FirePro.

Technical Guidelines

EMI signals prevention in Fixed Fire Fighting Systems

Issue July 2016 - Version 1.0

Reinventing
Fire Suppression

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SECTION/SUBJECT .... PAGE

1.0 Overview

In today's dynamic industrial environments, electronic devices, signal and power wiring, and other electrical plant/process equipment often interact to create electromagnetic interference (EMI) problems which can degrade critical measurement and control signals. Proper grounding and shielding techniques can help reduce or eliminate these problems and maintain system integrity.

Three basic elements are required in order for an EMI to exist;

1. A noise source to generate the EMI,
2. A receiving device which is affected by the EMI, and
3. A coupling channel between the source and receptor.

The objective in electromagnetic compatibility is to minimize, divert, or eliminate one of the three elements necessary for an EMI problem.

Induction or stray currents also can occur in systems. This should be taken into account when installing a fire firefighting system. These types of currents can be prevented from having undesired effects on the system's functioning.

As the mechanisms of induction, coils and magnetic fields are not always clear; this document contains a short theoretical introduction to the phenomena. Subsequently, there is an explanation as to why they sometimes occur, followed by practical tips and pointers concerning the cabling to prevent interference with the system.

2.0 Introduction

The coexistence of equipment of different technologies and the inadequacy of the installations favors the emission of electromagnetic energy and often causes problems of electromagnetic compatibility.

EMI is the energy that causes undesirable response to any equipment and may be generated by sparking on the motor brushes, tension circuits switching, activation of inductive and resistive loads, activation of switches, circuit breakers, fluorescent bulbs, heaters, automotive ignitions, atmospheric discharges and even the electrostatic discharge between persons and equipment, microwaves devices, mobile communication equipment etc. All this may provoke alterations with the resulting overload, sub-voltage, peaks, voltage transients etc., which may cause high impact on a communication network. This is very common in industries and factories, where EMI is fairly frequent in function of the use of large machines such as welding instruments, motors (MCCs) and in digital networks and computers in the vicinity of these areas.

Therefore electromagnetic interference is disturbance that affects an electrical circuit due to either electromagnetic induction or electromagnetic radiation emitted from an external source. The disturbance may interrupt, obstruct, or otherwise degrade or limit the effective performance of the electronic circuit. The source may be any object, artificial or natural, that carries rapidly changing electrical currents, such as an electrical circuit.

The biggest problem caused by EMI is the occasional situations that slowly degrade the equipment and its components. Many different problems may be generated by EMI on electronic equipment as communication failures between devices of the same equipment network and/or computers, alarms produced without explanation, action on relays that do not follow logic, without being commanded, in addition to the burning of electronic components and circuits etc. Is very common the occurrence of noises in power source lines due to bad grounding and shielding or even error in the project.

The topology and the distribution of the wiring, types of cables, protection techniques are factors that must be considered to minimize the EMI effects. Keep in mind that in high frequencies the cables work as a transmission system with crossed and confused lines, reflect and scatter energy from one circuit to another. Keep the connections in good conditions. Inactive connectors may develop resistance or become RF detectors.

A typical example of how the EMI may affect the work of an electronic component is a capacitor exposed to a voltage peak higher than its specified nominal voltage. This may deteriorate the dielectric, whose width is limited by the capacitor operation voltage, which may produce a gradient of potential inferior to the dielectric rigidity of the material, causing malfunctioning and even the capacitor burning. Or, still, the transistor polarization currents may be altered and cause their saturation or cut, or burn its components by the joule effect, depending on the intensity.

Quite often the reliability of a control system is jeopardized by its poor installations. Commonly, technicians tolerate them but a close look reveals problems involving cables, knowledge and packing, shielding and grounding.

Any industrial environment has EMI in sources, including AC power lines, radio signals, machines and stations etc.

Fortunately, simple devices and techniques as the use of adequate grounding methods, shielding, twisted wires, and filters may control noise.

The EMI reduction will minimize initial and future operational costs and problems on any system.

3.0 Capacitive Coupling

Any piece of plant equipment or wiring can develop an electric charge, or potential, which can be expressed as a voltage.

