MANUAL

# INSTRUMENT SIGNAL LINES

DEP 32.37.20.10-Gen.

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**DESIGN AND ENGINEERING PRACTICE**

## PREFACE

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## TABLE OF CONTENTS



## APPENDICES

# 1. INTRODUCTION

## 1.1 SCOPE

This DEP specifies requirements and gives recommendations for the design and engineering of instrument signal lines, with immunity from electromagnetic interference as appropriate. It covers design, material selection and installation methods for cabling the signal lines of the different systems. Cabling for transmitting digital and video signals is also covered in this DEP.

In the context of this DEP, instrument signal lines include:

a) Electric signal lines (paths), including thermo-electric voltage lines from thermocouples; lines from transmitters to their receiving instruments, auxiliaries, logic systems, controllers etc. and the lines from these to the relevant actuating elements such as solenoid valves, converters, transducers or control valves.

b) Pneumatic signal lines (paths) from pneumatic transmitters to their receiving instruments, auxiliaries, controllers and the lines from these to the relevant final control elements.

Signal lines for similar applications such as fire and gas detection and protection systems, plant communication systems, CCTV systems, plant information systems, maintenance management systems and plant security systems are also within the scope of this DEP.

This DEP is a revision of the DEP of the same number dated October 1990.

## 1.2 DISTRIBUTION, APPLICABILITY AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIOP and SIEP, the distribution of this document is confined to companies forming part of or managed by the Royal Dutch/Shell Group, and to contractors and manufacturers nominated by them (i.e. the distribution code is ‘F’ as defined in DEP 00.00.05.05-Gen.).

This DEP is intended for use in oil refineries, chemical plants, gas plants, exploration and production facilities and supply/marketing installations.

If national and/or local regulations exist in which some of the requirements are more stringent than in this DEP, the contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, economic and legal aspects. In all cases the contractor shall inform the Principal of any deviation from the requirements of this document which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the authorities concerned with the object of obtaining agreement to follow this document as closely as possible.

## 1.3 DEFINITIONS AND ABBREVIATIONS

### 1.3.1 General definitions

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

#### 1.3.2 Specific definitions

| | |
|---|---|
| **Bonding** | The act of connecting together exposed conductive parts and extraneous conductive parts of apparatus, systems or installations that are at essentially the same potential (IEC TR 61000-5-2). |
| **Cable ladder** | Above-ground, ladder-type cable tray without cover. |
| **Cavity floor** | Computer floor or false floor. |
| **Instrument earth** | Dedicated earth for instrument systems. |
| **Safety earth** | Plant safety earth. |
| **Sealing fitting** | Conduit fitting which, when filled with a suitable sealing compound, prevents transportation of flammable substances through the conduit. |
| **System cabling** | A wiring concept, consisting of cables, plugs and sockets, as detailed in DEP 32.37.20.31-Gen. |
| **Tray** | Above-ground, open cable support system, such as U-shaped flat-bottomed or ladder type. |
| **Trench** | Underground cable routing system provided with a mechanical protection on top of the cables. |
| **Trunking** | Above-ground, U-shaped cable support system with cover. It is flat-bottomed and has a top cover secured by cover clips/fasteners. |

#### 1.3.3 Abbreviations

| | |
|---|---|
| **AL/HDPE/PA** | Aluminium/High Density Polyethylene/Polyamide (nylon) |
| **CCR** | Central Control Room |
| **CCTV** | Closed Circuit Television |
| **DCS** | Distributed Control System |
| **EM** | Electro magnetic |
| **EMC** | Electro magnetic compatibility |
| **EMI** | Electro magnetic interference |
| **FAR** | Field Auxiliary Room |
| **IPF** | Instrumented protective function |
| **MDF** | Main Distribution Frame |
| **MESC** | Material and Equipment Standards and Code |
| **ROV** | Remote operated valve |
| **SWA** | Steel wire armouring |
| **SWB** | Steel wire braiding |

### 1.4 CROSS REFERENCES

Where cross references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced in this DEP are listed in (8).

# 2. ELECTRICAL CABLING

## 2.1 GENERAL

Single cables are used for signal transmission from field instruments to field mounted junction boxes. Multicore cabling will subsequently transmit the signals from the junction box to an MDF in the CCR or FAR.

Wherever possible and consistent with the design of other plant facilities, multicore cabling should be routed underground because it then has inherent protection against fire and mechanical damage. However, above-ground cabling is acceptable, subject to the Principal's approval, provided a definite cost advantage can be demonstrated, or where it is the standard local practice.

Outdoor, above-ground and underground cabling shall be provided with steel wire braiding (SWB) or steel wire armouring (SWA) to protect them against mechanical damage and for EMC reasons, even if these cables are installed in trenches / trunking or on cable trays. Underground cabling shall additionally be provided with a chemical/moisture barrier.

## 2.2 SIGNAL SEGREGATION IN MULTICORE CABLES

When electrical signals are assigned to multicore cables, the following signal segregation rules shall be followed:

- Intrinsically safe and non-intrinsically safe signals shall be segregated as required by IEC 60079-14.
- Segregation on the basis of cabling requirements may be required.

  Example: Thermocouple signals require extension cabling and thus can only be combined in one cable with signals from thermocouples of the same type.
- For practical reasons, segregation between disciplines is recommended (e.g. no signal cabling for Instrumentation and Electrical in one multicore cable).
- The supply and return conductor of a signal shall be contained in the same cable pair.
- Segregation on the basis of signal level classes shall be applied as shown in Table 1 to achieve EMC.

**TABLE 1: CLASSIFICATION OF INSTRUMENT SIGNAL LEVELS**

| SIGNAL LEVEL CLASS | SIGNAL TYPE | EXAMPLES |
|---|---|---|
| 1 | • Low energy digital systems | Computer bus signals |
| | • Analogue low level (mV signals) | Thermocouples |
| | • Analogue medium level (approx. 1V) | Resistance temperature measurements, analysers |
| 2 | • Analogue high level (e.g. 1-10 VDC, 4-20 mA) | Electronic instrumentation loops |
| | • Binary low level (below 24 VDC and below 0.5 VA) | Actuating logic systems, annunciators |
| | • Digital low level (pulse train) | Turbine meters, proximity sensors |
| 3 | • Digital high level (pulse train) | Tank gauging system |
| | • Proximitors for machine monitoring | Vibration sensors |
| 4 | • On-off medium level (< 50 V or > 0.5 VA, > 40 VA) | • 24 VDC solenoids (note 2) |
| 5 | • High level signals > 50 VAC and DC power signals higher than class 4 | • 110 VDC solenoids (note 2) |
| | • Power supply cables | • Power supply cables to instrument cabinets and field instruments |

NOTES: 1. The classification is based on the use of cables with metal screen for signal level classes 1, 2 and 3.

2. The classification is based on de-coupled solenoids to limit induction. DC solenoids shall be de-coupled with shunt diodes and AC solenoids with RC networks, connected directly across the solenoid terminals.

In addition to the above segregation rules for multicore cabling, functional segregation may be desirable for operability and maintainability reasons (e.g. segregation between process units or segregated cabling for fire and gas systems).

The design shall cater for spare capacity in multicore cabling. When the design is finalised, 10-15% of the installed cabling capacity shall be available in each signal level class and plant area to accommodate unforeseen future plant modifications.

## 2.3 SELECTION AND SPECIFICATION OF INSTRUMENT CABLES

### 2.3.1 Conductors

Solid insulated conductors should be used for instrument field cables. The minimum conductor diameter shall be 1.13 mm for single signal cables and 0.8 mm for multicore signal cables. The maximum permissible current rating and allowable voltage drop criteria shall be observed in selecting signal cables and larger conductor diameters may be required to reduce the voltage drop. Stranded wires are permitted for internal wiring inside cabinets; for connections in screw type terminals, wire crimp pins/lugs shall be applied

NOTES: 1. Cables having conductors of 0.8 mm diameter (cross section approx. 0.5 $mm^2$) have a maximum continuous current rating of 1 A per core. The fuse rating for these cables shall not exceed 4 A. The voltage drop in signal cabling shall be calculated and the available voltage at the terminals of field instruments shall be checked against the minimum requirements. If the allowable voltage drop is exceeded, a larger conductor diameter and/or a higher supply voltage shall be selected.

2. Crimped-on wire pins/lugs shall provide a gas-tight (corrosion free) connection between the crimp pin/lug and conductor in the signal cable.

