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EARTHING AND BONDING IN HAZARDOUS LOCATIONS

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Introduction

Protective earthing is an important part of the safety of almost all electrical systems where potentially explosive gases, vapours and combustible dusts may constitute a hazard. Correct earthing and bonding is important for all protection techniques in hazardous locations, to prevent any arcs or sparks.

Definitions

One of the main causes of difficulty is differentiation between bonding and earthing. In this tutorial the terms are defined as follows:

Earthing is the provision of a specific return path for fault currents so as to operate protective devices in a very short time.

Bonding is the interconnection of two adjacent pieces of conducting material so as to prevent a potential difference between them which would be a hazard to people or be capable of causing an ignition.

Design

In hazardous areas, the elimination of sources of ignition is very important and effective earthing and bonding plays an important role.The design and installation of earthing systems shall be generally in accordance with SANS 10313, SANS 10199, SANS 61024 and SANS 10142-1.The limitation of earth-fault currents (magnitude and/or duration) in frameworks or enclosures and the prevention of elevated potentials on equipotential bonding conductors are essential for safety.

The principal reasons for earthing and bonding are:

- To reduce personnel shock risk.
- To operate protective devices (fuses & Earth leakage circuit breakers).
- To deal effectively with Lightning Protection.
- To control Electrostatic Discharge.
- To minimise interference & provide signal reference.
- To satisfy segregation and define fault path requirements necessary to ensure the safety of explosion-proof apparatus

Earthing of equipment

Close circuit protection required.
Return path low resistance for rapid operation.

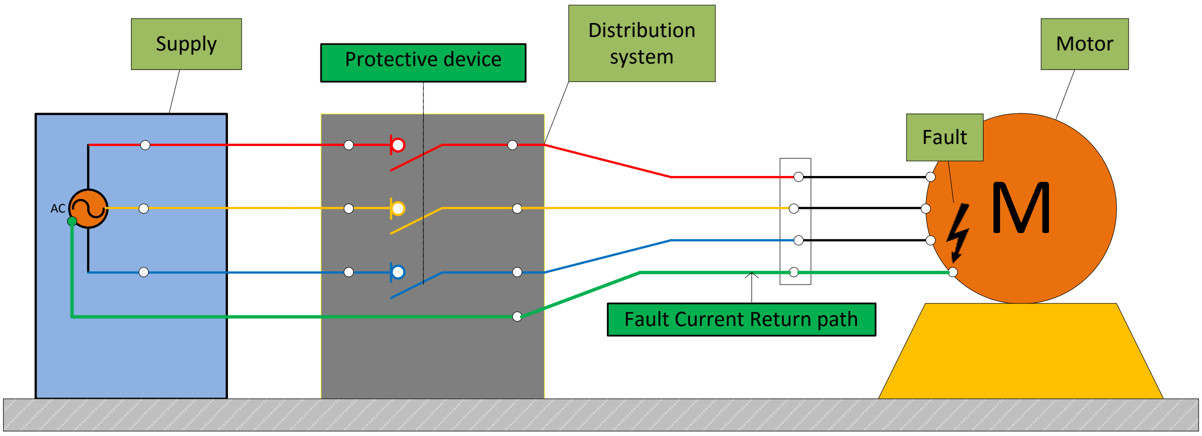

Figure 1: Power fault return path

Earthing system intended to eliminate voltage shock hazard to personnel caused by unintentional contact of an energized circuit with its metal frame or enclosure. It also provides a non-destructive current path for fault current until it can be interrupted by a protective device.

Types of system earthing

It is not always possible to cover all possible systems. The following applies to electrical systems, other than intrinsically safe or energy-limited circuits with voltages up to 1 000 V a.c. r.m.s./1 500 V d.c as per SANS 60079-14 and SANS 10142-1.

