

Session 13 – Wiring Methods & Cable Standards



NORSOK Standards

The NORSOK standards are developed by the Norwegian petroleum industry to ensure adequate safety, value adding and cost effectiveness for petroleum industry developments and operations. Furthermore, NORSOK standards are as far as possible intended to replace oil company specifications and serve as references in the authorities regulations. Key Norsok Standard to reference are below:

- I-001 – Field Instrumentation
- I-002 – Safety and Automated Systems
- **E-001 – Electrical Systems**
- H-003 – HVAC Systems
- S-001 – Technical Safety
- R-001 – Mechanical Equipment



- 1 Scope
- 2 Normative and informative references
- 3 Terms, definitions and abbreviations
- 4 General requirements and conditions (see IEC 61892-1)
- 5 System design (see IEC 61892-2)
- 6 Equipment (see IEC 61892-3)
- 7 Cables (see IEC 61892-4)
- 8 Mobile units (see IEC 61892-5)
- 9 Installation (see IEC 61892-6)
- 10 Hazardous areas (see IEC 61892-7)
- Annex A (Normative) Data sheets
- Annex B (Informative) Typical installation drawings

Notice that NORSOK has used the relevant IEC standards which are referenced above and expanded on these standards specifically around the Norwegian Offshore Market.

NORSOK STANDARD

E-001
Edition 5, July 2007

Electrical systems

This NORSOK standard is developed with broad petroleum industry participation by interested parties in the Norwegian petroleum industry and is owned by the Norwegian petroleum industry represented by The Norwegian Oil Industry Association (OLF), The Federation of Norwegian Industry, Norwegian Shipowners' Association and The Petroleum Safety Authority Norway. Please note that whilst every effort has been made to ensure the accuracy of this NORSOK standard, neither OLF nor The Federation of Norwegian Industry or any of their members will assume liability for any use thereof. Standards Norway is responsible for the administration and publication of this NORSOK standard.

Standards Norway
Strandveien 18, P.O. Box 242
N-1326 Lyseaker
NORWAY
Copyrights reserved

Telephone: + 47 67 83 86 00
Fax: + 47 67 83 86 01
Email: petroleum@standard.no
Website: www.standard.no/petroleum

NORSOK E-001 Example

NORSOK standard E-001

Edition 5, July 2007

10.2 Electrical equipment (see IEC 61892-7, Clause 6)

10.2.1 General

Requirements for equipment are stated in IEC 61892-7, Clause 6.

All Ex equipment shall have the ex labelling located so they are readable also when installed on site. Labels shall be designed and fastened to withstand environmental stresses (included high pressure cleaning with salt water) for the certified equipments expected lifetime.

10.2.2 Ex requirements

Ex-certified equipment should be selected in accordance with the following:

- Ex i and Ex e should be used;
- Ex n may be used in zone 2;
- Ex d and Ex p should be avoided. For motors, see Table 10:
However, if Ex d equipment is used, it should be provided with an Ex e indirect entry. Compression type Ex d gland may be accepted if the equipments ATEX certificate cover gland and installed cable type, actual gas group and Ex d compartment volume (normally under 2 litre). Reference is made to figure 1 in IEC 60079-14. Ex d compression glands shall be of the type where the braid is terminated in the gland and compression takes place on inner cable sheath.
- Equipment, which shall remain energised after an APS/ESD situation, should follow the requirements specified in NORSOK S-001.

10.2.3 Electrical apparatus with type 'n' protection

Ex n equipment shall be marked according to IEC 60079-0 and IEC 60079-15 and have a test certificate from a test institution recognized at national level.

10.3 Installation (see IEC 61892-7, Clause 7)

In hazardous areas conduit systems (see IEC 61892-7, 7.5.1) with drawn-in insulated conductors are not permitted.

NOTE The requirement means that "American conduit systems" among others is not permitted in hazardous areas. However, use of conduits as mechanical protection for cables is permitted.

For package equipment it may also be accepted to use vendor standardized conduit system if alternative cable installation is not recommended.

However, such installation shall end in a termination box designed to a connect conduit system to a cable system. The total installation shall be certified and fulfil requirements according to IEC 61892 (all parts).

10.4 Documentation (see IEC 61892-7, Clause 10)

10.4.1 Apparatus (see IEC 61892-7, 10.3)

The following additional documentation shall be delivered together with non standard Ex equipment:

- Ex-certificate issued by certified body;
- individual test certificate showing delivered variation;
- drawings and list of apparatus when relevant showing all components covered by the actual certification;
- any special conditions regarding installation, operation and maintenance of the equipment.

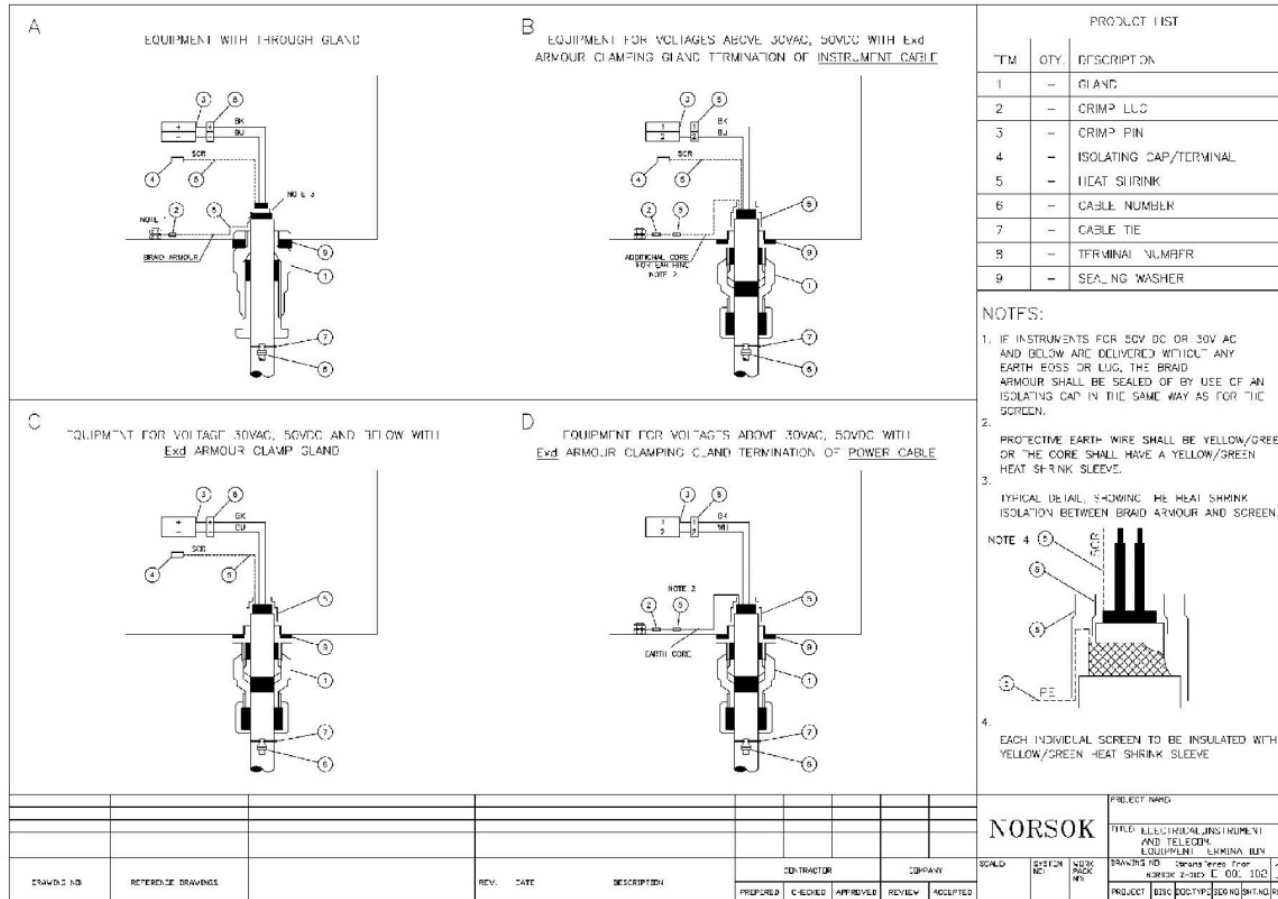
10.4.2 Installation (see IEC 61892-7, 10.4)