3. Solid conductors should not be provided with crimp-on wire pins/lugs.

For thermocouple signals, the conductors shall consist of pairs of dissimilar materials with the correct thermo-electric voltage as a function of temperature, based on IEC 60584-3. For all other signals, the conductor material shall be copper.

For resistance thermometer elements, the conductor resistance shall be compatible with the requirements as specified by the Manufacturer of the resistance thermometer elements and/or the instrument.

Signal wires shall be twisted in pairs. The use of quad cables requires approval by the Principal.

### 2.3.2 Cable Construction

2.3.2.1 Cable construction for signal level classes 1/2/3

Instrument signal cabling for signal level classes 1, 2 and 3 of Table 1 (2.2) shall be specified with a metal screen and drain wire. Multicore cabling shall be provided with a collective screen; individual pair screening should only be applied if specifically needed for the application.

Where possible, underground cabling shall be provided with an AL/HDPE/PA inner sheathing as a moisture/chemical barrier in preference to lead sheathing.

Cable capacitance and inductance shall not invalidate the requirements for intrinsically safe or non-incendive (switched) circuits.

Unless special cabling construction requirements apply, the following cables types are recommended:

**Table 2: Recommended cable types for signals level classes 1/2/3 (note 1)**

| | **Type-1** | **Type-2** | **Type-3** |
|---|---|---|---|
| Type ID (note 2) | PE-MS-PVC | PE-MS-PE-SWB-PVC | PE-AL/HDPE/PA-SWA-HDPE |
| Application | Indoor use in a protected EM environment, such as CCR/FAR | Above-ground cabling in a plant | Underground cabling |
| Conductor insulation | PE (note 3) | PE (note 3) | PE (note 3) |
| Screen | MS | MS | AL/HDPE/PA |
| Inner sheath | - | PE | |
| Mechanical protection | - | SWB | SWA |
| Oversheath | PVC | PVC | HDPE |

NOTES:
1. Cable types correspond with those mentioned in MESC specifications 68.51/001 and 68.71/001.
2. Identification of cable construction is from the centre to the outside.
3. Cross linked polyethylene (XLPE) may be used as alternative insulation material, see MESC specifications 68.51/001 and 68.71/001.
4. Cables of table 2 are not suitable for direct connection to a low impedance source, e.g. the public mains electricity supply.
5. For full specifications of the recommended cable types, see MESC specification 68.51/001 and 68.71/001. Other cable constructions may be applied within the constraints of this DEP.
6. For multicore cellular PE-insulated telecommunication cables, based on BS 3573, see MESC specification 68.68/001.

Background to and abbreviations used, in Table 2:

| | |
|---|---|
| AL/HDPE/PA | Aluminium / high density polyethylene / polyamide (nylon), that combines overall, metal screening with inner sheathing. The aluminium acts as metal screen and moisture barrier. HDPE and PA act as chemical barriers, while PA provides also protection against termite attacks.<br>AL/HDPE/PA is a low cost and light weight alternative for lead sheathing. |
| HDPE | High density polyethylene, used as outer sheathing.<br>HDPE as outer sheathing has a good chemical resistance and water tightness, but is inflammable (acts as torch) and stiff. Furthermore, HDPE is only UV-resistant, if it is of black colour and containing carbon black. |
| MS | Metal screen with drain wire. |
| PE | Polyethylene, used as conductor insulation or inner sheathing. |
| PVC | Polyvinyl chloride, used as outer sheathing.<br>PVC as outer sheathing is UV-resistant, flame retardant and commercially attractive. |
| SWA | Steel wire armouring by a single layer of round, galvanised steel wire. |
| SWB | Steel wire braiding. |

2.3.2.2 Cable construction for signal level classes 4 and 5.

Cables for signal level classes 4 and 5 of Table 1 (2.2) shall follow the requirements for low voltage cables, as defined in DEP 33.64.10.10-Gen. The conductor cross section for signal level classes 4 and 5 shall be at least 2.5 $mm^2$.

## 2.4 CABLES FOR DIGITAL AND VIDEO SIGNALS

Microprocessor-based digital instrumentation and CCTV systems may require special cables to transmit the associated digital and video signal paths.

Digital signals can be carried by screened twisted pair cables, coaxial cables or fibre optic cables, depending on the system requirements. The choice is usually dictated by bandwidth and layout requirements.

Wherever relevant (e.g. long cable runs via lightning-unprotected areas), fibre optic cabling shall be considered for digital and video signal paths (e.g. between a CCR and FAR) to take advantage of the large bandwidth capability, inherent EM immunity and inherent intrinsic safety offered by such cabling.

## 2.5 CABLES FOR SPECIAL APPLICATIONS

Special cabling and/or earthing requirements may apply for signal transmission outside the standard 4-20 mA range. This may be the case with inline flow meters with remote electronics, machine monitoring devices, analyser systems, systems for fire and gas detection & protection and other devices with non-standard output signals.

Manufacturer's instructions with regard to cable selection, routing, termination and earthing shall be followed.

The routing of special cabling in one unbroken length from the transmitting to the receiving instrument, i.e. bypassing the junction box and MDF, should be considered.

## 2.6 PROTECTION OF CABLES AGAINST FIRE DAMAGE

In general, above-ground cabling shall be routed via low fire risk areas. However, some cabling may be exposed to fires. The cabling for certain critical duties, such as cabling in fire protection, process isolation (ROVs) and depressuring duty, shall maintain circuit integrity for a limited period of time after commencement of a fire to reduce or limit the consequences of the fire.

For cabling associated with fire safety and fire protection, see DEP 80.47.10.12-Gen., DEP 80.47.10.30-Gen. and DEP 80.47.10.31-Gen.

For cabling associated with hydraulic systems for remote operation of shut-off valves, see DEP 31.36.10.30-Gen.

For cabling associated with depressuring systems, see DEP 32.45.10.10-Gen.

Protection against fire damage may be achieved by special cabling or by fire resistant covering. For the selection of cabling requiring protection against fire damage, reference is made to DEP 33.64.10.10-Gen and MESC 68.46, 68.48 and 68.55 series.

If chemical spillage is likely to occur during fire conditions, fire resistant cabling shall also be resistant to chemical attack.

# 3. CABLE SEGREGATION, ROUTING AND INSTALLATION

## 3.1 CABLE SEGREGATION

When combining instrument cables for electrical signals in trenches/trunking and on cable trays, the following cable segregation rules shall apply:

- Redundant cabling for critical services shall be physically segregated and follow separate cable routes in the field and in the CCR/FAR (e.g. redundant highways for the DCS and redundant signal cabling for normally de-energised IPF functions, such as depressuring systems).
- Intrinsically safe and non-intrinsically safe cabling shall only be segregated if so dictated by IEC 60079-14.
- Cables of signal level class 5 (Table 1) shall be segregated from cables for signal level classes 1 through 4. Cables for signal level classes 1 through 4 inclusive may be combined in the same trench/trunking and on the same cable tray without physical separation.

NOTE: Cables of signal level class 5 are to be considered as electrical cables.

- Pneumatic tubing and fibre optic cables may be combined with any type of instrument signal cable.

## 3.2 ROUTING

The optimum cable routing and junction box locations are related to plant layout and can only be determined after equipment and piping layouts have been finalised.

Single cables connect field instruments to junction boxes and shall be supported and protected against mechanical damage by cable trunking, cable trays, steel angles, beams etc. as appropriate. Use of conduits is not favoured. Cables shall not be supported from process equipment or piping.

When selecting the above-ground routing for cables, the following aspects shall be considered:

- Constructability and cost: make optimum use of structures for process equipment, pipe racks etc. The need for special passages/ducts and crossings will also affect the route selection.
- Required cable length and associated cost.
- EMC aspects: apply cable segregation (3.1) and do not route cabling through areas classified as severe EM environments; if feasible, route cabling through areas that are protected against direct lightning strikes. Cable routing along and in the direct vicinity of earthed steel structures and piping will reduce electromagnetic interference.
- Avoid obstructing other users: layout shall not obstruct traffic or interfere with the accessibility of process equipment (pumps, compressors, motors, heat exchanger bundles, etc.).
- Accessibility: layout shall guarantee sufficient access for cable pulling and maintenance.
- Prevent cable damage: the layout shall be selected so that the cables are not prone to damage. This involves at least the following:
    - Cabling shall be routed through low fire risk areas.
    - Cabling shall not be routed in the vicinity of sample points, drains, vents, hot pipes and hot surfaces.
    - Where riser points are liable to damage by traffic, they shall be protected by free standing, sturdy mechanical structures.