The requirements for the earthing of the neutral of a low-voltage (LV) system should be as follows as per SANS 10292:

- to provide a return conductive path for any earth fault current and earth leakage current;
- to maintain the neutral of the LV system as close as possible to the earth potential;
- to ensure that the medium-voltage (MV) protection operates in the event of a fault between the medium-voltage and LV windings of a transformer; and
- to reduce the prospective touch voltage as much as is reasonably practical.

System earthing identification code

These have been designated in the IEE Regulations using the letters:

T, N, C and S.

These letters stand for:

- T - terre (French for earth) and meaning a direct connection to earth.
- N - neutral
- C - combined
- S - separate
- When these letters are grouped, they form the classification of a type of system.

- The first letter denotes how the supply source is earthed.
- The second denotes how the metalwork of an installation is earthed.
- The third and fourth indicate the functions of neutral and protective conductors.

Different types of systems are as followed:

TN System

If a type TN power system is used, it must be the type TN-S (with separate neutral N and protective conductor PE) in the hazardous area, i.e. the neutral and the protective conductor must not be connected together, or combined in a single conductor, in the hazardous area. At any point of transition from TN-C to TN-S, the protective conductor must be connected to the equipotential bonding system in the non-hazardous area.

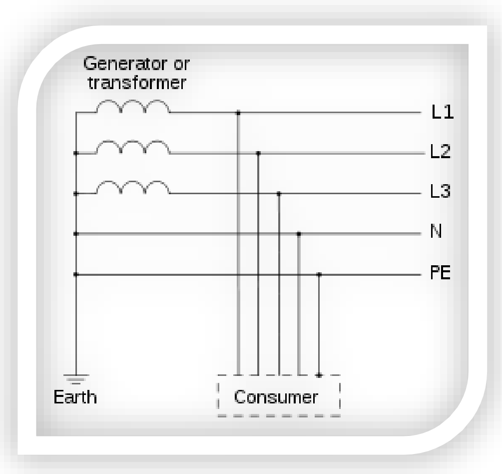

Figure 2: TN-S system earthing

TT systems

If a type TT system earthing (separate earths for power system and exposed conductive parts) is used, then it must be protected by a residual current device.

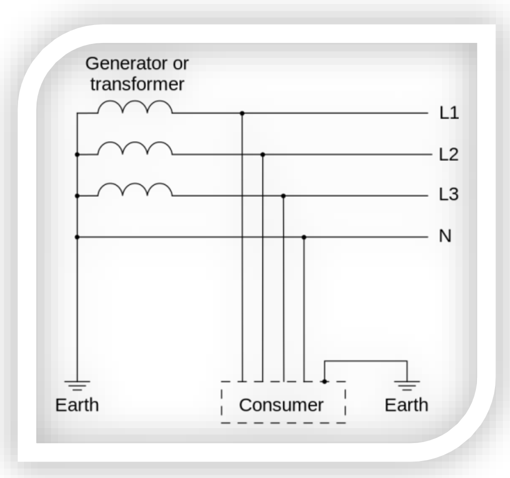

Figure 3: TT system earthing

IT systems

If a type IT system earthing (neutral isolated from earth or earthed through sufficiently high impedance) is used, an insulation monitoring device must be provided to indicate the first earth fault.

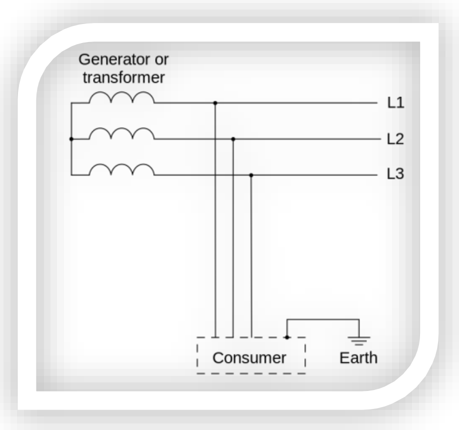

Figure 4: IT earthing system

NOTE: In TN-C and TN-C-S (PME) supplies, the neutral conductor is also the earthing conductor; therefore, there could be a potential difference between the main earthing terminal of the installation and the general mass of earth. Incendive sparking could then occur between the earth of the electrical installation and any extraneous metalwork which is in contact with the general mass of earth.