All IS loops shall be calculated individually and documented to be according to requirements.

Specific Guidance
on types of Ex
equipment and
gland usage

Norsok E-001 Cable Gland Termination

Figure B-2 – Electrical, instrument and telecom equipment termination



NORSOK standard E-001

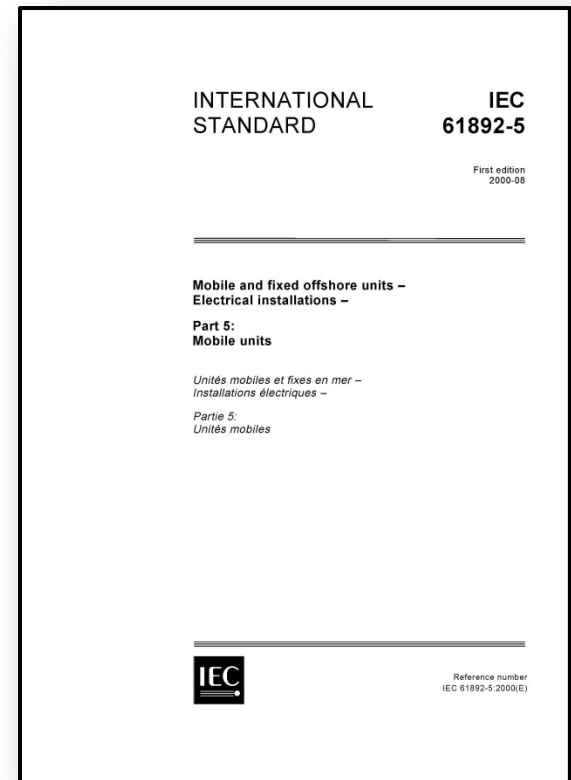
Edition 5, July 2007

Notice the use of Ex e glands not terminating the armour in the gland...

IEC 61892 Standards

Mobile and Fixed Offshore Units – Electrical Design

- IEC 61892-1 – General Information – Very general information
- IEC 61892-2 – System Design – Key document.
Reviews:
 - Power sources
 - System Earthing
 - Distribution Systems
 - Protection
 - Lighting
 - Controls and Instrumentation
- IEC 61892-3 - Equipment
- IEC 61892-4 – Cables –
- IEC 61892-5 – Mobile Units in particular
- IEC 61892-6 – Installation



Guidelines for design of fixed offshore installations - Denmark

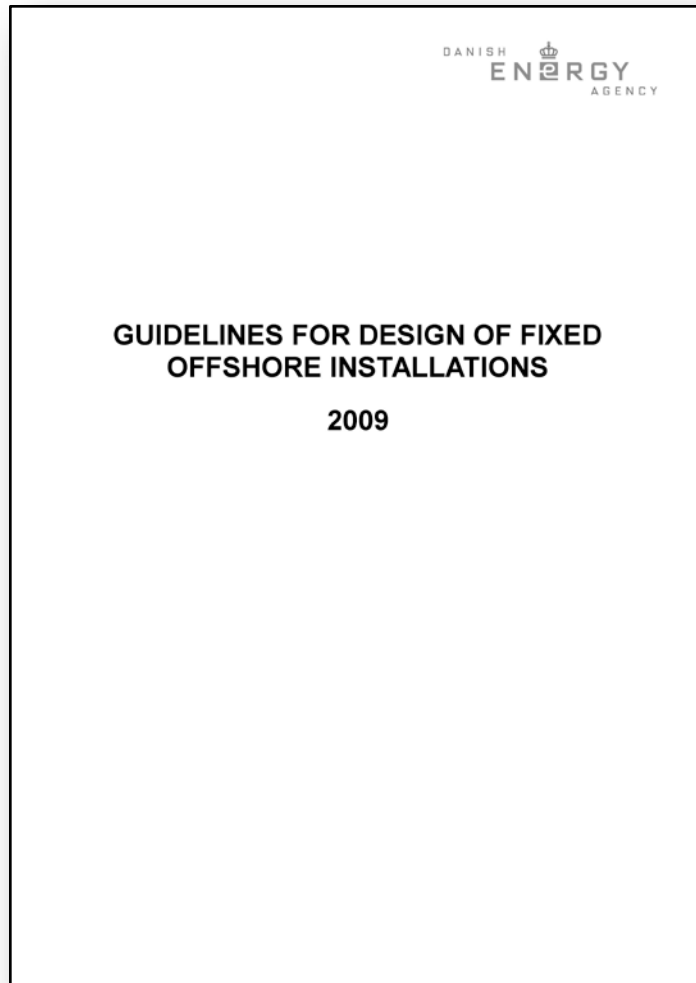
GUIDELINES FOR DESIGN OF FIXED OFFSHORE INSTALLATIONS

2009

List of Contents and Document Control

Chapter	Title	Rev. no.	Pages	Date
1	Introduction	0	1-4	July 2008
2	Design of Unmanned Production Platforms	0	1-14	July 2008
3	Safety, etc. for Personnel	0	1-3	July 2008
4	Process Equipment	0	1-15	July 2008
5	Auxiliary Equipment	0	1-8	July 2008
6	Life-saving Appliances	0	1-6	July 2008
	- Change of reference to regulations for equipment in vessels.	2 (rev. 1 is skipped)	1-6	June 2009
7	Design and Maintenance of Pipelines and Design of Offshore Steel Structures in connection with Fixed Offshore Installations	0	1-3	July 2008
8	Fire Protection, Fire Fighting as well as Fire and Gas Detection	0	1-22	18.07.2006
	Update of reference to Executive Order on p. 18	1	1-22	August 2008
9	Area Classification and Electrical Equipment	0	1-45	18.07.2006
	Update of reference to Executive Order on p. 41, paragraph 1.1, subpara c. Marking of fan position on figure on p. 31	1	1-45	August 2008

