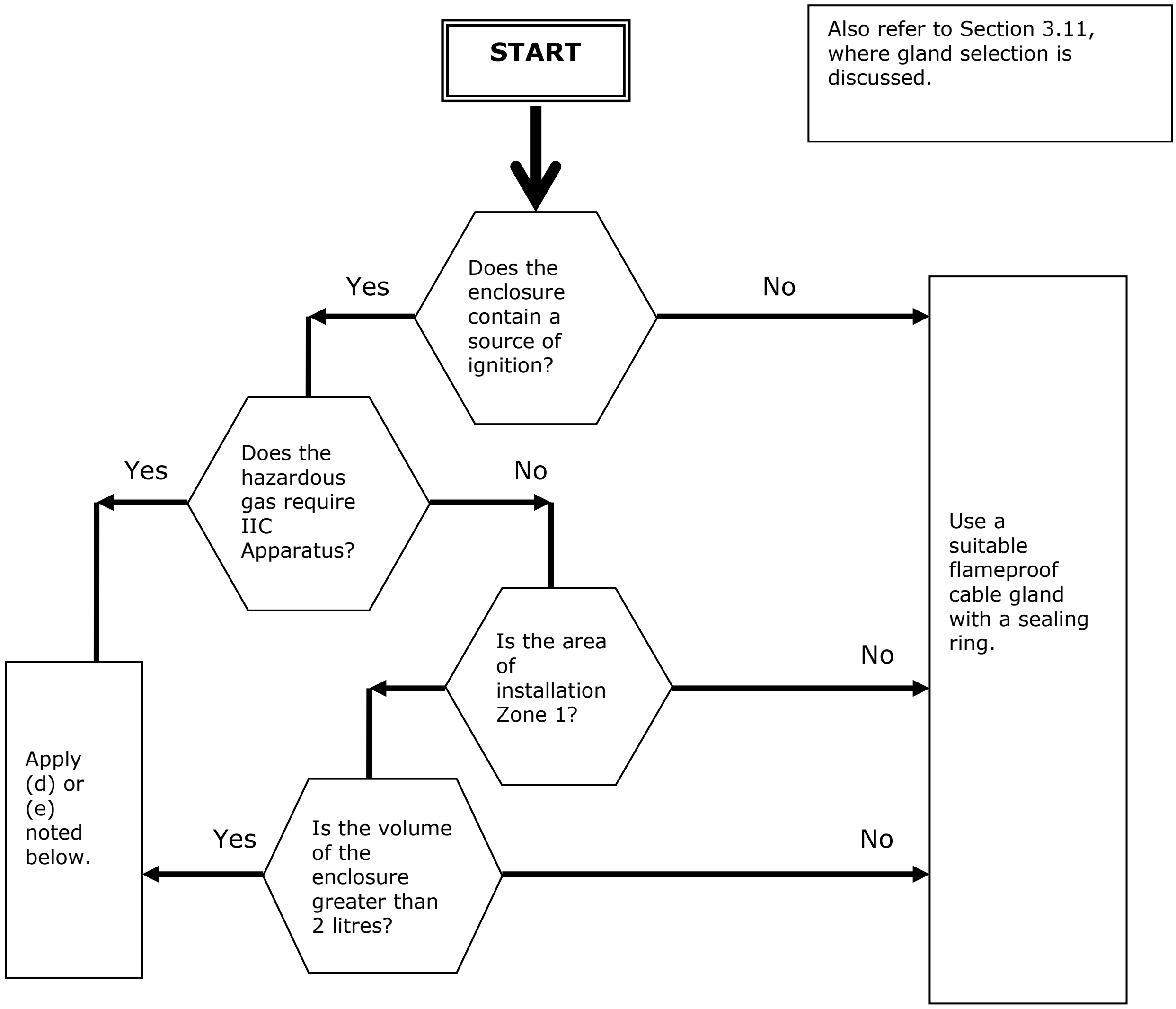

Figure 16 Selection diagram from IEC 60079-14

Notes
(a) Cable gland complies with IEC 60079-1 and the particular kind of cable intended for use with that device.
(b) Thermoplastic, thermosetting or elastomeric cable which is substantially compact and circular, has extruded bedding and the fillers, if any, are non-hygroscopic may utilise flameproof cable glands, incorporating a sealing ring as may be selected by reference to the chart above.
(c) Mineral insulated cable, with or without plastic covering, with appropriate flameproof cable gland.
(d) Flameproof sealing devices (for example a stopper box or sealing chamber) specified in the equipment documentation or having component approval and employing cable entry devices appropriate to the cable used. The stopper boxes or sealing chambers should incorporate compound or other appropriate seals which permit stopping around individual cores. Sealing devices should be fitted at the point of entry to the equipment.
(e) Flameproof cable glands incorporating compound filled seals around the individual cores or other equivalent sealing arrangements.

4.4.7.4 Terminating MICC in Ex 'd' and 'e' Enclosures

For Ex 'd' flameproof applications, a certified Ex 'd' MICC gland should be used.