An easy and effective way to minimize capacitively coupled interference is to use cable shielding. The shield is a Gaussian function or equipotential surface on which electric fields can terminate and return to ground without affecting the internal conductors.

A floating shield provides no protection against interference.

The correct place to connect an electrostatic shield is at the reference potential of the circuitry contained within the shield. This point will vary depending upon whether the source and receiver are both grounded. It is important to ground the shield at only one point to ensure that ground currents do not flow through the shield.

4.0 Inductive Coupling

When a cable carries current, a magnetic field is generated. Imagine the complicated magnetic fields which exist near heavy electric machinery or where many cables are routed in a common tray.

The "disturbing cable" and the "victim cable" are accompanied by a magnetic field. See Figure 1. The level of disturbance depends on the variation of the current and the mutual inductance coupling.

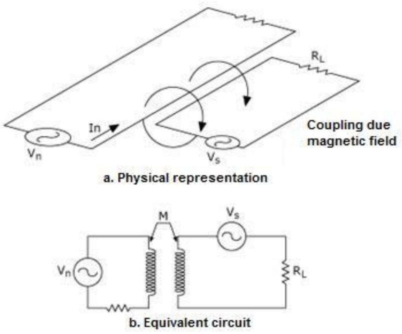


Figure 1 – Inductive Coupling – Physical Representation and Equivalent Circuit

Currents can be made to flow in conductors by moving them through a magnetic field.

Similarly, a changing magnetic field will induce currents in a stationary conductor which is in the field. Since most wiring is fixed in place, varying currents are the usual cause of magnetic coupling.

The inductive coupling increases with:

- Frequency: the inductive reactance is directly proportional to the frequency.
- The distance between disturbing and victim cables and the cable length which are parallel.
- The cable height in relation to the reference plane (above ground).
- The load impedance of the cable or the disturbing circuit.

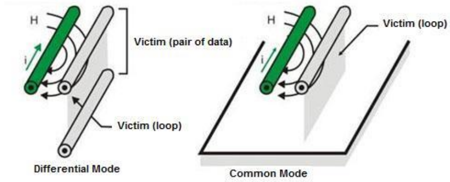


Figure 2 – Inductive Coupling between Conductors

Magnetic coupling is much more difficult to reduce than capacitive coupling because magnetic fields can penetrate conductive shields. Two types of loss, reflection and absorption, characterize how a shield works.

A ground system must be considered from the beginning in order for the circuit or system to work in the intended environment and pass interference, emissions, and safety requirements.

Proper grounding is dependent upon many factors such as the frequencies and impedances involved, the length of cabling required, and safety issues. When designing a ground or troubleshooting a ground problem, it is first necessary to determine where the current is flowing. When several kinds of grounds coexist, the current may not return by the assumed path.

The most desirable type of ground for low frequency applications is the single-point ground.

The preferred ground is the parallel connection.

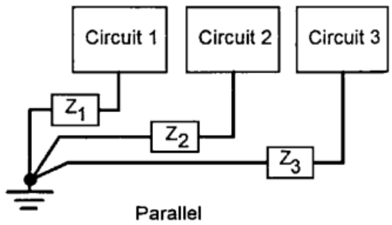


Figure 3 – Parallel Grounding

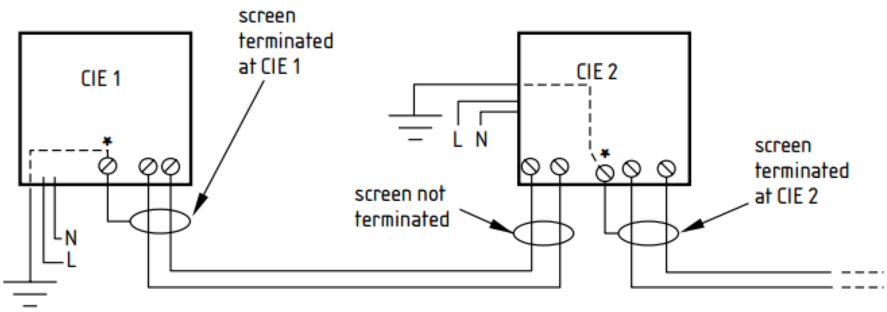


Figure 4 – Grounding cables and devices together

It is usually more difficult and more costly to implement because of the amount of wiring involved. Determine first the circuit common-impedance coupled noise immunity when choosing between these ground configurations.