Guidelines for design of fixed offshore installations - Denmark



3. General Guidelines

The process equipment system shall be designed and built so as to ensure safe and efficient processing of flow liquids and gases during all possible production systems.

The process equipment shall be designed and installed according to Order No. 700 of 26 June 2008 on arrangement of equipment on fixed offshore installations, which implement **Council Directive 98/37/EC of 22 June 1998 (compilation of the Machine Directive 89/392/EEC as subsequently amended) and Directive 94/9/EC of 23 March 1994 (ATEX-Directive).**

Guidelines for design of fixed offshore installations - Denmark

GUIDELINES FOR DESIGN OF FIXED OFFSHORE INSTALLATIONS 2008**Chapter 9. Area Classification and Electrical Equipment**

Rev. no.: 1	Rev. date: August 2008	Page: 41 of 45
-----------------------	---------------------------	--------------------------

1. Guidelines for Electrical Equipment

1.1

Installation and operation of electrical equipment shall be carried out in accordance with:

- a. Act on Electrical Power Plants and Electrical Equipment, Act on Authorisation of Electricians, etc. and rules issued pursuant to these, cf. Order No. 1260 of 9 December 2004 on Electrical Power Plants and Electrical Equipment on Fixed Offshore Installations.
- b. Danish Standard, DS 700. Guidelines for Artificial Lighting in Working Premises.
- c. Order No. 700 of 26 June 2008 on Design of Equipment on Fixed Offshore Installations, in which section 6 and section 17 is referring to Executive Order No. 696 of 18 August 1995 on Design of Work Equipment for use in Explosive Atmospheres and Executive Order No. 697 of 18 August 1995 on Electrical Equipment and Electrical Safety Systems for Use in Explosive Atmospheres.

1.2 Special Material

1.2.1 Cables

1. Cable dimensioning, manufacturing and installation are allowed to be carried out according to the requirements of the IEC 60092 series.

2. Cables that are not otherwise protected against fire shall be provided with an exterior cap of self-extinguishing material. Cables shall fulfil the requirements of the DS/IEC 60332 series for fire-retardant cable material.

1.2.2 Cable Entry in Exd Equipment, Definition

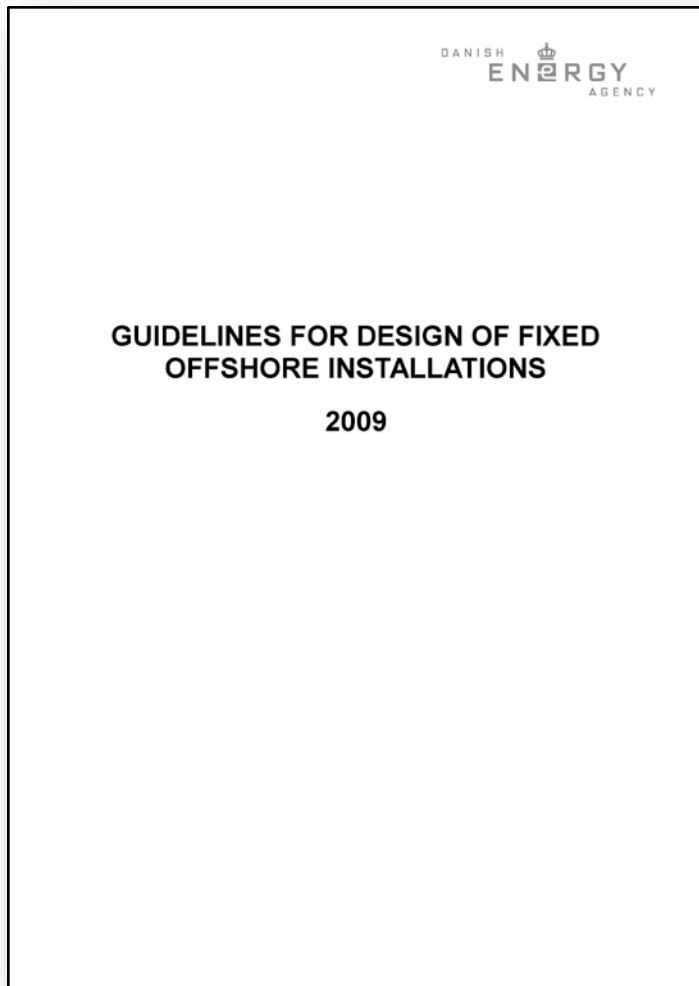
Cables can be connected either indirectly or directly in a cable entry in Exd equipment.

1.2.3

It shall be ensured that the electrical equipment used can resist the special environmental impacts on an offshore installation, corrosive impacts in particular.

How does this compare with NORSOK?

Area Classification Documents – Danish Offshore



GUIDELINES FOR DESIGN OF FIXED OFFSHORE INSTALLATIONS 2008		
Chapter 9. Area Classification and Electrical Equipment		
Rev. no.: 1	Rev. date: August 2008	Page: 15 of 45

