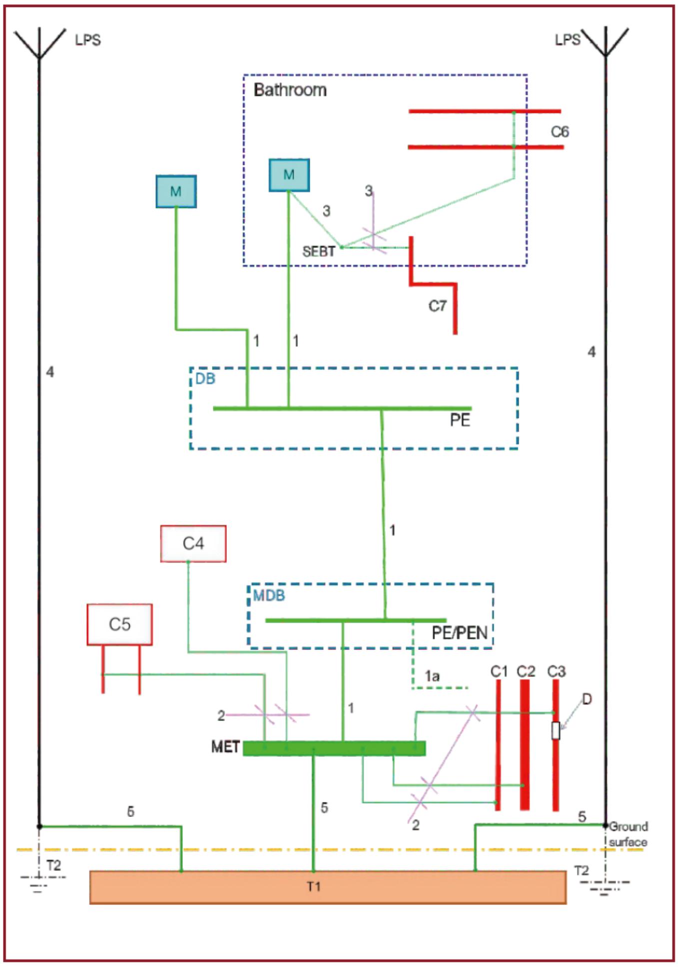
1. Main protective equipotential bonding (*connection between MET and extraneous conductive parts).*
2. Main protective equipotential bonding conductor (individual connection, no looping).
3. Earthing conductor. *(Connects MET & earthed point of the source in TN system or MET & earth electrode in case of TT / IT system).* One connection from MET is also necessary to LPS (*if installed).*
4. Protective earthing by Protective Earthing conductor (PE).
5. Supplementary equipotential bonding terminal *(SEBT) (to reduce touch voltage during fault to a level less than 32 volt as per NEC, SP-30).*
6. Supplementary equipotential bonding conductor.
7. Functional Earthing conductor (FE) - cream colour (*e.g. Telecommunication bonding conductor).*
8. Parts of functional earthing system *(e.g. PBB - Primary bonding busbar of a telecommunication bonding network).*

Fig. Main and supplementary protective equipotential bonding applicable for a large building

The rules for making equipotential bonding is well explained in both IS732 and IS3043. The effectiveness of equipotential bonding is ensured by visual inspection and testing. The author has been visiting industrial and commercial sites for safety audits and accident investigations for almost 2 decades. In majority installations (>80%), protective equipotential bonding is not carried out due to lack of awareness. Installations where this protective measure is implemented are not maintained well. Very few installations (<1%) implemented and maintained this protective measure properly. In comparison to new buildings, older buildings have this protective measure properly implemented. Majority electrical engineers neglect this safety measure making a serious compromise to safety.

Earthing in an Installation as per IS 732 and NBC-2016

The below picture and the explanations will provide the correct information about earthing in a consumer installation. This picture is a typical example, which can be used in commercial and industrial installations as well.



Key	Explanation
C	Extraneous conductive part
C1	Water pipe, metal from outside
C2	Wastewater pipe, metal from outside
C3	Gas pipe with insulating insert, metal from outside
C4	Air-conditioning
C5	Heating system
C6	Water pipe, metal e.g. in a bathroom
C7	Wastewater pipe, metal e.g. in a bathroom
D	Insulating insert
MDB	Main distribution board
DB	Distribution board supplied from the main distribution board
MET	Main earthing terminal
SEBT	Supplementary equipotential bonding terminal

Key	Explanation
T1	Concrete-embedded foundation earth electrode or soil-embedded foundation earth electrode
T2	Earth electrode for LPS (if necessary)
LPS	Lightning protection system (if any)
PE	PE terminal(s) in the distribution board
PE/ PEN	PE/PEN terminal(s) in the main distribution board
M	Exposed conductive part
1	Protective earthing conductor (PE)
1a	Protective conductor, or PEN conductor, if any, from public distribution
2	Main bonding conductor (connection to the MET)
3	Supplementary bonding conductor
4	Down conductor of a lightning protection system (LPS) if any
5	Earthing conductor

Type of Earth Electrodes for Dissipation of Current in Soil

The primary requirement of an earth electrode is its ability to withstand corrosion and mechanical strength for the intended lifetime. Different type of earth electrodes are

1. Vertical conductors such as a solid rod (or pipe) in soil
2. Plates in soil
3. Solid conductors laid horizontally in soil or inside concrete

Copper or copper bonded steel materials provide longer life in comparison to Bare, Galvanised or Cast steel.

Conclusion

1 Earthing is the most mis-interpreted subject in electrical engineering.

2 Earth electrode in soil is a small part of total earthing system.

3 Protective equipotential bonding and automatic disconnection of supply is the correct way of earthing in an earthed system.

4 There is no need for separate connections to 2 for Neutral and 2 for body of each source. This is a misinterpretation of standard and regulation.

5 Earthing in an installation is the methods adopted to reduce touch voltage and fire hazards in an installation. Earth electrodes in soil do not play major role to achieve this goal in a modern building.

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