For multicore cabling, underground routing is preferred as it provides excellent protection against mechanical and fire damage. The route selection for underground cable trenches shall take the following rules into consideration:

– Maintain a safe distance from power and lighting cables. For separation distances, see Appendix 1. When power cables intersect instrument signal cables, the crossing shall be at right angles, with a minimum separation distance of 0.3 m.

– Trenches shall be kept away from buried hot surfaces (e.g. pipes) so that the properties of the cable shall not be adversely affected. The minimum separation distance shall be 0.2 m plus 0.1 m for every 100 °C temperature of the non-insulated surface.

The conceptual design for the cable routing shall be submitted to the Principal for approval.

## 3.3 JUNCTION BOXES FOR MULTICORE CABLES

Junction boxes shall be located in low fire risk locations that are either electrically safe or classified as Zone 2. Furthermore, they shall be located close to the instruments they serve, to keep the single cable runs short (typically 15 to 20 m).

In the plant, stainless steel junction boxes should be applied. For signal levels classes 1, 2 and 3 of Table 1 (2.2), see Standard Drawing S 37.603.

Junction boxes should be supplied complete with terminals and accessories such as mounting rails, end plates, earth bolts, drain plug, gland plates, glands etc. All cables shall be provided with metallic glands located at the bottom of the junction box.

All terminals in junction boxes shall have facilities to protect them from accidental loosening. Terminals in intrinsically safe circuits shall be of light blue colour, terminals in non-intrinsically safe circuits shall be of the Ex ’e’ type and shall not be of blue colour.

The minimum degree of protection for junction boxes (containing terminals only) shall be IP 65 as specified in IEC 60529.

## 3.4 CABLE GLANDS

Metallic cable glands shall be used for electric signal cabling entering the housing of field instruments and junction boxes, to provide:

– a means to attach and secure the cable end;

– the type of protection to avoid ignition of a surrounding explosive atmosphere, as appropriate, according to the requirements of IEC 60079-14 or EN 50014 (if applicable), e.g. Ex ‘d’ glands are required for Ex ‘d’ enclosures;

– the required degree of ingress protection (IP code according to IEC 60529) of the instrument or junction box enclosure;

– an earthing connection for cable armouring/braiding and, if applicable, the metallic sheathing. EMC requires the cable armouring/braiding to be earthed onto the instrument/junction box housing via the metal gland by a robust, circumferential (360 degrees) connection at low impedance. Glands constructed in accordance with BS 6121-1 types C/D/E or BS 6121-3 types CK/EK provide such an earthing connection.

NOTE:

1. For instruments that are not designed for cable entry by a metal cable gland (e.g. proximitors with flying leads), the Manufacturer’s installation instructions should be followed.

2. Many cable gland suppliers provide metal glands with dual certification (Ex ‘d’ and Ex ’e’). The use of these types of glands may be considered for all applications for reasons of uniformity and variety control.

3. The practice of using a ‘litze’ wire between the cable armouring/braiding and the safety earth connection of the instrument/junction box should not be adopted as it is not suitable for the large equalising currents in the armouring/braiding. Furthermore, this technique brings magnetic fields inside the cable, instrument and junction box that were intended to be ‘Faraday cages’.

4. Cable glands for SWB cabling shall be constructed so that the grip force cannot be reduced after installation as a result of braiding settling.

5. Where cable glands should grip on steel wire braiding, this shall be specified explicitly, as most clamping rings are designed for steel wire armouring.

Where brass glands are used in atmospheres which attack the brass, the glands shall be provided with shrouds.

Cable glands on plant instruments should preferably be located at the bottom, never at the top, to prevent ingress of water. Where cable glands are installed in the side wall of the instruments, the cables shall enter from below. Cables coming from above shall first drop to below the elevation of the gland. The entry thread of the cable glands should preferably be ISO metric. Cables shall be clamped just below the cable glands to prevent excessive force on the cable gland.

## 3.5 TRUNKING AND TRAYS

Cable trunking and cable trays are intended to provide a protected routing for multicore cables from the trenches to the junction boxes. They may also contain single cables, running from an instrument to a junction box.

The trunking/tray shall be of metal construction and the sections shall be connected to each other and to instruments/junction boxes/structures by short connections at low impedance.

For EMC purposes, closed metal trunking has preference over open, U-shaped cable trays. Cable trays of the ladder type have limited EMC quality. For guidance on this subject, see IEC TR 61000-5-2, clause 7.

NOTE: The shielding capability of metal trunking is, amongst other things, used to achieve the required level of EMC. Non-metal trunking does not contribute towards EMC and is therefore not recommended. The trunking design shall be in accordance with the latest SIOP/SIEP requirements. The Principal will inform the Contractor of the applicable requirements.

Trunking/trays shall be firmly supported by structures. The strength and spacing of the supports shall take into account the weight of the cables they are designed to carry. The trunking shall be internally smooth, bolts shall be installed with the head inside and the nut outside. The cable exits from trunking should be protected by plastic or metal bushings.

Trunking constructions shall be in accordance with standard drawing S 37.604. Trunking/trays can be made of stainless steel, galvanised mild steel or painted mild steel. Galvanized steel shall not be used for cable trunking/trays or other supporting materials in the vicinity of stainless steel process equipment or piping in a fire risk area.

Note: In the event of a fire, molten zinc from galvanized metal parts may drop on stainless steel process equipment or piping, thus causing liquid metal embrittlement.

In order to prevent galvanic corrosion, non-ferrous metals shall not be in direct contact with trunking, supports etc. EMC requirements do not allow the use of insulating methods.

Welding of trunking/tray supports to structures may be considered.

The trunking/trays shall be positioned so that cables can be laid from the side of the run, instead of pulling them through consecutive holes. The free space above the trunking/tray shall be at least 0.3 m for small trays (maximum nominal width of 100 mm if accessible from one side, and 200 mm if accessible from both sides) and 0.5 m for wide trays.

To minimise mechanical stress, cabling shall be suitably fixed to trunking/trays with UV-resistant ties, especially in the vertical runs.

Trunking and trays shall be suitably sized for the number of cables they are required to carry. The final design shall cater for a minimum spare space of 30%.

Based on an average cable overall diameter of 25 mm for SWA multicore cables, Table 3 below gives the number of cables that can be accommodated by the trunking, leaving 30% spare space for the installation of future cables.

**Table 3: Number of multicore cables in trunking, leaving 30% spare space**

| | | | | | | |
|---|---|---|---|---|---|---|
| Nominal width (mm) | 50 | 100 | 150 | 200 | 250 | 300 |
| Nominal height (mm) | 50 | 100 | 100 | 100 | 100 | 100 |
| Number of multicore cables | 1 | 8 | 14 | 19 | 25 | 30 |

The curvature of trunking/tray bends and branches shall be selected so that the permissible bending radius of the cables is not exceeded. Where trunking/trays enter buildings, special measures to be taken to support the cables and to prevent ingress of water or gas.

Trunking/tray design shall be submitted to the Principal for approval.

## 3.6 TRENCHES

Underground instrument signal cables shall be laid in dedicated trenches and their routing shall be indicated by above-ground markers. Cross-sectional drawings of trenches shall show the location and laying pattern of each group of cables.

The trenches shall have such a depth that the signal cables are not damaged by traffic passing over them. Where possible, the bottom of the trench shall be kept above the ground water level, to avoid cable deterioration. For general construction details for trenches in paved and unpaved areas, refer to Appendix 2 and Standard Drawings S 19.001, S 19.002 and S 68.009. The distance between cables, as indicated on Standard Drawing S 68.009, does not apply to instrument cables of signal level classes 1 through 4: they may be laid without spacing.

The bottom of the trench shall not have a slope of more than 10 degrees and the transition of horizontal surfaces shall have a smooth curvature. Where trenches for signal cables pass under roads or below other cable trenches or pipes, protective DN 100 or DN 150 pipes or concrete ducting shall be provided to facilitate future cable laying. Such pipes/ducting shall be capped or plugged at the ends.

Particularly for cables entering buildings, a detailed proposal shall be made by the Contractor with respect to supporting the cables to prevent cable damage by soil settlement over a prolonged period.