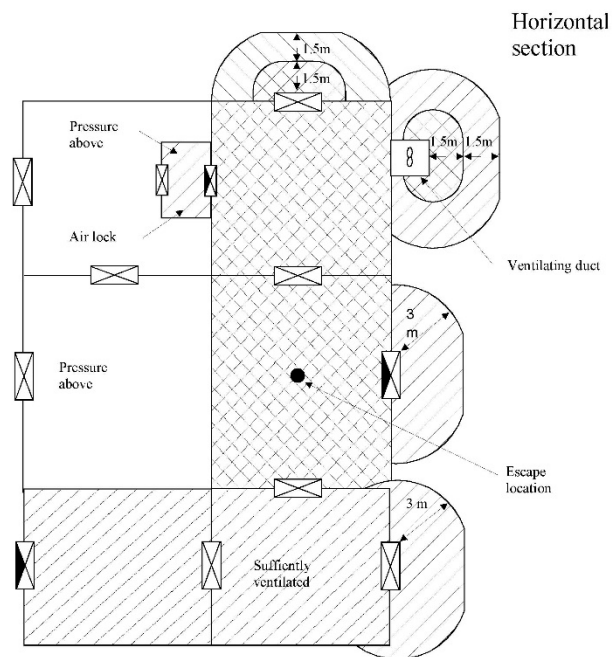


Fig. 5 Indoor premises and areas near openings

Area Classification Documents – IEC/EN Offshore/Onshore

EUROPEAN STANDARD **EN 60079-10-2**
 NORME EUROPÉENNE
 EUROPÄISCHE NORM
 August 2009
 ICS 29.280.20 Supersedes EN 61241-10:2004

English version

**Explosive atmospheres -
 Part 10-2: Classification of areas -
 Combustible dust atmospheres**
 (IEC 60079-10-2:2009)

Atmosphères explosives -
 Partie 10-2: Classification des
 emplacements -
 Atmosphères explosives poussiéreuses
 (CEI 60079-10-2:2009)

Explosionsfähige Atmosphäre -
 Teil 10-2: Einteilung der Bereiche -
 Staubexplosionsgefährdeten Bereiche
 (IEC 60079-10-2:2009)

This European Standard was approved by CENELEC on 2009-06-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

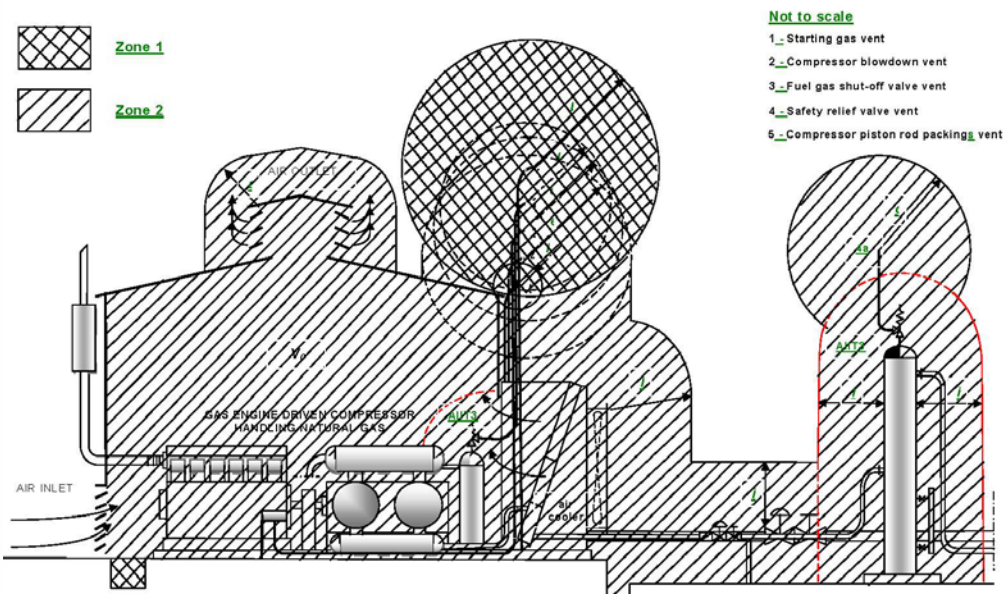
CENELEC

European Committee for Electrotechnical Standardization
 Comité Européen de Normalisation Electrotechnique
 Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: Avenue Marnix 17, B - 1000 Brussels

© 2009 CENELEC - All rights of exploitation in any form and by any means reserved worldwide for CENELEC members.

Ref. No. EN 60079-10-2:2009 E

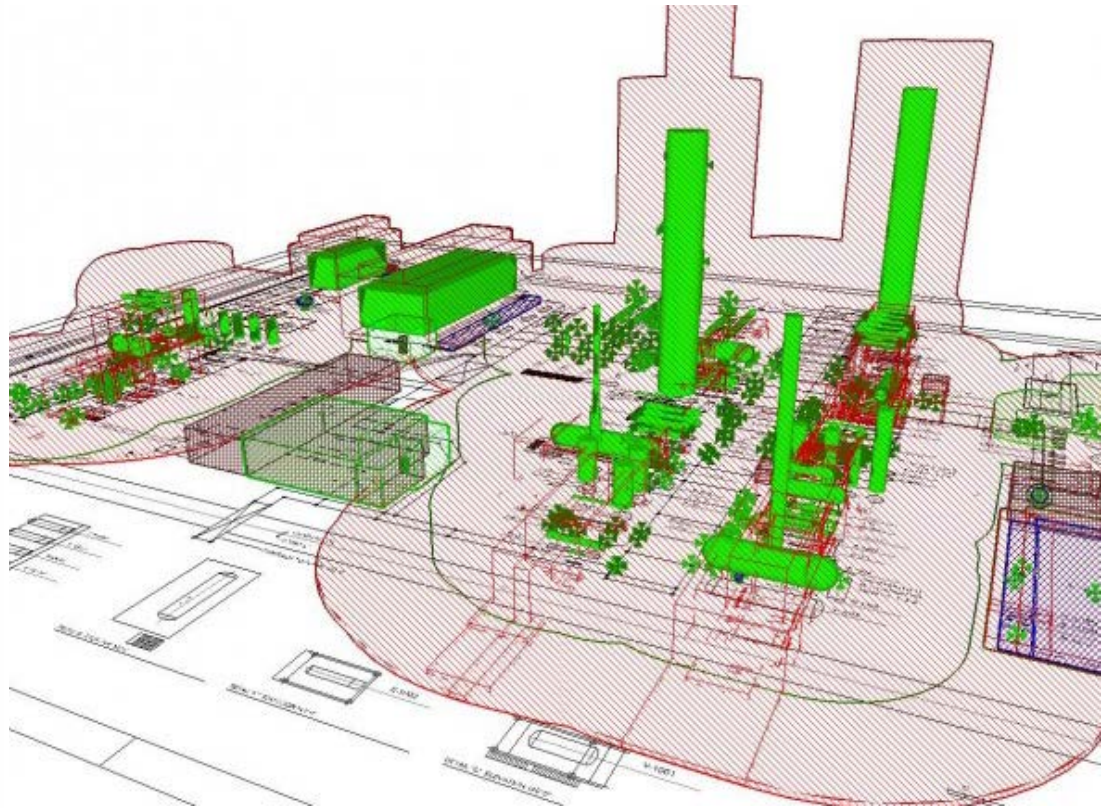


IP 15: Area Classification code for installation....