Note: Currently, suitable glands appear only to be available from Pyrotenax. They are certified by BASEEFA (Certificate Number: 03ATEX0347X marked II 2GD EEx d IIC). Prior to ATEX the standard termination pot was regarded as suitable provided that the gland was an approved type where the threads formed a flame path with the enclosure body.

Terminations into an Ex 'e' enclosure required the use of the Pyrotenax 'increased safety seal' which was available for cables with one, two, three, four or seven conductors. It is not clear if the above Ex 'd' Pyrotenax MICC gland can be used into Ex 'e' enclosures. Advice should be sought from the enclosure manufacturer and/or the cable supplier.

Figures 17 and 18 indicate the parts forming a complete assembly and assembly of the pot seal respectively.

For more specific and additional details, particularly where an earth lead is required, the user is referred to the manufacturer's specific literature.

Note: Several items are to be placed over the cable before the pot seal is completed. Note also that in most situations, an external overall protection sheath is required as the first item to assemble onto the cable end.

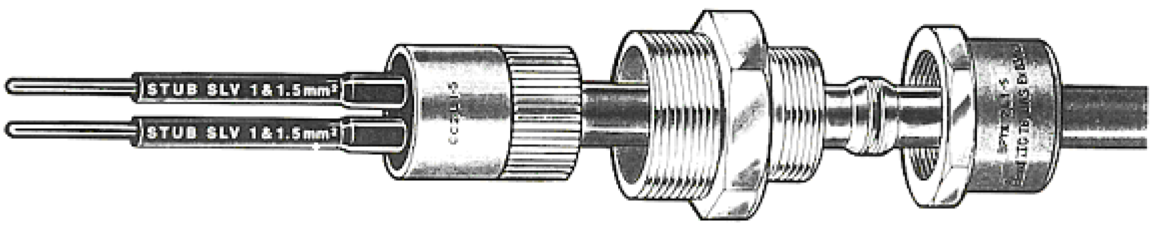

Figure 17 Component parts of an MICC Gland
With acknowledgement to Pyrotenax

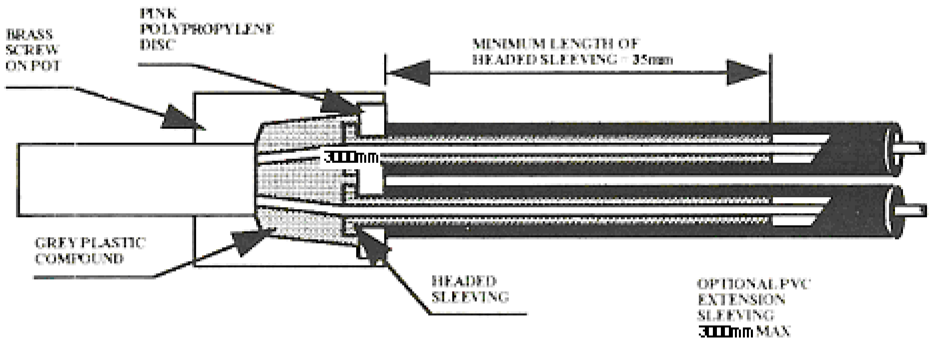

Figure 18 Section through an Ex 'e' MICC termination
With acknowledgement to Pyrotenax

For filling station use, earth tail pots are required. A separate earth continuity conductor is also required.