NOTES:

1. Backfilling of the trenches shall be carried out with sand, free of stones to grade 2-5 mm, and shall contain no contaminants which may cause deterioration of the cable.

2. The top cable layer shall be covered with protective material, such as tiles, to provide mechanical protection. Alternatively plastic cover plates may be applied, provided the same degree of protection is obtained.

3. The procedure for jointing cables underground shall be submitted for approval to the Principal, detailing as a minimum the materials to be used, work method, supervision, inspection, testing and labelling.

Where large quantities of signal cables cross or branch off, the trench depth shall be increased locally.

The curvature of the corners in trenches shall be selected so that the permissible bending radius of the cables is not exceeded.

## 3.7 CABLE PULLING AND INSTALLATION ASPECTS

To prevent cable damage, cables shall not be pulled at ambient temperatures below 5 °C.

All cables in a particular trench shall be pulled in one consecutive and uninterrupted operation. When interruption is unavoidable, the trench shall be covered temporarily with steel plates.

Cables shall be installed in one unbroken length between two termination points.

NOTE: For optimum cable usage and to prevent wastage, a cable drum and cable number take-off schedule shall be prepared. This is best prepared by the construction Contractor during the construction phase.

The cables shall be laid with sufficient slack (especially at rising points) to prevent stress, in particular where trenches are made in soft soil.

All above-ground cables not installed in trunking or on trays shall be suitably supported and clamped, especially at the end. Instrument cables shall not be clamped to equipment, process piping, handrails, access ladders, structural steel etc.

Near the plant mounted instrument, a cable slack of at least 0.5 m shall be provided to facilitate termination/disconnection.

Cables connected to instruments in which there may be an internal release of flammable medium shall be sealed off with a fitting to prevent liquid/gas transport.

During plant welding operations, the electronics of adjacent instruments will be damaged if all or part of the welding current flows through the instrument. During plant construction, electric cabling should only be connected to instruments after completion of welding activities, preferably just prior to loop testing.

For fibre optic cables, the Manufacturer's instructions shall be followed with respect to termination, allowable bending radius and pulling force.

Cable trunking, trays and trenches shall be designed so that cable laying and cable pulling is possible within the allowable mechanical properties of the cable. Cable Manufacturer’s specifications shall be followed with respect to the minimum bending radius and pulling force of the cables.

## 3.8 CONTROL ROOM/AUXILIARY AREAS

The control room and auxiliary areas shall be fitted with cavity floors, designed to allow for cable segregation. The cabling shall enter the buildings through proper sleeves that are made fire resistant and waterproof and are in compliance with EMC requirements.

NOTE: The limited access under the cavity floor makes the installation of cable trays impractical. Cables should be segregated in bundles on the basis of the segregation rules given in (3.1).

When the design is finalised, the cable entry in buildings shall have at least 20% spare space to accommodate additional cables for unforeseen future plant modifications.

When a cellar type of auxiliary room is used with the control room above it, the interconnecting cabling shall be routed through riser cabinets, connecting the cavity floors of these rooms.

All signal, power and earthing cables shall be routed and connected via the cavity floor and shall enter cabinets from the bottom. Cabinets/racks shall not be placed against the walls of auxiliary rooms.

The bottom of the cabinets shall be sealed to prevent dust entry from the cavity floor into the cabinets.

Signal marshalling shall take place in MDF cabinets only; system cabling (see DEP 32.37.20.31-Gen.) shall interconnect MDFs and instrument cabinets. An MDF cabinet typically consists of:

- rows of test/disconnect terminals for termination of field cables;
- rows of socket boards into which auxiliary room wiring is connected via system cables;
- cross wiring between field terminals and socket board terminals for signal marshalling.

Remote input/output cards of systems, such as DCS, may also be located in MDFs.

Thermocouple compensation cable shall be used up to the device where the cold junction compensation resides (usually the input card).

Instrument cabinets shall be designed to terminate the full capacity (including spare capacity) of the cabinet on system cables, organised in a logical fashion (input/output card channels modularly into system cables). Thus any input or output from any instrument cabinet shall be marshalled at the MDFs only. The final design of instrument cabinets shall provide a minimum of 20% spare capacity.

Cable glands are not required for cable terminations in control/auxiliary room cabinets. Cables shall be suitably anchored with clamps and fixtures to take their weight and for EMC purposes, before connecting them to terminals or sockets.

# 4. EARTHING AND BONDING

## 4.1 GENERAL

Earthing systems are the responsibility of the Electrical Engineering discipline and provisions for earthing are covered by DEP 33.64.10.10-Gen.

This Section identifies aspects affecting personnel safety and proper functioning of instruments and instrument systems.

The number of earthing types should be limited to two, i.e.:

- Safety earth
- Instrument earth

For a typical configuration of a safety earth and instrument earth system at the FAR/CCR, refer to standard drawing S 68.030 and Appendix 3. Instrument earth cables shall connect the instrument earth bar to MDFs and instrument cabinets, using one cable for each MDF/cabinet. The cross-sectional area of these cables shall be at least 6 $mm^2$ and the terminal insulation colour shall be yellow/black. Each instrument earth cable shall be properly identified at the side of the instrument earth bar, showing the MDF/cabinet number it is connected to.

NOTE: Earthing bolts shall have a diameter of at least 10 mm.

Some Manufacturers require a dedicated earth: Manufacturers' recommendations on the arrangement of earthing and maximum allowable resistance to earth should be followed.

Requirements for earthing and bonding of enclosures containing electric and electronic components may be dictated by local regulations (e.g. European standards associated with CE-marking). Where this is not the case, international standards such as IEC TR 61000-5-2 should be followed.

## 4.2 CONNECTIONS TO THE EARTHING SYSTEMS

### 4.2.1 Connections to instrument earth

Screens of instrument signal cables shall be connected to the instrument earth by the 'star' method. Screens shall be insulated from cable armouring/braiding/metal sheathing, instrument enclosures and metal structures. Refer to Appendices 3 through 5.

Screens shall be earthed at one point only:

– For screened cables between the field and the CCR or FAR, the screens shall be earthed at the MDF in the CCR/FAT. The screen shall be insulated at the field instrument side. Dedicated terminals in junction boxes shall connect the screens of single and multicore cables. These terminals shall be insulated from safety earth.

NOTE: 1. Most field instruments do not have insulated connection facilities for the screen. The screen shall be insulated with a protective sleeve and left unconnected, with the same length as the signal wires. This creates the possibility for checking interconnections between the two earth systems.

2. For (special) screened cabling running directly from the field instrument to the receiving instrument (i.e. bypassing junction box and MDF), the screen shall be earthed at the receiving instrument end only.

– For screened cables between the CCR and FAR, the screens shall be earthed at the MDF in the CCR.

– For screened system cabling running inside the FAR or CCR, the screens shall be earthed at the MDF.

– If screened cabling is run between two MDFs or between two instrument cabinets, the 'star' method requires the screen to be earthed at one of the MDFs/cabinets only.

### 4.2.2 Connections to safety earth

Steel wire armouring, steel wire braiding and metal sheathing of cables shall be connected to safety earth, at least at both ends.

For typical safety earthing installation details, refer to Appendices 3 through 5.

Instrument housings, junction boxes, local panels and local cabinets shall be bonded to cable trunking/steel angles etc. In addition, earthing or mounting bolts of instrument housings shall be fitted with two shark rings to allow low resistance bonding to plant structures/safety earth. Junction boxes, local panels and local cabinets shall be provided with an earthing bolt to enable a proper earthing connection to plant structures/safety earth.

Any outside earthing connection shall comply with IEC 60079-0.

## 4.3 EARTHING OF INTRINSICALLY SAFE CIRCUITRY

Safety barriers should preferably be connected to safety earth or alternatively to a dedicated earth bar, connected to safety earth.

## 4.4 EARTHING OF CAVITY FLOORS

A 1.20 x 1.20 m safety earth grid is required for cavity floors, consisting of bare copper stranded wires with a minimum cross section of 16 $mm^2$, connected to the cavity floor construction. The grid shall be connected to the safety earth ring at a maximum spacing of 5 m.

# 5. LIGHTNING PROTECTION OF INSTRUMENTATION

## 5.1 GENERAL

The lightning protection for instruments described in this Section assumes that plants are equipped with lightning protection as specified in DEP 33.64.10.10-Gen.

Protective measures shall not adversely affect the protection of the instrument or instrument system against ignition of a surrounding explosive atmosphere.

Protective measures against lightning are subject to the approval of the Principal.