Research report: Dispersion modelling
and calculations in support of
*EI Model code of safe practice Part 15: Area
classification code for installations handling
flammable fluids*

2nd edition



IEC 60079 Standards....

- IEC 60079-0 – General Information – Very general information
- IEC 60079- 1 – Flameproof Protection – Ex d
- IEC 60079-2 – Pressurized Enclosures – Ex p
- IEC 60079-5 – Powder Filled – Ex q
- IEC 60079-6 – Oil Immersion – Ex o
- IEC 60079-7 – Increased Safety – Ex e
- IEC 60079-11 – Intrinsic Safety – Ex i
- IEC 60079-15 – Non-sparking – Ex n

All of these standards show you how to build a product to meet these performance standards but not necessarily how to apply

- IEC 60079-14 – Design, Installation Ex Equipment
- IEC 60079-17 – Inspection, Maintenance of Ex Equipment



Typical International Wiring Specification - Generalities

Multicore cables on racks or trays may be bunched in a maximum of two layers.

HV and LV single core cables shall be laid in trefoil groups with 150 mm clear spacing between trefoils.

On trays or racks HV cables shall be segregated from the LV cables. Individual cables emerging from floors or soil shall be protected against mechanical damage by means of galvanized steel pipes or rigid PVC pipes. Single core cables emerging from floors or soil shall be protected by rigid PVC pipes. These pipes shall extend at least 100 mm above ground or floor level.

Grouped cables emerging from floors or soil shall be protected collectively by a properly designed metal shield or duct in such a way that heat dissipation of the sustained load carrying cables is not hampered. The propagation of fire from one space to the other shall be prevented by proper sealing of openings around cables.

Cables or cable supports shall not be fixed directly or indirectly to plant, equipment or process piping which may require removal or replacement. Cables shall be laid on racks or trays strictly in accordance with the laying patterns stated on the layout drawings. Metal parts of the cable racks and trays shall be bonded and connected to the common earthing grid.

Typical International Wiring Specification - Generalities

Bends and corners in the cable racks, trays or ladders shall take account of the minimum cable bending radii. Cable racks and trays shall be closed by removable top covers, allowing adequate ventilation, in situations where:

- mechanical damage of the cables is likely to occur during plant maintenance activities,
- oil or chemical spillages on the trays can be expected,
- sun shielding is required against direct solar radiation.

Vertical cable rack risers shall not be installed in front of, or over, pipe risers.

Flexible cabling

The application of flexible cables in industrial plants and installations shall be limited to:

- welding cables;
- trailing cables, e.g. for movable equipment, hand tools, hand lamps;
- winches, hoists, soot blowers, and electric motors, if connected by means of a nearby intermediate junction box.

An earth continuity conductor, equal in cross-sectional area to the largest phase conductor, shall be provided. This requirement applies even when the cable is armored.

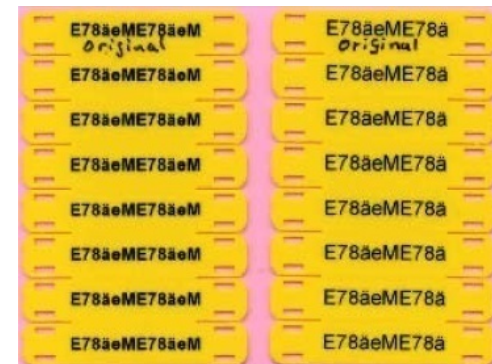
Typical International Wiring Specification - Generalities

Cable marking/numbering

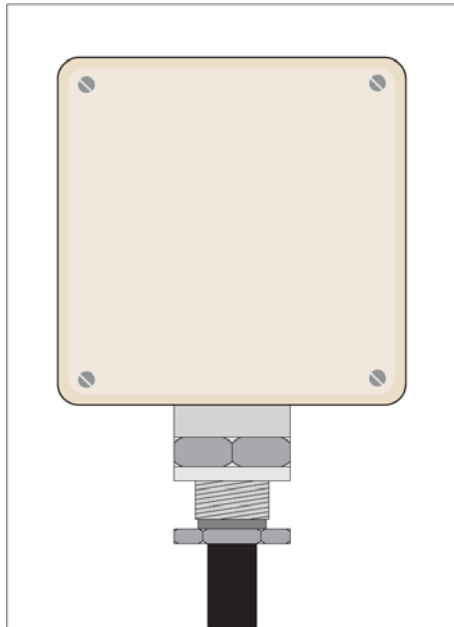
Cable numbers shall be marked on the cables along their routes and at both termination points. For underground cabling, the spacing between cable numbers along the route should not exceed 5 m, and for above ground cabling, 25 m. Cables shall also be numbered where they branch off from a main route.

For underground cable marking purposes non-corroding strips shall be used, each having ample length to be wrapped twice around the cable and in which the cable number has been imprinted by means of letter/cipher punches. For above ground cabling, plastic markers resistant to the site conditions shall be strapped round the cables.

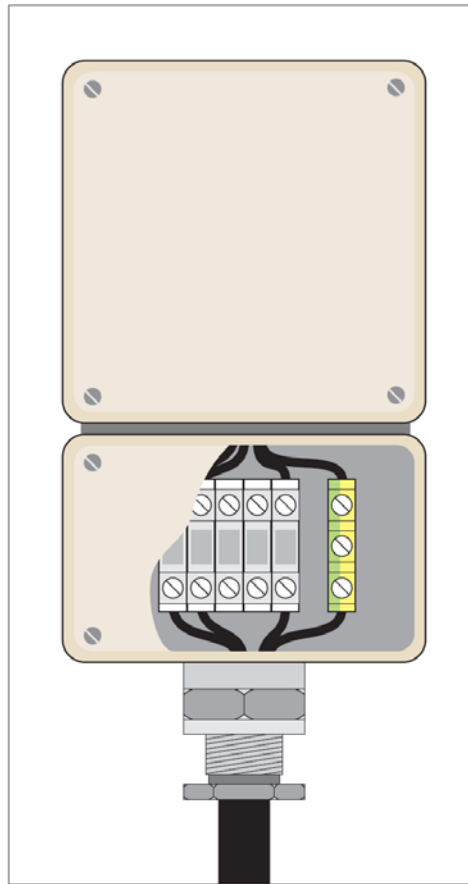
For underground cabling, above ground route markers shall also be provided at every change of direction in the routing and at both sides of road or pipeline crossings, except when cable routing is already indicated by colored concrete pavement.