Summary

- Wherever possible, use screened cables and avoid running these cables in parallel with power cables.
- Ensure screened cables are correctly bonded to earth in accordance with BS5839-1:2002 clause 29 requirements (copied below).
- Limit the effects of electromagnetic interference by good installation practice in accordance with BS5839-1:2002 clause 28 requirements (copied below).
- For analogue detection loop circuits, perform loop calculations to ensure that overall cable length, volt drop, inductance and capacitance does not also affect the signaling between control panel to detection device signaling.

5.0 Methods to reduce the effect of electromagnetic interference between circuits

5.1. Type of cable required

The use of the fire resistant cables, twisted and shielded is necessary.

A twisted pair has two wires of a cable twisted around each other, where the interfering signal tending to cancel the effect of the interference.

Figure 5 –- twisted pair wires

The Shielded Cable is encased for its entire length in foil or wire mesh. All wires running inside this shielding layer will be to a large extent decoupled from external electric fields, particularly if the shield is connected to a point of constant voltage, such as earth.

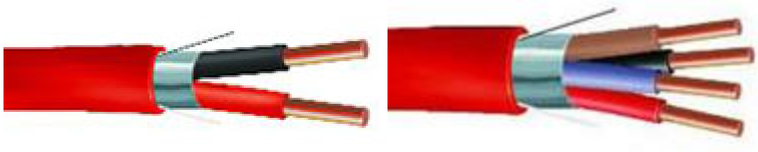


Figure 6 – Shielded Cables

Environment with substantial electromagnetic fields, (substations, transformer rooms, high voltage electrical cabinets) simple shielding of the above mentioned type of cable is not greatly effective against electromagnetic fields. Coaxial design helps to further reduce electromagnetic transmission and pickup.

The use of fire resistant **twisted**, **shielded**, **armoured** cable is necessary.

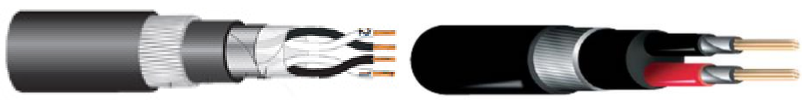


Figure 7 – Twisted, shielded, armoured cables

5.2. Electronic equipment protection

Also the electronic equipment should be protected from electromagnetic interference by grounding the metal casing of the equipment to earth.

All earth wires of the cables used for the system, should be connected together and grounded, such that the electromagnetic interference to be released from the system.

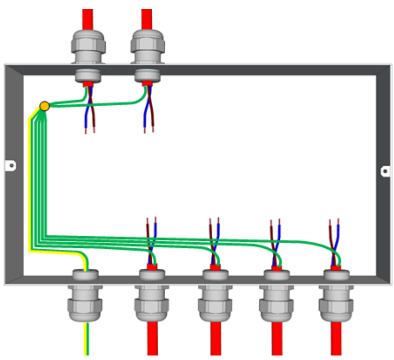


Figure 8 – Grounding all the cables

5.3. Grounding the Aerosol Generators

By using an earth tag on the cable gland, the aerosol generator can be grounded with the earth wire included in the cable used.