## 5.2 INSTRUMENTATION AND CABLING IN THE FIELD

### 5.2.1 Instruments and cabling inside "Protected" areas.

Where feasible, instruments and cables should be located/routed so that some degree of protection is obtained from earthed structural steel and dedicated lightning conductors. Instruments and cabling installed in such a "protected" area are protected against direct discharges to earth.

Together with common installation practices such as the use of twisted conductor pairs, screening, armouring/braiding and proper earthing, no additional protection should be required to abate the induction effect.

### 5.2.2 Instruments and cabling outside "Protected" areas.

During detailed engineering, instruments and cabling located outside protected areas (5.2.1) shall be identified, as lightning protection is required in addition to the common installation practices mentioned in (5.2.1). This may include instruments and cabling located at high points (e.g. instruments on the top of process equipment, cabling installed on top of pipe racks) or in open areas (e.g. tank farms).

Instruments located outside protected areas and instruments connected to cables that are routed outside protected areas shall be provided with protective lightning arrestors at both ends of the transmission line.

NOTES:

1. A lightning arrestor shall consist of a gas tube/varistor/zener diode combination approved by the Principal. Devices with fuses shall not be applied.

2. For field instruments such as tank level gauges, telemetry systems, local multiplexers, etc. advice on lightning protection should be obtained from the instrument Manufacturer.

Long communication lines should preferably use fibre optic cabling. If coaxial or twisted pair cabling is applied, galvanic isolation should be used.

# 6. PNEUMATIC TUBING

## 6.1 GENERAL

Single tubing shall be used for signal transmission from field instruments to field mounted junction boxes. They shall be routed above ground through low fire risk regions and shall be provided with some form of protection against mechanical damage. Multicore tubing will subsequently transmit the signals from the junction box to an MDF in the CCR or FAR.

Wherever possible and consistent with the design of other plant facilities, multicore tubing should be routed underground because it then has inherent protection against fire and mechanical damage. However, the use of above-ground tubing is acceptable, subject to the Principal's approval, provided a definite cost advantage can be demonstrated, or where it is standard local practice.

The design shall cater for spare capacity in multicore tubing. When the design is finalised, 10-15% of the installed tubing capacity shall be available to accommodate unforeseen future plant modifications.

Tubing in fire protection and depressuring duties requires protection against fire damage.

The design intent of (2.6) and (3) for electrical signal lines applies equally to pneumatic signal lines, except for electrical aspects.

## 6.2 SELECTION AND SPECIFICATION OF TUBING

All tubing cores shall have an outside diameter of either 6 mm or 0.25 inch, as advised by the Principal. For recommended tubing types, see Table 4 below.

**Table 4: Recommended tubing types**

| **Type** | **Service** (note 1) | **Tube material** | **Sheath** | **Outer colour** | **MESC numbers** 6 mm OD | **MESC numbers** 0.25 inch OD |
|---|---|---|---|---|---|---|
| Single | Indoor | PE | - | Black | 74.86.60.101.1 | 74.86.60.001.1 |
| | | Copper | - | - | 74.66.22.264.1 | 74.66.22.244.1 |
| | Outdoor above ground only | Copper | PVC | Black | 74.66.22.364.1 | 74.66.22.354.1 |
| 7-core | Indoor | PE | PVC | Black | 74.86.60.250.1 | 74.86.60.225.1 |
| | | Copper | PVC | Black | 74.66.22.607.1 | 74.66.22.407.1 |
| | Outdoor above and under-ground | PE | PVC and lead (note 2) | Black | 74.86.60.260.1 | 74.86.60.230.1 |

NOTES: 1. Indoor service includes field cubicles and enclosed field panels.

2. Lead sheathing may be replaced by another type of suitable sheathing.

Background to and abbreviations used, in Table 4:

PE Polyethylene, used as tube material.

PVC Polyvinyl chloride, used as outer sheathing.
PVC as outer sheathing is UV-resistant, flame retardant and commercially attractive.

## 6.3 JUNCTION BOXES FOR MULTICORE TUBING

Pneumatic junction boxes shall be located in low fire risk locations and close to the instruments they serve, to keep the single tubing runs short (typically 15 to 20 m).

Tubing shall enter via adapter plates. Any transition from plastic to copper tubing shall be accomplished by means of bulk head connectors mounted on the side walls of the junction box.

## 6.4 INSTALLATION

All fittings shall be brass or plastic, of the compression type and be suitable for the size and material of the tubing. Refer to MESC series 76.40.xx.xxx.1.

Where air lines leave trunking, bulkhead unions shall be applied. If feasible the bulkhead unions should be of the angle type. If tubing serves instruments without instrument air supply (e.g. to a control valve not having a positioner or booster), the tubing shall be clamped to a 25 mm dummy pipe or angle iron firmly attached to a structure.

# 7. IDENTIFICATION AND MARKING

## 7.1 IDENTIFICATION OF SYSTEM CABLES

Each system cable (see DEP 32.37.20.31-Gen.) should have a unique identification of the format:

c-SC-x

whereby

| | |
|---|---|
| 'c' | A two-digit number used to identify the relevant MDF. |
| 'SC' | Abbreviation for System Cable. |
| ‘x’ | A three-digit number used to identify the system cable termination board/block number at the MDF. |

## 7.2 IDENTIFICATION OF SINGLE CABLES/TUBING

Each single cable or tube should have a unique identification, linked to the associated instrument, e.g. 120FT-101 and 120FCV-101 are single cables in loop 120F-101 for the transmitter and control valve respectively.

## 7.3 IDENTIFICATION OF MULTICORES AND JUNCTION BOXES

Each instrument multicore signal cable, other than a system cable, and multicore pneumatic tubing should have a unique identification of the format:

a-bi-y

Junction boxes should have a unique identification of the format:

a-Jbi-y

whereby:

'a' — A two or three digit number is used to identify the process unit. It should be similar to the ‘a’ used for instrument tag number assignment, see DEP 32.31.00.32-Gen.

‘J’ — Abbreviation for junction box

'b' — Letter code to identify the service and/or signal type, as follows:

- D Cabling for Data transmission, such as telecommunication, data transmission lines, LAN systems, etc.
- E Electric multicore cabling, except system cabling and cabling covered by one of the other codes. This includes multicore cabling for signals to/from measuring elements, transmitters, transducers, valve positioners, solenoid operated valves.
- P Pneumatic tubing.
- Q Cabling for Quality measurement signals.
- S Field cabling for Special applications, such as off-plot cables.
- T Thermocouple extension cabling.
- X Special cabling such as fibre optic cables, coaxial cables, etc.

‘i’ — Letter ‘I’ , to be used only if the cabling contains intrinsically safe circuits.

‘y’ — A three digit serial number, starting from 101 for each unique ‘a-b’/’a-Jb’ combination. The serial number is related to the junction box number.

Example:
In unit 1200, a junction box is installed with intrinsically safe circuitry. The junction box is identified as 120-JEi-123 and the multicore cable as 120-Ei-123.

## 7.4 MARKING

Signal conductors should be individually marked on each termination side with the corresponding terminal number.

NOTE: If multicore cables are fitted which have a colour coding according to BS 5308-1/2 or another standard numbering, e.g. according to IEC 60304, the Principal may waive the requirement for marking the individual conductors.

Instrument tubing shall be marked with the instrument tag number at the point of connection to the multitube.

Junction boxes shall be identified with an engraved nameplate of synthetic material. For details of nameplate requirements, refer to DEP 32.31.00.32-Gen. and Standard Drawing S 37.601.

Cable and tubing markers shall show at least the cable/tubing number.

Underground cables and tubing shall be marked at intervals of approximately 5 m by means of lead or stainless steel strips. For long cable stretches (e.g. alongside roads or in tank farms), marking at 10 to 15 m intervals may be sufficient.

Above-ground cables and tubing should be marked at their termination points (outside the instrument and junction box) with a suitable label of engraved or embossed material.

## 8. REFERENCES

In this specification reference is made to the following publications.

NOTE: Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.