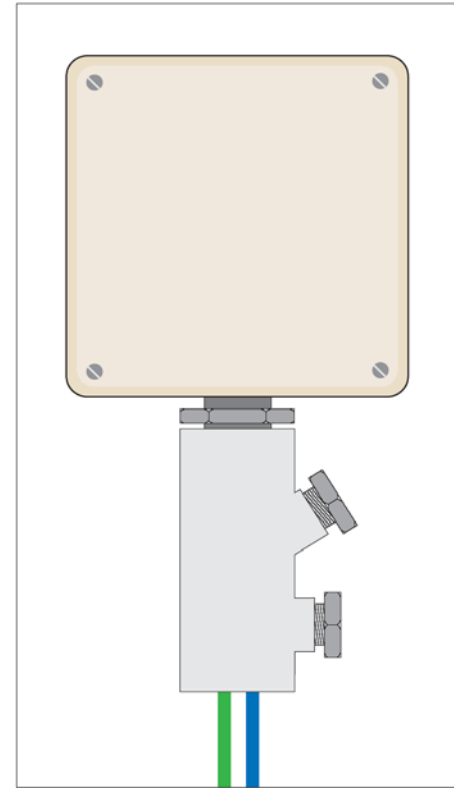
Ex Installation Methods Conduit or Cable Glands...



Direct Entry via Ex 'd'
gland



Indirect Entry via Ex 'e'
gland & enclosure



Direct Entry via Ex 'd'
conduit

Typical Wiring Methods

Rigid Conduit →



Unarmored Cable →



Armored Cable →



International Cable Types and Construction

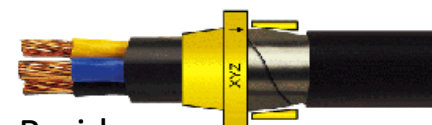
Unarmored Cable similar to US TC type cables but with fully extruded fillers. Armored Cable similar in concept to IEEE45 Type P marine shipboard cable and continuous corrugated aluminum armor cable.



Type SWA – Steel Wire Armor



Type STA – Steel Tape Armor



Type SWB – Steel Wire Braid



Cable/Conductor Requirements in Zone applications

The following main requirements are listed in the IEC 60079 standard for cables and conductors:

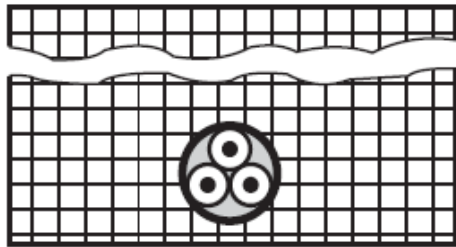
- use only insulated cables and conductors (test voltage ≥ 500 VAC),
- in special cases earth the required screening only once at the end of the non-explosive environment,
- protect intrinsically safe circuits against external electrical or magnetic fields through the maintenance of adequate distances, screening and/or core twisting, isolate intrinsically safe cables and conductors from non-intrinsically safe cables and conductors or, protect against mechanical damage or, protect through metal housing, or screening of the cables and conductors do not combine conductors of intrinsically safe and non-intrinsically safe circuits
- prevent the fraying of fine wired conductors through the use of cable sleeves, for example:
- isolate intrinsically safe and non-intrinsically safe circuits in cable bundles or ducts via insulation spacer or an earthed metal spacer (not required with screening or sheathing),
- identify (i.e. light blue) the cables and conductors of intrinsically safe circuits (not required with shielding or metal sheathing)



Cable/Conductor Requirements in Zone applications

When selecting cables and conductors, only use those which can withstand the expected mechanical, chemical and thermal influences. Cables and conductors with thermoplastic sheath, duroplastic sheath, elastomer sheath or mineral insulation with metal sheath may be used for fixed routing. Cable branch lines must comply with the requirements for hazardous areas.

The cables and conductors must be connected to the electrical equipment in line with the directives for the associated type of protection. Unused openings on devices and equipment must be closed. When cables and conductors are installed through openings into non-hazardous areas, care must be taken to provide an adequate seal at the openings (e.g. sand filling, mortar) to prevent carrying-over of the zone. At particularly hazardous points, cables and conductors must be protected against thermal, mechanical or chemical stress by, for example, conduits, tubing or covers. The flame retardance of cables and conductors for fixed routing must be proven in accordance with IEC 60332-1.



Cable Types and Construction

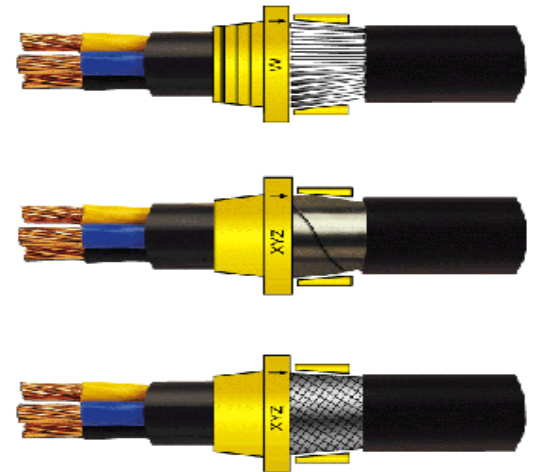
In general, SWA cable has been the cable of choice in the UK for onshore installations. It is somewhat flexible, readily available and has good bending capabilities.

SWB cable has become the choice for installations offshore with various armor materials including tinned copper, bronze and other materials. Very flexible yet durable under very demanding conditions. Many different jacket types available.

STA is more of an onshore type cable and is widely used in onshore applications in continental Europe, especially for power applications. Clients have started to shy away from STA as it is generally regarded as slightly more difficult to terminate than either SWA or SWB.

One variation commonly used for direct bury applications is a Lead sheathed armor cable. Lead provides a very good insulation due to corrosive elements and is particularly resistant to rodents and ants. Cable glands for lead sheathed cable typically need an additional component to seat the lead portion of the cable.

Designations on glands is to mark a XZ for braid and tape, with a W for wire armor for field installation.



Cable Types and Construction



BFOU & RFOU instrumentation cables are manufactured with either overall or individual screens, the cores are either laid up as pairs or triples. Ideal for signal and instrumentation circuits where the fire performance and Low Smoke Zero Halogen properties are increasingly being required within public buildings and power stations, as well as traditional Petro/Chem industries. The cable is designed to carry on working for a period of 3 hours when exposed to fire, according to IEC 60331 test procedure. BFOU also offers good screening properties, reducing Electro Magnetic Interference (EMI).

Construction

Tinned stranded copper conductor, MICA tape, EPR insulation, overall screen of Copper backed Polyester tape with a stranded copper drain wire 0.75mm², inner sheath of Halogen Free Thermoset Elastomer, tinned copper wire braid and an outer sheath of Halogen Free Thermoset Elastomer. The individually screened version has a Copper backed Polyester tape with a stranded copper drain wire 0.75mm² around each pair or triple.