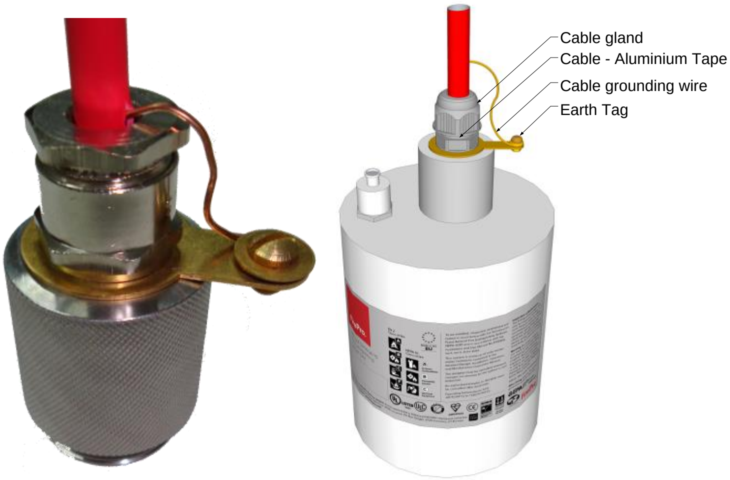


Figure 9 – Grounding the aerosol generator

5.4. Shielding the L.H.D. cable

Electromagnetic interference can be absorbed into permeable conductive materials, such as shielding placed around individual conductors within a cable assembly or wire harness. This shielding material (Conductive EMI/RFI braided shielding) either captures the EMI, taking it to ground, or dissipates it as heat. Metallic braids and high-tech plated fabrics also shield cable conductors from line-of-sight penetration or escape, again by taking EMI to ground.

The flexible shielding tube can be used to protect the LHD cable.

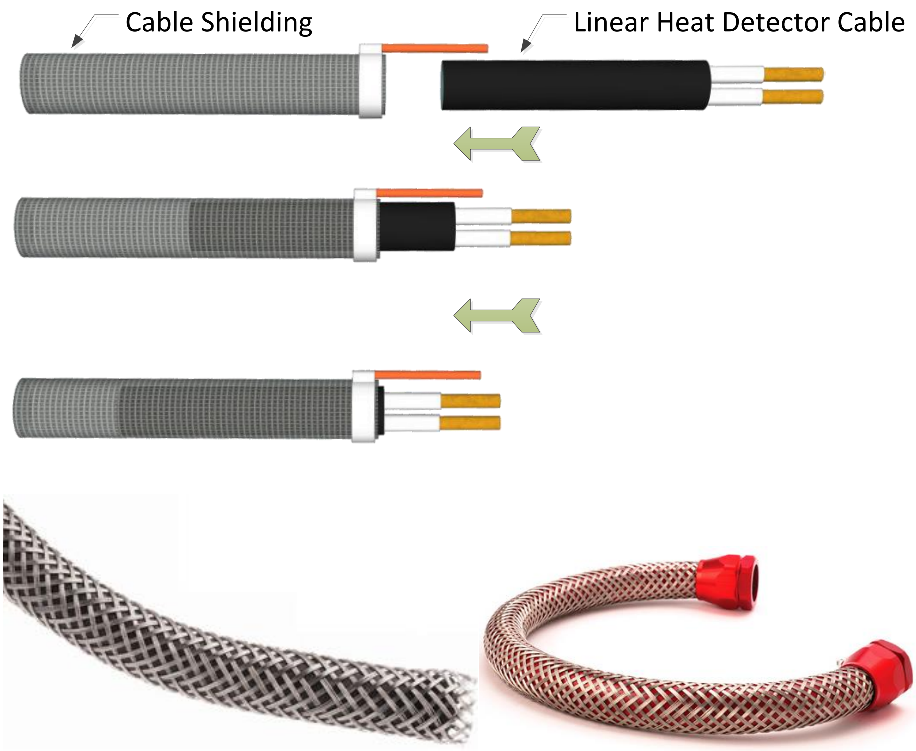


Figure 10 – Shielding the L.H.D. cable

5.5.Grounding with the Armoured Cable

The Armoured Fire Resistant cable, should be installed between the panel and all other system accessories like, aerosol generators, sounders, detectors, etc.
All cable glands (panel side) should be connected on the metal plate of the extinguishing panel and all earthing tags connected together with an earthing wire (4-6 mm).
This earthing wire should also be connected with the ground (via earth-rods-copper) or with the electrical circuit of the building (assuming already connected to the ground properly).