The following earthing systems are **NOT** suitable for use in hazardous locations:

- TN-C

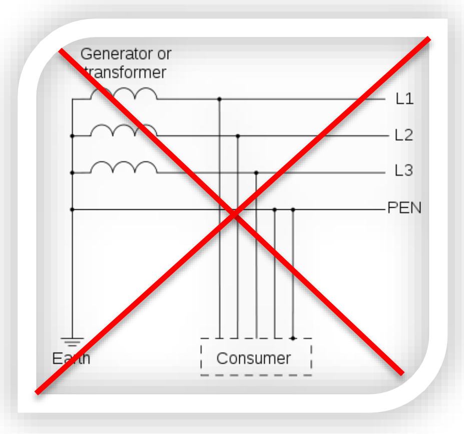

Figure 5: TN-C system earthing

- TN-C-S (PME)

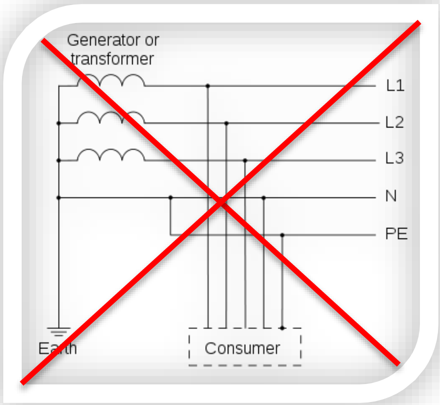

Figure 6: TNC-S system earthing

	TT	IT	TN-S	TN-C	TN-C-S
Earth fault loop impedance	High	Highest	Low	Low	Low
RCD preferred?	Yes	N/A	Optional	No	Optional
Need earth electrode at site?	Yes	Yes	No	No	Optional
PE conductor cost	Low	Low	Highest	Least	High
Risk of broken neutral	No	No	High	Highest	High
Safety	Safe	Less Safe	Safest	Least Safe	Safe
Electromagnetic interference	Least	Least	Low	High	Low
Safety risks	High loop impedance (step voltages)	Double fault, overvoltage	Broken neutral	Broken neutral	Broken neutral
Advantages	Safe and reliable	Continuity of operation, cost	Safest	Cost	Safety and cost

Table 1: Comparison of different earthing systems.

Termination of earth

When terminating earth conductors it is not permitted to terminate more than one conductor under one screw. This is because if we disconnect one earth connection, we may also disconnect the others. This results in that the circuits that remains connected to the power will loose their earth connection and become unsafe.