**SHELL STANDARDS**

| | |
|---|---|
| Index to DEP publications and standard specifications | DEP 00.00.05.05-Gen. |
| Index to standard Drawings | DEP 00.00.06.06-Gen. |
| Hydraulic systems for remote operation of shut-off valves | DEP 31.36.10.30-Gen. |
| Instruments for measurement and control | DEP 32.31.00.32-Gen. |
| System cabling | DEP 32.37.20.31-Gen. |
| Instrumentation for depressuring systems | DEP 32.45.10.10-Gen. |
| Electrical engineering guidelines | DEP 33.64.10.10-Gen. |
| Water-based fire protection systems for offshore facilities | DEP 80.47.10.12-Gen. |
| Assessment of the fire safety of onshore installations | DEP 80.47.10.30-Gen. |
| Active fire protection systems and equipment for onshore facilities | DEP 80.47.10.31-Gen. |
| Material and Equipment Standards and Code, issued by Shell Services International (SSI) | MESC |

**BRITISH STANDARDS**

| | |
|---|---|
| Specification for polyolefin copper conductor telecommunication cables. | BS 3573 |
| Instrumentation cables,<br>Part 1: Specification for polyethylene insulated cables. | BS 5308-1 |
| Instrumentation cables,<br>Part 2: Specification for PVC insulated cables. | BS 5308-2 |
| Mechanical cable glands,<br>Part 1: Specification for metallic glands | BS 6121-1 |
| Mechanical cable glands,<br>Part 3: Special corrosion resistant glands | BS 6121-3 |
| Code of practice for protection of structures against lightning | BS 6651 |

*Issued by:*
*British Standards Institution*
*389 Chiswick High Road*
*London W4 4AL*

*England United Kingdom*

**EUROPEAN STANDARDS**

| | |
|---|---|
| Electrical apparatus for potentially explosive atmospheres: General requirements | EN 50014 |

*Issued by:*
*CENELEC, European Committee for Electrotechnical Standardization*
*2 Rue Bréderode, B-1000 Brussels, Belgium*

**INTERNATIONAL STANDARDS**

| | |
|---|---|
| Electrical apparatus for explosive gas atmospheres, Part 0 : General requirements | IEC 60079-0 |
| Electrical apparatus for explosive gas atmospheres, Part 14: Electrical installations in explosive gas atmosphere (other than mines) | IEC 60079-14 |
| Standard colours for insulation for low-frequency cables and wires | IEC 60304 |
| Degrees of protection provided by enclosures (IP Code) | IEC 60529 |
| Thermocouples Part 3: Extension and compensating cables - Tolerances and identification system | IEC 60584-3 |
| Electro Magnetic Compatibility(EMC) | IEC 61000 series |
| Electro Magnetic Compatibility(EMC) Part 5: Installation and mitigation guidelines Section 2: Earthing and cabling | IEC TR 61000-5-2 |

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*Central Office of the IEC (Sales Dept)*
*3, Rue de Varembé*
*1211 Geneva 20*
*Switzerland.*

*Copies can also be obtained from national standards organizations*

**STANDARD DRAWINGS**

*NOTE: The latest edition of Standard Drawings can be found in DEP 00.00.06.06-Gen.*

| | |
|---|---|
| Electrical and instrument cable trenches in concrete paved areas | S 19.001 |
| Cable routing in unpaved, brick-paved or tiled areas and crossing roads | S 19.002 |
| Instrument nameplates | S 37.601 |
| Junction box construction | S 37.603 |
| Instrument cable trunking | S 37.604 |
| Typical arrangements of cable trenches in plant areas | S 68.009 |

| | |
|---|---|
| Typical earthing arrangements for substations, control buildings and field auxiliary rooms and associated typical mounting details. | S 68.030 |

## APPENDIX 1 DISTANCE BETWEEN CABLE TRENCHES

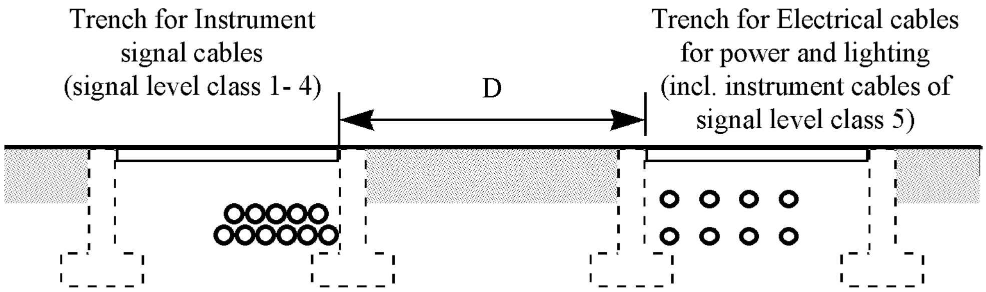
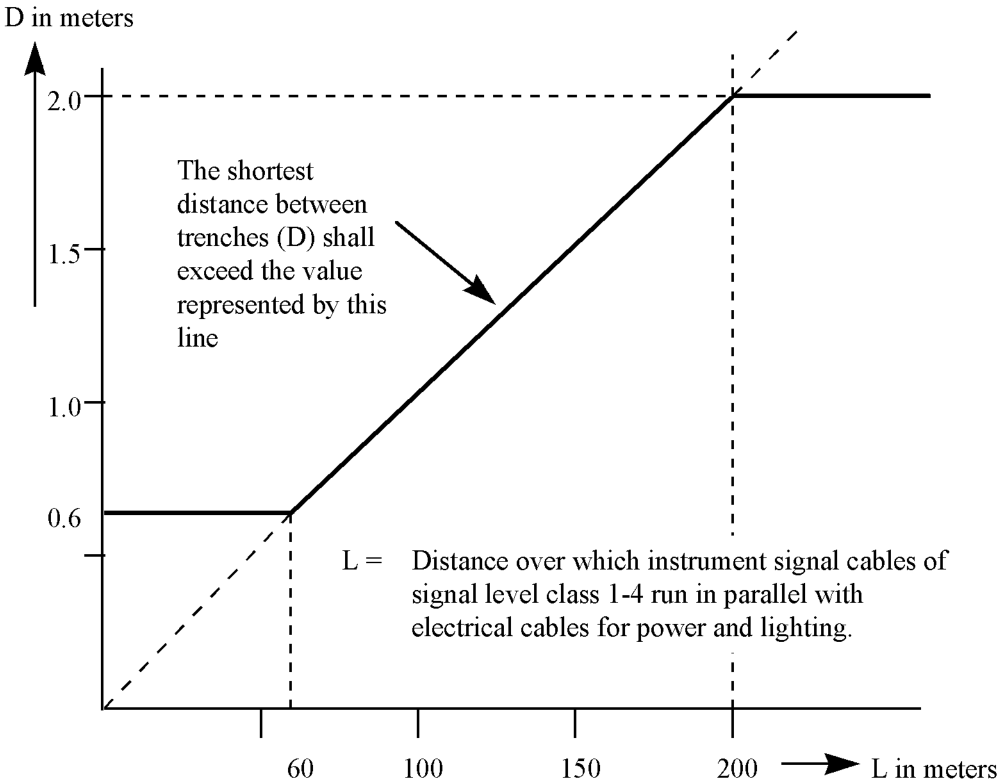