Figure 11 – Earth-rods-copper

Below are some useful internet links that illustrate how to install the copper earth rods:
http://www.lightningrodparts.com/installation.html
https://www.erico.com/catalog/literature/E1243C-NAEN.pdf

Below are some useful internet links that illustrate how to install the cable gland on the Armoured Fire Resistant cable:
http://www.ultimatehandyman.co.uk/how-to/electrics/armoured-cable (Recommended, step by step procedure.)
http://www.cmp-products.com/Installation-Instructions
http://www.nexans.co.nz/NewZealand/2013/Instructions-dc454a3d-62fc-41df-8f40-e04327a7edbd.pdf0(p_C.pdf

5.6. Additional accessories needed for grounding the armoured cable:

"Fire cable glands" with "earthing tag" for the armoured cable in order to earth the cables.

Figure 12 –- Fire cable glands" with "earthing tag

Fire cable clips to install the cable.

Figure 13 – cable clips

5.7. Dirty Electricity

Dirty electricity is a form of electromagnetic pollution or radiation. It is also called electromagnetic interference (EMI) or electrical “noise.

Dirty Electricity is actually a Mid-high frequency (100Hz-100000KHz) electric noise that make it's way over the electric wires and that is created because of the way that electronics and none linear electric and also from external sources (like RF sources next to power lines).

This noise is carried over the electric wires all around the room/boat and since the noise frequency is higher than 50Hz (relatively to 50 or 60 Hz electric frequency) the electric and magnetic fields that are created by these currents can cover all the room/boat.

The dirty earth circuit, is an electronic filter to stop feeding back to the system Radio Frequencies through the earthing point.