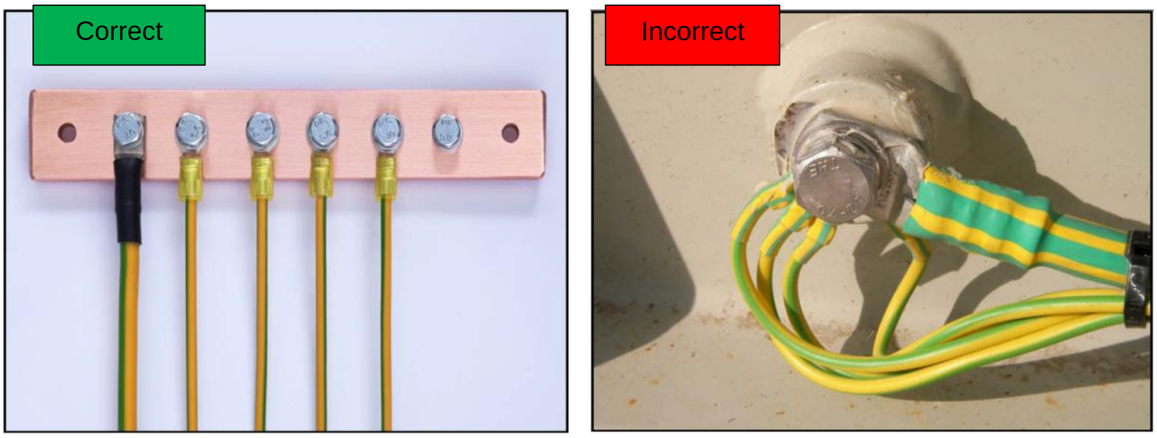

Figure 7: **Earth termination**

Bonding

Equipotential bonding

- Potential equalization is required for installations in hazardous areas to prevent potential differences between equipment, structures and people.
- For TN, TT and IT systems, all exposed and extraneous conductive parts must be connected to the equipotential bonding system.
- It is also advisable to connect metal constructions, metal conduits and metal cable sheaths to the system.
- Connections must be permanent and secured against self-loosening.
- Exposed conductive parts need not be separately connected to the equipotential bonding system if they are firmly secured to and in metallic contact with structural parts or piping which are connected to the equipotential bonding system.
- Metallic enclosures of intrinsically safe apparatus do not have to be connected to the equipotential bonding system unless required by the apparatus documentation or to prevent accumulation of static charge.

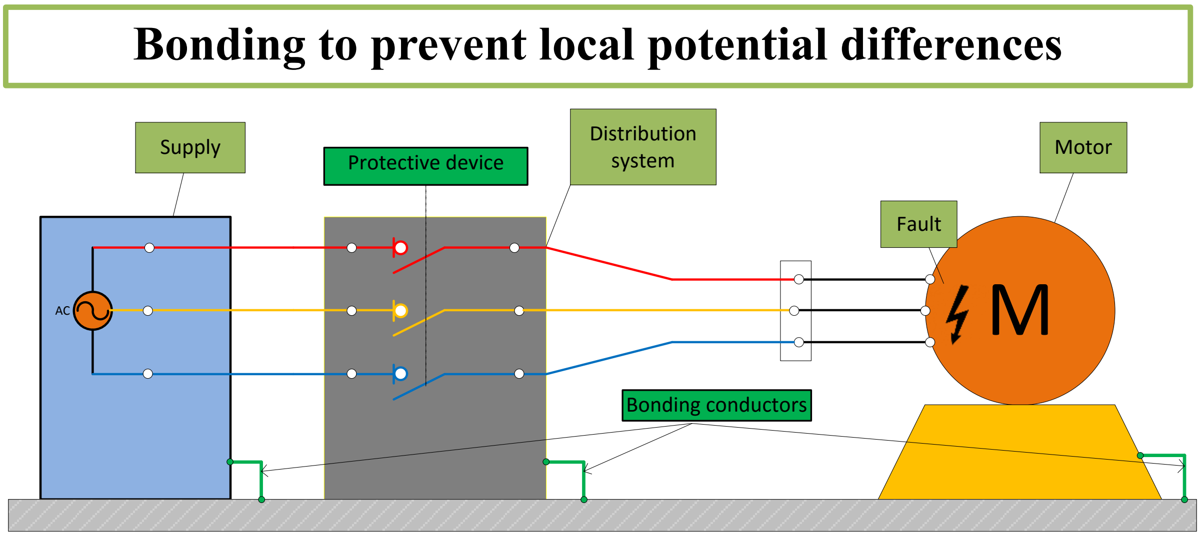

Figure 8: Typical example of potential equalization of electrical equipment

NOTE: If the armour is earthed only outside of the hazardous area in a TN system there is a possibility, that dangerous sparks may be created at the end of the amour in hazardous areas, therefore this armour or screen should be treated like unused cores (see 9.6.3 of SANS 60079-14).