Figure 1-1: Distance between cable trenches




Graph 1-1: Distance between cable trenches

**APPENDIX 2 ARRANGEMENT OF CABLE TRENCHES**

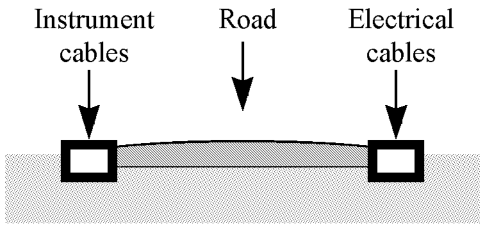



Figure 2-1: Cables in roadside

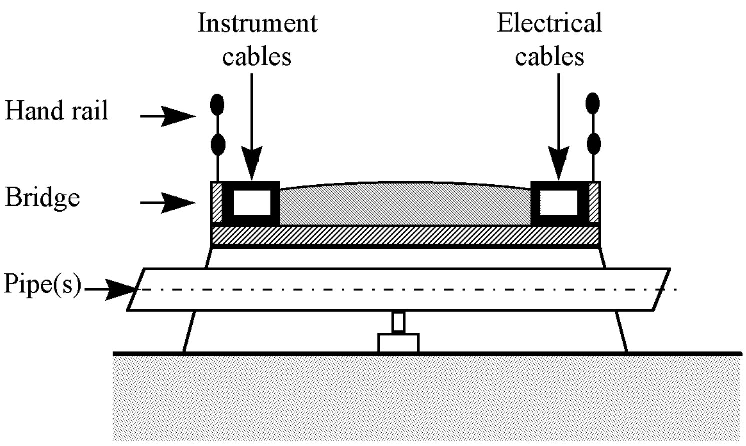



Figure 2-2: Cables in bridge, crossing pipe track

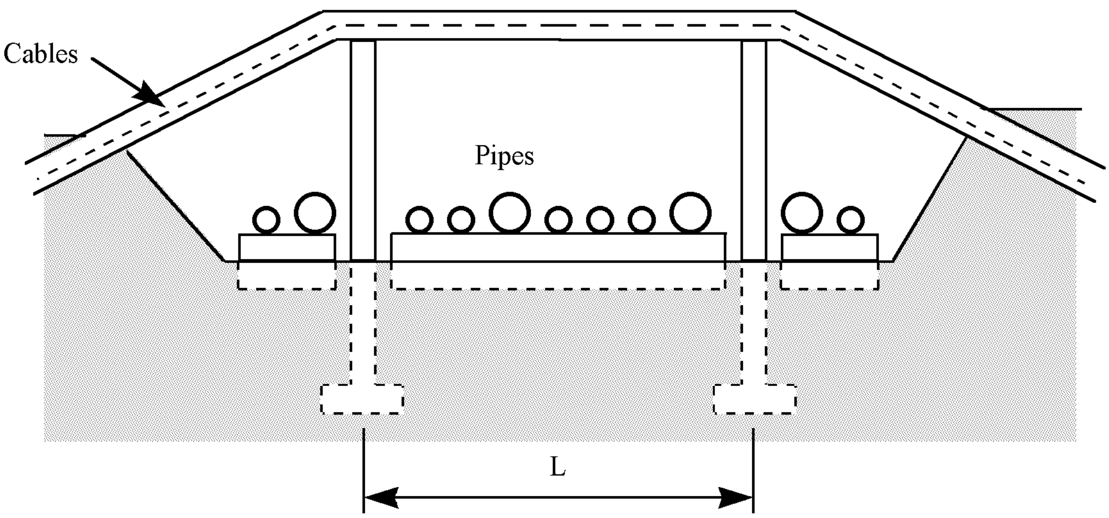



Figure 2-3: Cable trench crossing pipe trench

Note 1: Deflection to be limited to 1/200 of L

Note 2: Supports for trenches shall be separate from sleepers for pipes

**APPENDIX 2 ARRANGEMENT OF CABLE TRENCHES (Continued)**

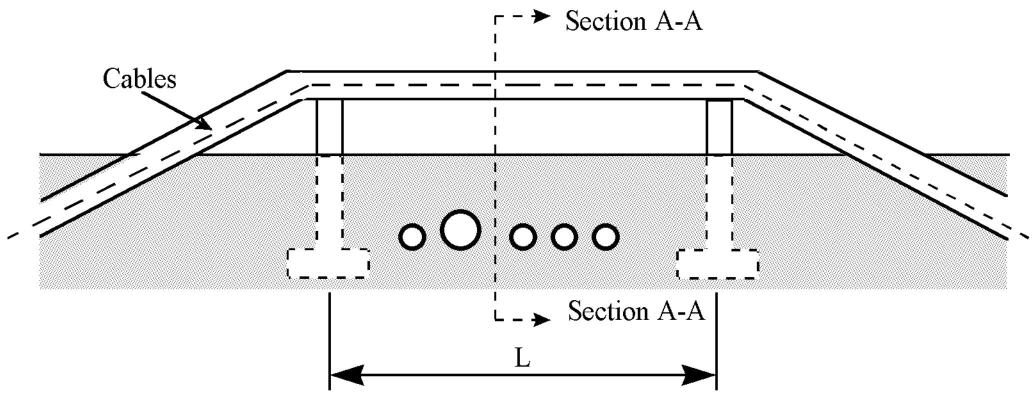



Figure 2-4: Cable trench crossing buried hot pipes
Note: Deflection to be limited to 1/200 of L