Core colors

Pairs - Light blue, black

Triples - Light blue, black and brown

Each pair or triple is identified by a numbered tape.

Cable Types and Construction

The most common sheath material for data cabling in use in the UK is PVC. For many environments, PVC is the ideal material, having superior mechanical characteristics and high reliability. However, in a fire, PVC emits heavy black smoke mixed with hydrochloric acid, thus reducing vision, immediately impairing breathing, and additionally initiating corrosion of all equipment exposed to the fumes. For improved fire performance, it is common for LSZH Low Smoke Zero Halogen (usually meeting IEC61034, IEC60754-2 and IEC60332-3) cable sheaths to be used within Europe.

The major Standards in common use are shown in the table.

Test	International Standard <i>(Note 1)</i>	Other Standards <i>(Note 1)</i>
Tests for evolution of acidic and corrosive gas	IEC60754 Part 1 - halogen acid gas Part 2 - total acid gases	EN50267
Tests for smoke opacity	IEC 61034 IEC60695-6	BS7622 (possibly the same content) NES 711 Smoke Index
Tests for toxicity	None known	
Tests for flame propagation	IEC 60332 <i>(Note 2)</i> Part 1 - single vertical cable Part 3 - bunched cable	EN50265 EN50266 US Standards: - UL1581 - General - UL1666 - Riser - UL910 - Plenum <i>(Note 3)</i>
Tests for fire resistance	IEC60331	

Cable Tests for Fire Applications

Classification	Fire Performance	Typical Tests	Guidance Notes
A	General Flammability Resistance	IEC 60332-1	This cable provides a level of flammability resistance for general purpose applications
B	Reduced Flame Spread	IEC 60332-1 & IEC 60332-3	This cable provides reduced flame spread from bunched cables, as required in cable risers
C	Low Smoke & Fume	IEC 60332-1 & IEC 60754-1 & IEC 60754-2 & IEC 61034	This cable provides low emission of smoke and corrosive fumes
D	Reduced Fire Hazard	IEC 60332-1 & IEC 60332-3 & IEC 60754-1 & IEC 61034	This cable provides reduced flame spread from bunched cables with low smoke and acid gas emission.
E	Limited Fire Hazard	IEC 60332-1 & IEC 60332-3 & IEC 60754-1 & IEC 60754-2 & IEC 61034 & Toxicity (?)	This cable provides an overall limited fire hazard performance and combines reduced flame spread with low emission of smoke and noxious fumes
F	Fire Resistant	IEC 60331	This cable is designed for wiring and interconnection where it is required to maintain circuit integrity under fire conditions for long periods

Typical Cable Tests



Fire Resistant Test – IEC60331-21 Under long fire exposure, the cable must maintain the power supply for vital safety equipment (emergency lighting, alarm, systems & fire pumps, etc.)

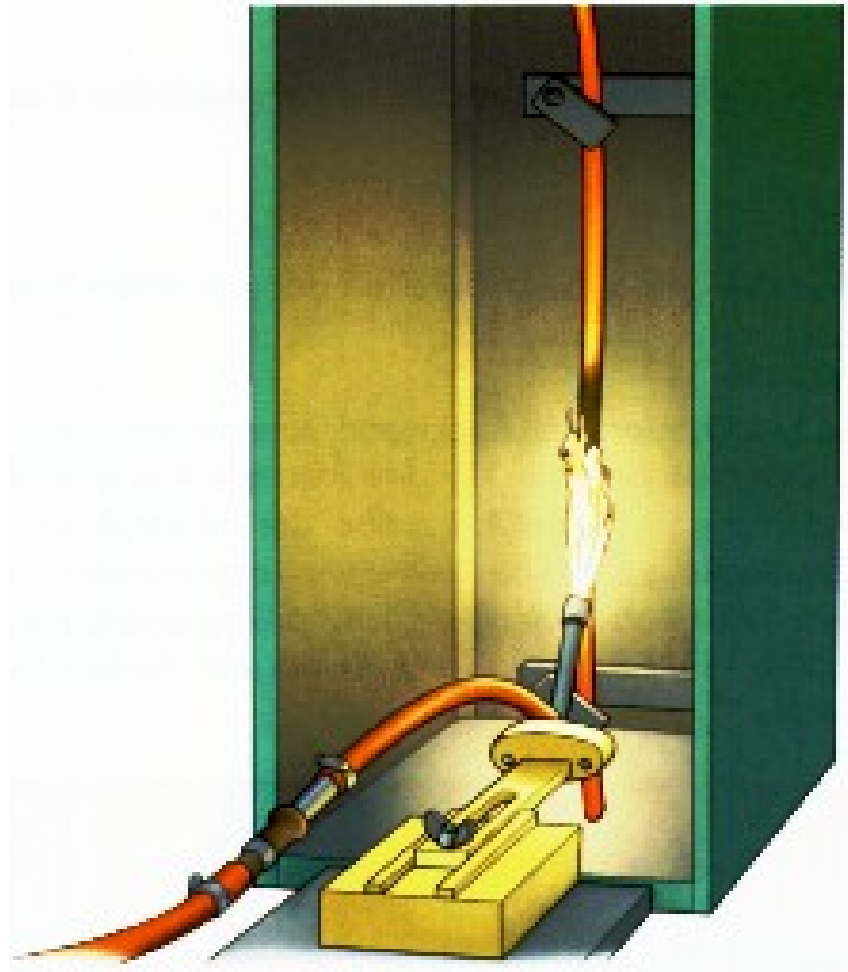
Smoke Density Test – IEC61034-1/2
The smoke density test evaluates the smoke emissions of the cable and the jacket construction.



Test under fire condition – IEC60332-3 Flame retardant test simulating cables installed in bunch on a vertical ladder under fire conditions.

IEC60332-1-2 Single wire or cable

- A test on a single length of cable 600mm long held between 2 clamps.
- The flame is applied for a predetermined amount of time based on the weight of the cable.
- To pass the test there should not be any visible damage or charring within 50mm of the lower edge of the top clamp (Equal to 425mm higher than the flame source) once all combustion has stopped.
- This test replaces IEC60332-1, BS4066 pt 1 & BS EN 50265-2-1.



IEC60332-3 “The ladder test”

- The IEC60332-3 ranges of tests are conducted on bunches of cables and are much closer to a real life installation. 3.5m Lengths of cables are bunched onto a cable ladder in a chimney simulating a building riser.
- The volume of cable on the ladder is determined in litres of combustible material to offer a balanced view of performance across a cable range.
- A flame is applied 500mm from the base of the ladder for a predetermined time. When the burner has extinguished a one hour after-burn period is allowed then the cables are checked for performance.
- To pass the tests the cables should not be affected by the flame 2.5m above the flame source.