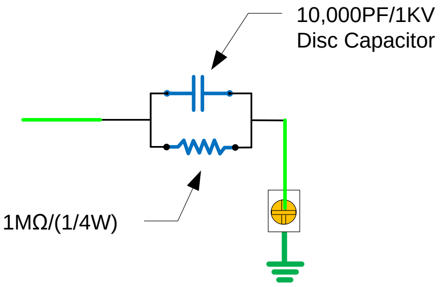


Figure 14 – Dirty Electricity filter

6.0 Grounding a system as an example

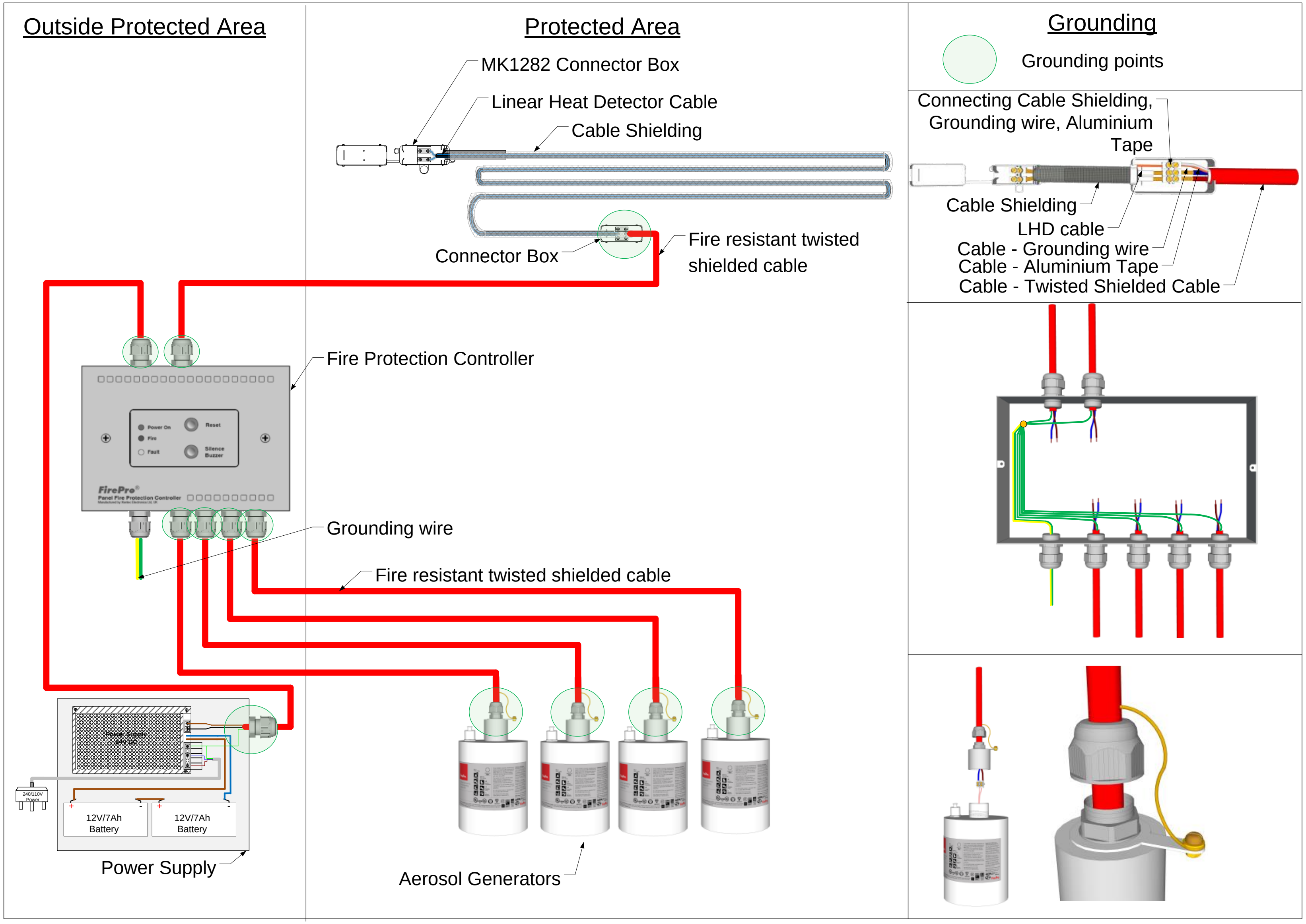


Figure 15 – Grounding of a system

7.0 Standards Recommendations

BS 5839-1_2002+A2_2008 "Fire Detection and Fire Alarm Systems for Buildings – Part1"

Section 28: Electromagnetic compatibility

Subsection 28.1 Commentary

Particular care needs to be taken in the design and installation of the fire alarm system to avoid electromagnetic interference, particularly received from, but also transmitted to, other equipment.

Electromagnetic interference to a fire alarm system can result from mobile telephones, radio transmitters, other equipment used within the building, lightning and power transients. It is known that mal-performance of some fire alarm systems has occurred owing to electromagnetic interference as a result of close proximity of fire alarm cables to power cables with high current, inductive loads. The extent to which this might occur depends on a number of factors including:

- the susceptibility of the particular fire alarm equipment to electromagnetic interference;
- the level of screening afforded by the cable;
- the separation distance between the fire alarm cables and the cables of other services.

All cables recommended in 26.2b) provide a degree of screening, but care needs to be taken to ensure good installation practice in, for example, terminations, and that where practicable, fire alarm cables do not run unnecessarily long distances (say, more than 35 m in aggregate) in close proximity to high current power cables, particularly if these serve high inductive loads.

Electromagnetic interference can be reduced where there is a metal partition between the fire alarm cables and the power cables (as in the case of compartmented trunking). Achievement of separation between fire alarm cables and the cables of other services throughout an entire installation might not be practicable; for example, economy of installation might dictate that fire alarm cables share common tray or ducts with cables of other services. Care should, however, be taken to minimize the extent to which separation is not maintained, particularly in addressable and networked systems, unless guidance from the system manufacturer indicates that separation is unnecessary; the extent will be minimized if, for example, fire alarm cables always cross the cables of other services at right angles.

More definitive guidance cannot be offered in this standard, but it is necessary to ensure compliance with any more specific recommendations of the fire alarm equipment manufacturer.

Subsection 28.2 Recommendations

The following recommendations are applicable.

a) Fire alarm systems should be so designed and installed that they do not cause, and are not unduly susceptible to, electromagnetic interference, in accordance with the Electromagnetic Compatibility Regulations 1992 (as amended to date), which implement the EMC Directive 89/336/EEC (as amended).

b) In order to comply with the Regulations, there should be compliance with, at least, the following recommendations, although these might not, alone, be sufficient to ensure compliance:

1) Every system component should satisfy the relevant requirements of the product standard for that component in respect of electromagnetic capability (see Clause 11);