The suppliers' instructions should be followed in all cases.

Under exceptional atmospheric conditions, brass is subject to corrosion and plastic shrouds may disintegrate after a few years. Alternative materials for the gland parts may be available and should be specified.

Provision for re-terminating, an essential provision, is normally met by providing a loop of cable external to the terminal/junction box.

4.5 Earthing

4.5.1 Introduction

Earthing implies the establishment of an electrically continuous path from a conducting body to the conductive mass of the earth.

Bonding implies the provision of an electrically continuous connection between exposed conductive parts and/or extraneous conductive bodies, such that they are all at a substantially equal potential. The bonding system may include protective conductors, metal conduits, metal cable sheaths, steel wire armouring and metallic parts of structures. Bonding may be applied to two or more bodies without involving earth. Bodies with a robust permanent connection to earth are effectively bonded via the earth's conducting path.

Protection through earthing or bonding is only effective if the earth path resistance is sufficiently low that there is no danger from any voltage developed due to any prospective current flow.

The earth resistance value depends on the individual application. In a typical plant many items are in contact with earth, or there are fortuitous interconnections between different plant items via pipelines, structures, cable armouring, etc. These interconnections tend to nullify any attempt at providing a completely separate and independent earthing system appropriate to each installation. It is preferable to ignore fortuitous earth paths and provide earth continuity conductors for the system which are adequate for the most onerous conditions.

The required impedance of the earth loop, and therefore of the earth conductor size, depends on the maximum potential fault current available and the need to prevent conductor overheating or the development of excessive voltage drop in the earthing conductor. Values are given in later sections for lightning protection and dissipation of electrostatic energy. These are substantially higher than that required for power systems.

The procedures adopted for earthing and bonding should follow the requirements of national standards in the country of installation. In the UK, BS 7671 and BS 7430 cover the requirements for earthing and bonding of electrical systems and equipment in order to protect personnel from danger due to electric shock and also to minimise damage to electrical equipment from earth fault currents.

4.5.2 Earthing Terminology

4.5.2.1 Exposed Conductive Parts

Exposed conductive parts are parts of the electrical installation which, in the event of an equipment fault, might become live. These include motor frames, transformer tanks, switchboards, fuse boards, control stations, cubicles, etc.

4.5.2.2 Extraneous Conductive Parts

Extraneous conductive parts are any other conductive parts which might be touched by a person simultaneously with an exposed conductive part.

4.5.2.3 Earth Continuity Protective Conductor

The earth continuity protective (ECP) conductor is typically the principal earth conductor which connects back from the point of use to the supply system main earthing terminal.

The size of any earth continuity or protective conductor is based on the maximum acceptable temperature rise in the conductor under fault conditions. The size is usually determined without taking into account any earth paths through metal cable sheaths, armouring or other fortuitous earth paths. However, some companies have conducted surveys into the likely contribution from 'fortuitous paths' and have reduced their requirements for ECP conductors accordingly.

4.5.2.4 Equipotential Bonding Conductors

Equipotential bonding conductors are used to maintain extraneous metallic parts which may be touched simultaneously at substantially the same potential (usually earth). These conductors do not replace the need for an earth continuity conductor.

The cross sectional area of equipotential conductors depends on the capacity of the principal power supply in the area. This power supply would incorporate a neutral conductor and the size of the neutral is used as a basis for determining an appropriate size for the equipotential bonding conductors as follows.