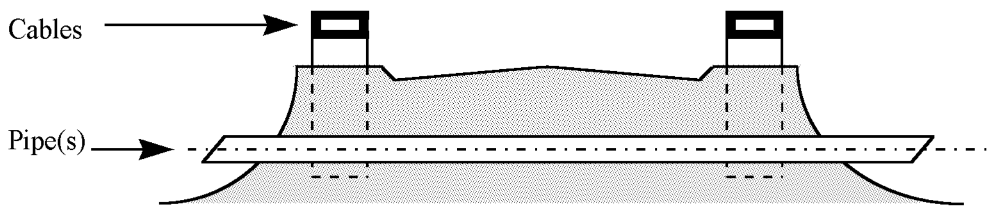



Figure 2-5: Section A-A

## APPENDIX 3 TYPICAL EARTHING AT FAR/CCR

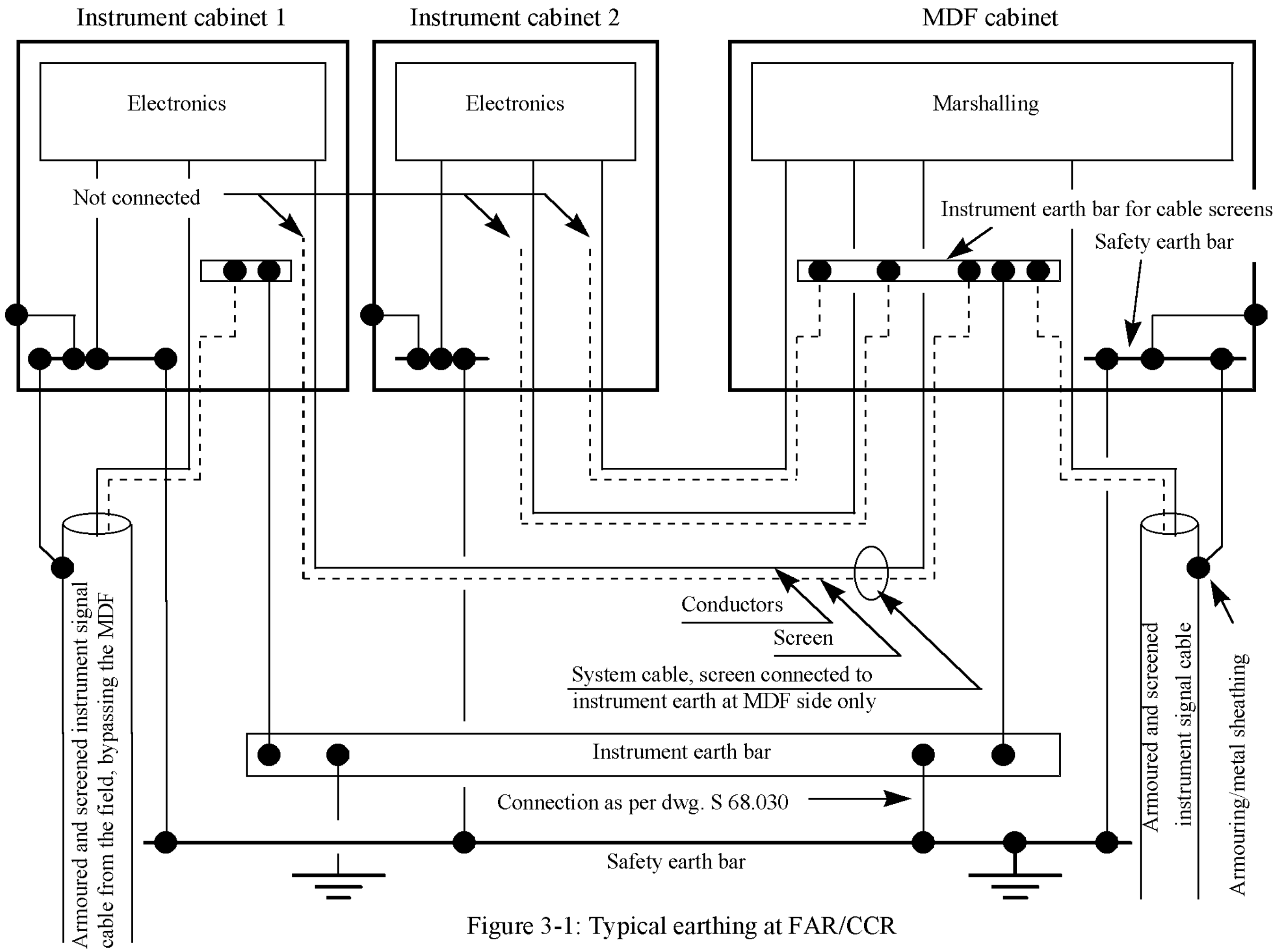



Figure 3-1: Typical earthing at FAR/CCR

## APPENDIX 4 TYPICAL EARTHING OF INSTRUMENT SIGNAL CABLES IN THE FIELD

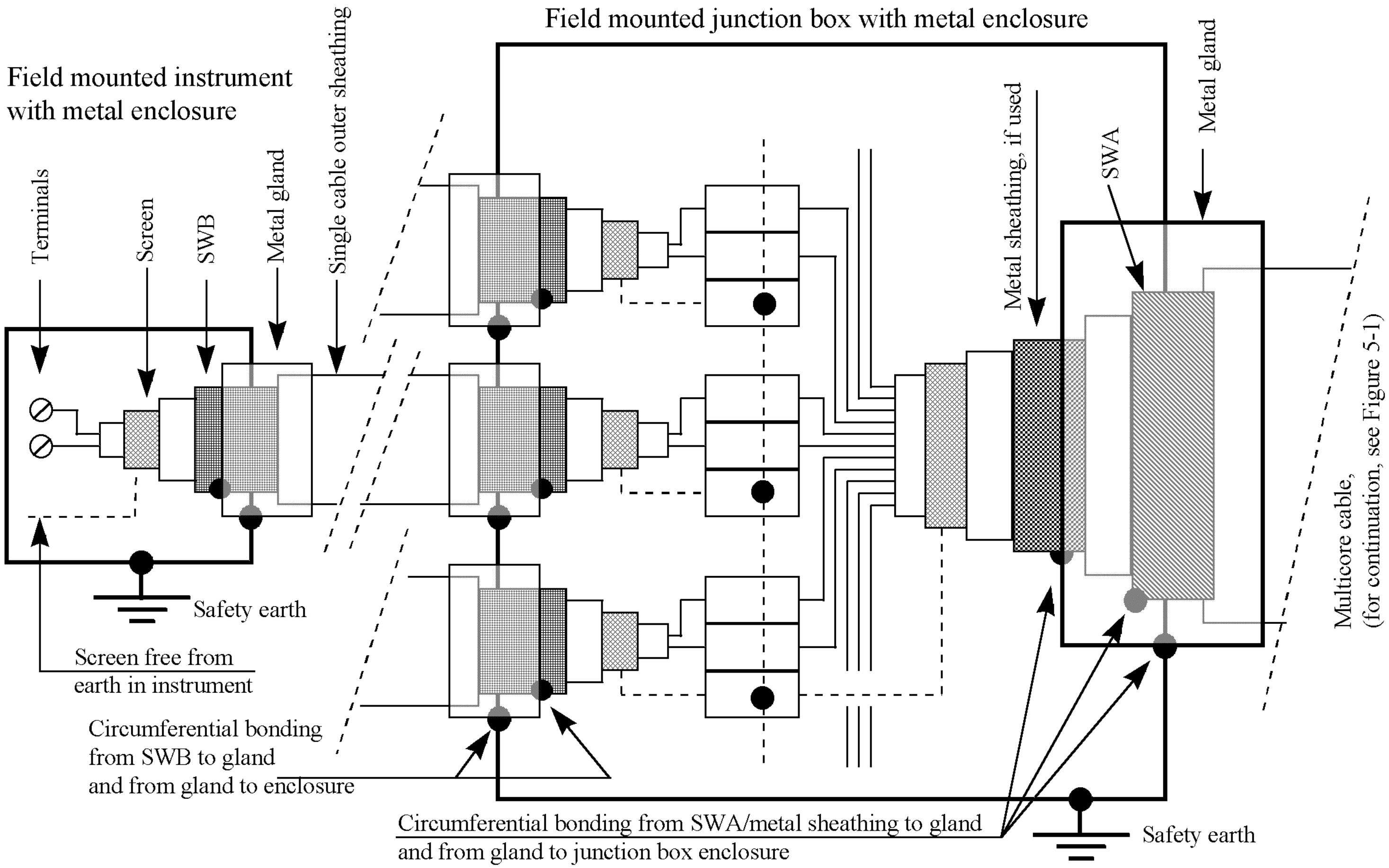



Figure 4-1: Typical earthing of instrument signal cables in the field

## APPENDIX 5 TYPICAL EARTHING OF INSTRUMENT SIGNAL CABLES IN THE MDF

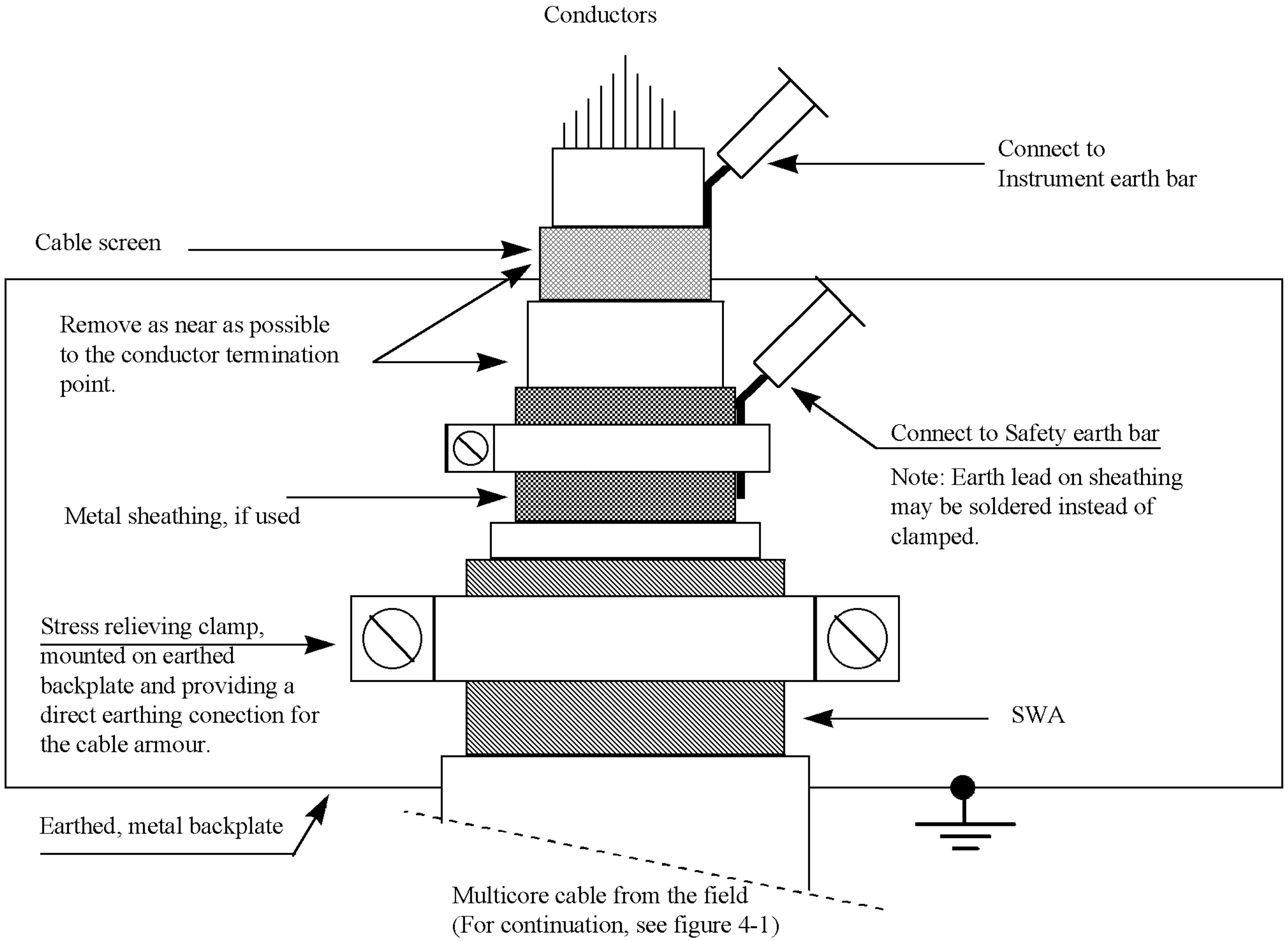



Figure 5-1: Typical earthing of signal cables in the MDF