- Exposed conductive parts need not be separately connected to the equipotential bonding system if they are firmly secured to and are in conductive contact with structural parts or piping which are connected to the equipotential bonding system.
- Extraneous conductive parts which are not part of the structure or of the electrical installation, for example frames of doors or windows, need not be connected to the equipotential bonding system, if there is no danger of voltage displacement.
- Cable glands which incorporate clamping devices which clamp the braiding or armour of the cable can be used to provide equipotential bonding.

Figure 9: Example of armouring connected to a gland to establish equipotential bonding

- Installations with cathodic protection shall not be connected to the equipotential bonding system unless the system is specifically designed for this purpose.

Note: Metallic enclosures of intrinsically safe or energy-limited apparatus **need not** be connected to the equipotential bonding system, unless required by the apparatus documentation or to prevent accumulation of static charge.

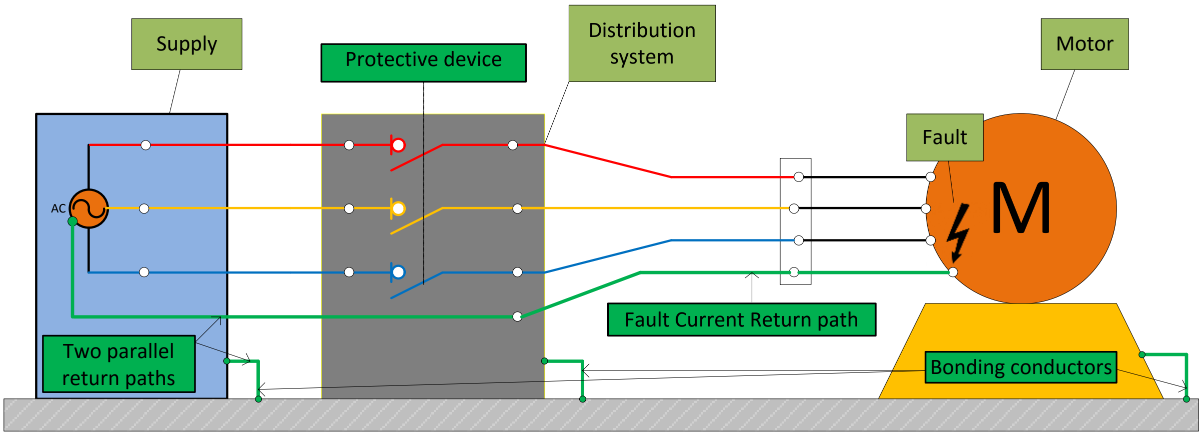

Figure 10: Overall protection (Earthing and bonding)

When both bonding and earthing are installed, then fortunately they reinforce one another. The bonding and the earthing always provide a parallel return path for a fault current. The system becomes as illustrated in figure 10, creating an effective interconnected network of return path and bonding. This has the benefit that safety is no longer reliant on a single conductor or connection.

Lightning

Lightning presents a substantial threat to potentially explosive atmospheres, both through a direct strike, flash over and the risk of partial lightning currents entering the hazardous area via incoming/outgoing metallic services. A strategy of good bonding is important to minimize the risks if lightning is usual in the plant's location.

In the design of electrical installations, steps shall be taken to reduce to a safe level the effects of lightning as per SANS 10313**.** Subclause 16.3 of SANS 60079-14 gives details of lightning protection requirements for Ex "ia" apparatus installed in locations requiring EPL "Ga".

Conclusion

People are our most valuable asset and the industry must ensure a safe work environment as per Section 8 and Electrical Machinery regulation 9 as per the latest issue of the Occupational Health and Safety Act and Regulations (85 of 1993).

Reference

[1] **SANS 60079 Part 14:** Installation (and selection) of equipment in hazardous areas.
SANS 60079 Part 17: Inspection and maintenance of equipment
SANS 10142-1: The wiring of premises
SANS 10292: Earthing of low-voltage (LV) distribution systems