Copper is subject to a minimum of 6 mm^2 and need not exceed 25 mm^2. Other materials may be used provided their conductance is equivalent. Aluminium should not be used in hazardous areas.

4.5.2.5 Supplementary Earth Bonding

Supplementary earth bonding relates to the situation where earth conductors other than copper (e.g. steel) are used to maintain earthing continuity. Welding, or solidly bolting together appropriate parts, may be adequate to provide supplementary bonding. However, if there is any danger of corrosion adversely reducing the conductivity of the connection, a supplementary copper bonding conductor should also be applied.

4.5.3 Earthing and Bonding Systems

4.5.3.1 Supply systems - Normal Earth Points

The following are normally earthed:

- on low voltage systems (i.e. below 1000 V) - the neutral (star) point of three phase generators and the star point of the secondary windings of three phase transformers;
- on extra low voltage systems - the midpoint of a secondary (single phase) winding providing a supply for portable tools and hand lamps;
- screening between transformer windings;
- one line of the secondary winding of control and instrumentation supply transformers.

4.5.3.2 Intrinsically Safe Systems and Apparatus

Special requirements exist regarding the earthing requirements for intrinsically safe systems, see Section 4.4.6 and also Section 3.6.

It is normal practice to provide a special earthing terminal for the intrinsic safety earth point. Intrinsically safe apparatus requiring an earth are connected to this point. This intrinsic safety earth has dedicated insulated earth conductors connecting back to the power system earthing terminal - not to any busbar earth point. Mechanical protection may be required.

Screened cables are often used in intrinsically safe circuits (see Section 4.4.6).

4.5.3.3 Neutral Earthing

For normal industrial applications, the method to be adopted should follow guidance given BS 7671.

4.5.3.4 PME Protective Systems Unsuitability

PME (protective multiple earthing) systems are not suitable for use in potentially explosive atmospheres. This is because, for all or part of the system, the neutral is also the earth conductor and the main earth terminal may be above true earth potential. Therefore, if it is inadvertently connected to a true earth, a spark could occur having the capability to ignite a flammable atmosphere.

Where a public utility provides a TN-S system there can be no guarantee that it is, or would remain, a truly TN-S system, in which in theory the neutral conductor is not earthed except at the supply point transformer. Safety can be increased in exceptional situations by the addition of buried earth electrodes adjacent to the point of use. Consultation with the appropriate superior authority is advised.

Section 8.11 provides additional information.

4.5.3.5 Earth Systems for Hazardous Area Earthing

Types TN-S, TT and IT earthing systems are suitable for hazardous area earthing. Types TT and IT rely on the use of several buried earthing electrodes.

Consultation with the appropriate superior authority is advised to determine type and locations.

Where the only power supply to a facility provides a TN-C or TN-C-S earthing system, this may be satisfactory in safe areas but is not suitable for hazardous areas. Provision of an isolating transformer in the non-hazardous area to provide power for the hazardous area installation may be the most appropriate solution. This may then be connected as appropriate. The earthing system can be TN-S, TT, or IT.

Note on safety: The metalwork associated with the PME supply would be connected to the neutral/earth of that supply. Under some unbalanced load or fault conditions this would be at a voltage above a true earth, such as an earthing electrode which would be used in a TT or IT earthing system.

A separation distance between metal which may be connected to the PME system and metalwork connected to earthing electrodes is required to provide safety. The separation distance should make it impossible for a person to touch both at the same time.

Section 8.11 provides additional information.

4.5.3.6 Earth Path Integrity

The integrity of the earth is maintained throughout the system via a combination of the following:

- screwed metal conduit and any joints;
- the metal sheath of mineral insulated cables;
- steel wire, tape or braid armouring of cables;
- joints made through glands;
- a separate protective conductor incorporated in an armoured flexible cable;
- a separate earthing core in any other cable;
- a separate, bare or insulated conductor of copper or steel.

4.5.3.7 Use of Aluminium Earthing Conductors

Aluminium conductors are not recommended for use in potentially explosive areas. However, if there is no alternative available, they should have a minimum cross sectional area of 16 mm^2 and have a protective insulating oversheath.