2) Cables should be segregated in accordance with the recommendations of 26.2l) and 26.2n);

3) Installation workmanship should comply with the relevant recommendations of Section 4, particularly in relation to quality of terminations and continuity of screens. For mineral insulated copper sheathed cables, terminations of screens should be effective around the entire 360° of the screen. For other cables, care should be taken to ensure that the screen of the cable is continued to the appropriate terminal in the control panel or device. This is normally achieved using cables where an uninsulated circuit protective conductor is in constant contact with the screen throughout its length;

4) Any cable specifications stipulated by the manufacturer as important for the compliance with the requirements of the EMC Directive should be adhered to. However, cables not compliant with the recommendations of this standard should only be used with the prior agreement of all interested parties and should be recorded as a variation;

5) Correct earthing of equipment is vital for adequate EMC performance as well as electrical safety.

Note should be taken of the recommendations of Clause 29, in particular respect of the differences between protective and functional earth connections;

6) Exposure of the cores outside of the screen should be kept to a minimum, consistent with practical installation requirements;

7) where the manufacturers of the control equipment advise that the system is sensitive to multiple screen earths for each circuit, then their instructions in respect of these should be followed (see Clause 29);

8) Where required, the screen should have continuity throughout the whole circuit;

9) Where it is necessary to cross fire alarm system cables with those that can potentially cause interference, the cables should be crossed at right angles.

Section 29: Electrical safety

Subsection 29.1 Commentary

A fire alarm system is a special form of electrical installation, much of which operates at extra low voltage (ELV), and the recommendations of BS 7671 regarding safety and earthing are applicable.
It is important to understand that mains supplied equipment normally has a circuit protective conductor (CPC) to provide a protective earth. Some electrical equipment, such as double insulated, does not have a protective earth because of inherent safety built into the design but, in general, low voltage mains supplied (LV) fire alarm equipment does require a protective earth.

ELV systems may have one or both of the following types of earth connection:

a) Protective earth (PE), intended to protect from shock hazard anyone touching exposed conductive parts of the installation. In the event of a fault, the CPC is intended to conduct the fault current to earth, causing a final circuit protective device to operate and disconnect the supply, so preventing shock hazard;
b) Functional earth (FE), an earth provided for purposes not necessarily related to safety, but primarily a screen for electromagnetic compatibility (EMC) purposes (see Clause 28). The FE needs to have continuity throughout all relevant circuits. The FE needs to be connected according to the fire alarm equipment manufacturer's instructions. There may be more than one FE, each associated with, for example a loop, a radial circuit or an interface. Unless the manufacturer advises otherwise, each FE circuit needs to be connected to the PE at one place only. The FE might not necessarily meet the requirements of a CPC. An example of FE for loop wiring is shown in Figure 15a). Note that, in this example, the FE or screen for the loop is terminated only at the CIE, avoiding fortuitous earths and retaining separation from the FE of the ancillary circuit. An example of FE for a network is shown in Figure 15b). Note that in this example, the FE does not interconnect two equipment's, but is terminated at one only. The whole network in this example would be made up in this way.

If, according to the manufacturer's instructions, the FE and PE may be or are intended to be the same (as would normally be the case when mineral insulated copper sheathed cable is used), it may be acceptable to connect the screen to the earth at more than one point.

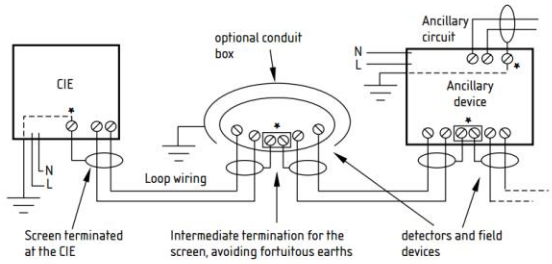
Particular care is necessary to ensure the adequacy of earthing and of protection against shock from exposed metal parts. Expert advice (for example from the equipment manufacturers) might be necessary in complex sites in which different earth potentials exist, so that electrical safety is not compromised and circulating currents are avoided.

The designer also needs to ensure that the system can be maintained safely. The mains (LV) power supply for each equipment needs to have a double pole isolation facility nearby. Maintenance is then safe from shock hazard. See 25.2.