4.5.4 Earthing Continuity

4.5.4.1 Protective Conductor Size

BS 7671 quotes the following earth conductor sizes with respect to phase conductor size (see Table 21 below).

Table 21 Protective conductor size

Phase Conductor	**Earth Conductor**
up to and including 16 mm^2	same as phase conductor but not less than 2.5 mm^2 if protected, otherwise 4 mm^2
from 16 to 35 mm^2	16 mm^2
over 35 mm^2	0.5 x phase conductor size

4.5.4.2 Use of Bare Earthing Conductor

Where bare copper or steel earthing conductors are considered, a maximum temperature of 500°C is acceptable where the conductor is in a protected place and cannot be touched.

However, 500°C is not normally acceptable in zoned areas as it is greater than the ignition temperature of many gases. In tables in BS 7671 Clause 543 reference is made to earth conductor temperature. This topic is relevant to design and not installation.

As a guide only, Table 22 below gives the cross sectional areas, in mm^2, of bare earth conductors which would produce a temperature of 500°C in a normal ambient temperature, under the fault duration and current levels noted.

Table 22 Power system bare earthing conductor size (mm^2)

Material	**Fault Duration (seconds)**	**Earth Fault Current (kA)**				
		7	**14**	**35**	**44**	**70**
Copper	0.1	10	25	50	70	95
	0.2	16	35	70	95	100
	1.0	35	70	150	185	300
	3.0	50	120	250	300	500
Material	**Fault Duration (seconds)**	**Earth Fault Current (kA)**				
		7	**14**	**35**	**44**	**70**
Steel	0.1	30	60	150	200	300
	0.2	50	85	240	300	420
	1.0	90	180	450	600	900

The ignition temperature of any gas which might be in the area should have been considered during the risk assessment undertaken during the area classification procedures.

Earth fault currents of 35 kA and above are only likely to occur in the vicinity of main substations. Thus the earthing conductor sizes listed in Table 21 would only be necessary for connections to a solidly earthed substation earth bar. Such substations are normally located in non-hazardous areas.

4.5.4.3 Connecting two separate Exposed Conductive Parts

Where sheathed or protected conductors are used, they should have a conductance of not less than that of the smaller protective conductor connected to either exposed conductive parts. Where no mechanical protection is provided this minimum size in copper is 4 mm^2.

4.5.4.4 Connecting an Extraneous Conductive Part to an Exposed Conductive Part

Where sheathed or protected conductors are used, they should have a conductance of not less than half of that of the protective conductor connected to the exposed conductive part. Where no mechanical protection is provided this minimum size in copper is 4 mm^2.

4.5.4.5 Connecting two Extraneous Conductive Parts

Where one of the extraneous conductive parts is also connected to an exposed conductive part, apply Section 4.5.4.4 as above. Otherwise use a minimum of 2.5 mm^2 if sheathed or mechanically protected and 4 mm^2 if not so protected.

4.5.4.6 Connecting a Fixed Appliance via a short length of Flexible Cord

Where the connection is from an adjacent connection unit or accessory incorporating a flex outlet, the circuit protective conductor within the flexible cord should be deemed to provide the supplementary bonding conductor to the exposed conductive parts via the earthing terminal within the connection unit or accessory.

4.5.5 Lightning Protection

The earthing and bonding should comply with the regulations appropriate to the country. In the UK this is IEC 62305, which has superseded BS 6651.

Where down conductors are required they should be every 20 m of perimeter for buildings up to 20 m in height and every 10 m of perimeter for higher buildings.

Terminations, suspended conductors, external down conductors and external bonds should be 50 mm^2 in copper or galvanised steel. A heavier section may be advised for some installations, mainly for mechanical reasons.