Fire alarm power supplies need to be compliant with BS EN 54-4. If terminals for ELV circuits can be exposed, when for example a detector is removed from its base, the fire alarm power supply needs to incorporate a safety isolating transformer so that the terminals are safe to touch in dry conditions.

Addressable circuits are often sensitive to circulating currents arising from multiple earths.
Non-addressable circuits are usually less sensitive and multiple earths may be tolerated.

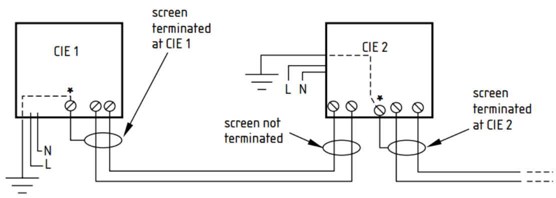
Segregation needs to be in accordance with the recommendations of 26.2l) and Clause 28 and by using cable suitable for the highest relevant voltage in the fire alarm system and in the other circuits relevant to the segregation.



* Terminals provided by the equipment manufacturer for terminating the screen

NOTE If the manufacturer's instructions differ from this example, they should be followed.

Figure 15a) — Example of system loop wiring



* Terminals provided by the equipment manufacturer for terminating the screen

NOTE If the manufacturer's instructions differ from this example, they should be followed.

Figure 15b) — Example of network conditions

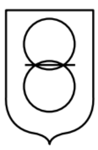


Figure 16 — Appropriate marking for the transformer, the power supply housing or the internal power sub-assembly enclosure to denote the use of a safety isolating transformer

Subsection 29.2 Recommendations

The following recommendations are applicable.

a) The system design should be such as to satisfy the relevant requirements of BS 7671. In particular, CPCs should be adequately rated.

b) The CIE manufacturer's instructions or product marking should be followed, particularly in respect of earthing arrangements.

c) LV and ELV circuits should be segregated throughout in accordance with 26.2n) and Clause 28 of this standard. In particular, if any ELV fire alarm cables share the same wiring containment with other cables, the cable insulation of the fire alarm cables should be rated for the highest voltage.

d) For ELV circuits with removable components (e.g. detectors or parts of detectors) that expose to touch conductive circuit parts at ELV potential, the following applies.

   1) All relevant power supplies for the fire detection and alarm system should conform to BS EN 54-4 and incorporate safety isolating transformers conforming to BS EN 61558. The transformer, the power supply housing or the internal power supply sub-assembly enclosure, should be marked accordingly with the appropriate symbol. The marking should be visible and easily legible when inspecting or opening the equipment (e.g. routine servicing).

      NOTE 1 Safety isolating transformers are not a requirement in BS EN 54-4, so they have been included in this standard for reasons of electrical safety.

      NOTE 2 The appropriate marking given in BS EN 61558 (parts 2 to 6 and 2 to 17) is a shield enclosing two overlapping circles with a line through the overlapping parts; see Figure 16. There are enhancements on the safety isolating transformer symbol, but the symbol shown in Figure 16 is the basic format and there may be additional parts to the symbol such as an F near the shield or lines at the bottom of the lower circle.

   2) In dry conditions, fire detectors do not have to be locked into their bases.

   3) In areas where conditions are wet, the arrangement should be one or more of the following:

      - Circuit voltages are less than 15 V ripple free d.c. or 6 V a.c. rms;
      - A tool or special technique is necessary to remove parts exposing ELV parts;
      - The parts are positioned out of reach of persons other than authorised maintenance personnel.

      NOTE 3 Wet areas include the following:

      - Locations containing a bathtub or shower basin;
      - Swimming pools;
      - Hot air saunas;
      - Agricultural and horticultural premises;
      - Abattoirs, cold stores and certain food preparation areas.

e) Means should be provided for double pole isolation of the mains supply to all parts of the system; the isolation facilities should be suitably sited, in the vicinity of the equipment served, for use by maintenance technicians without the need for access to remote parts of the building. It should be possible to lock the facilities in both the normal and isolate positions to prevent unauthorized use. See Clause 25.

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