It is recommended that, for lightning protection, the resistance to the main body of earth of any metal part of a structure should not exceed 10 Ω. This may be achieved by the normal ground contact of metal structures and storage tanks, etc. However this may not be so in all cases and at least two independent embedded earthing electrodes should be incorporated.

4.5.6 Static Electricity

4.5.6.1 Main Hazards

The main hazard from static electricity is the explosion or fire initiated by incendive electrostatic discharges. BS 5958-1 gives guidance. See also PD CLC/TR 50404.

Static electricity hazards can be created by events such as:

- the transfer of liquids to and from both metallic and non-metallic road/rail tankers, decanting of liquids into drums, IBC's (intermediate bulk containers) and other containers;
- the transfer of liquids (both conducting and non-conducting) through pipelines of either metallic (conducting) or non-metallic (high resistivity) construction;
- blending and mixing of liquid/liquid and solid/liquid when materials can become charged, with the charge quickly re-combining, either directly or via the earth, unless prevented from doing so.

4.5.6.2 Static Electricity on Personnel

BS 5958-1 notes that the volume resistivity of the body is low enough for it to be classed as a conductor of electricity.

If a person, insulated from earth, becomes charged, a body charge of about 50 kV is possible. A spark could be produced if the stored energy is discharged to earth.

When the person is wearing insulated footwear, this body charging can occur by direct contact electrification, by charge sharing with other charged objects and particularly by movement of clothing. In the UK, DSEAR requires that anti-static clothing is available and used where there is any risk from static electricity in potentially explosive areas.

4.6 Completion of the Installation

The installer has a number of further tasks to complete before signing that in the installer's opinion the task is completed in accordance with the details on the job card and other relevant documentation.

4.6.1 Advising Appropriate Bodies

The installer should have been advised, at the commencement of the work, to whom they should report.

When the installer is satisfied that they have completed the work in accordance with the job sheets, this is to be recorded and the appropriate management body or notified authority advised.

A commissioning team may then take over the task of proving that the system operates as required.

The installer may be asked to carry out a number of tests to prove earthing and continuity.

4.6.2 Compliance with Job Specification

Checks are to be made to ensure that the installation complies with the job specification and work details. Any discrepancies are to be noted and recorded.

4.6.2.1 Visual Checks on Cabling

Visual checks are to be made to ensure that cable runs are secure, cables have correct identifiers and that segregation requirements for intrinsically safe cables have been met. If work is required, then the terminals should be re-checked for correct segregation and marking.

4.6.2.2 Gland Checks

Checks are to be made to ensure that all glands fitted are appropriate, correctly fitted and tightened.

Glanding into Ex 'e' and Ex 'n' enclosures are required to meet ingress protection IP54 or better. Seal washers on the outside or thread sealant are required if the threaded gland plate is less than 6 mm thick, or the gland is not fitting squarely on the gland plate. Unthreaded gland plates require an IP seal washer or thread sealant and a lock nut inside.

4.6.2.3 Power-on Tests

In only the simplest systems would the installer apply power to the installed circuits. In contracts where the installation contractor is contracted to commission the equipment in association with the plant operators, they may undertake all the necessary power-on tests. However, where this is a requirement, all relevant permits must be completed prior to application of power.

4.6.3 Signing Off

Prior to leaving the site there are a number of duties to complete.

4.6.3.1 Re-checks

Mistakes may occur. If installer has not already done so, they should completely re-check all the equipment which they have installed to ensure conformity with the relevant documentation and written instructions. If there is reason to query any matter the appropriate superior authority should be advised.

4.6.3.2 Clear Site

All ends of cable and pieces of insulation are to be removed from site. All enclosures are to have all dropped wire ends and waste material removed.

Where scaffolding has been used, the scaffold controllers should be advised that the scaffolding is no longer required.

4.6.3.3 Surplus Equipment

All unused equipment and usable cable lengths are to be recorded and returned to safe storage.

4.6.3.4 Completion of Permits

All permits are to be signed off.

4.6.3.5 Completion of Report

All duly requested reports are to be completed and handed to appropriate authorised body.