IEC60332-3 categories

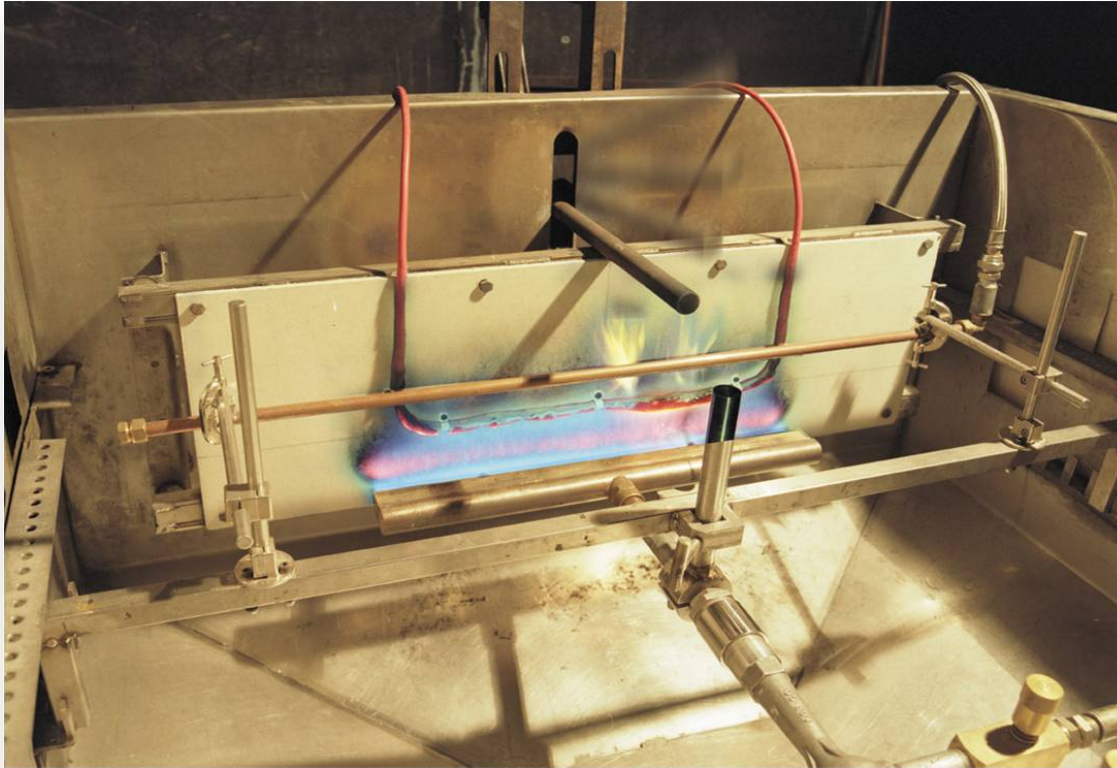
Test	Qty of material	Flame application	Supersedes
60332-3-22 Cat A	7.0 litres	40 minutes	IEC60332-3A BS4066 pt 3A
60332-3-23 Cat B	3.5 litres	40 minutes	IEC60332-3B BS4066 pt 3B
IEC60332-3-24 Cat C	1.5 litres	20 minutes	IEC60332-3C BS4066 pt 3C
IEC60332-3-25 Cat D	0.5 litres	20 minutes	

60332-3-21 Cat A F/R Used for large O.D cables instead of “3-22 Cat A”. The cables are mounted on the front and back of the ladder

- All these tests are to be conducted on complete cables.
- Compounds alone cannot be tested to IEC60332



Fire Resistant Testing



- A cables ability to continue operating safely during a fire. Also referred to as circuit integrity.
- Widely used in commercial/public buildings & MOG applications to control fire alarm/monitoring systems, emergency lighting, fire shutters and emergency evacuation equipment.

European Fire Standards

- | Standard | Ref. | Performance requirement |
|----------------------|------------------------|---|
| IEC60331 | Cables \leq 0.6/1kV. | 3 hours at 750°C (1970 edition) |
| IEC60331-21
spec) | Cables \leq 0.6/1kV | 90 minutes @ 750°C (unless alt. stated in the cable |
| IEC60331-23 | Data cables | 90 minutes @ 750°C |
| IEC60331-25 | Optical fibre | 90 minutes @ 750°C |
| IEC60331-31 | Cables \leq 0.6/1kV | 120 minutes @ 830°C with vibration |
| VDE0472 | FE180 | This test is equal to IEC60331 (1970 edition) |
| DIN 4102 | E30 | Complete system integrity for 30 minutes |
| DIN 4102 | E90 | Complete system integrity for 90 minutes |



Smoke Emission & Toxic Gas

- Obscuration of vision and toxic gas are the main threat to people during a fire leading to disorientation and choking from fumes. Death is normally caused by . choking rather than flames. Reducing smoke & fume emissions is vital to enable safe evacuation.
- Equipment damage is caused by HCl gases mixing with moisture from the sprinkler systems and creates acid rain leading to long term component failure even if the equipment does not look damaged.
- Not all materials that are low smoke are halogen free, examples :
 - LS-PVC (Limited Smoke PVC to UL1685)
 - Fluorocarbons (PTFE, FEP etc.)
 - “Type B” CSP to BS6883 (1991)



European Smoke Testing

- **IEC 61034-2:** A one meter sample of cable (or a bundle of cables depending on the outer diameter) is placed in a 3m cube and subjected to combustion by an alcohol produced flame for 20 minutes. The light transmission through the cube should not fall below 60% during the test (at peak or total)
- Measurement method :
- 100W halogen light source sensed by a photoelectric cell positioned on the opposite side of the smoke cube.
- IEC61034-2 is the most popular test used for cable in Europe.
- IEC61034-1 covers the apparatus required and test procedure.



Toxic Gas Evolution IEC60754

- IEC60754-1 (BS EN 50267 pt1) measures the amount of hydrochloric acid (HCl) evolved during burning. The result is normally expressed as a percentage of the sample weight. There is no pass/fail criteria.
- This method is not suitable for testing cables classed as “Zero Halogen” and compounds containing less than 5mg/g (5%)
- IEC60754-2 (BS EN 50267 pt2) measures the corrosiveness of the evolved gas in terms of acidity (pH) and conductivity. IEC 60754-2 recommended values are :
- pH > 4.3. & Conductivity of combustion gases < 10 mS/mm



Panel Wiring to IEC requirements

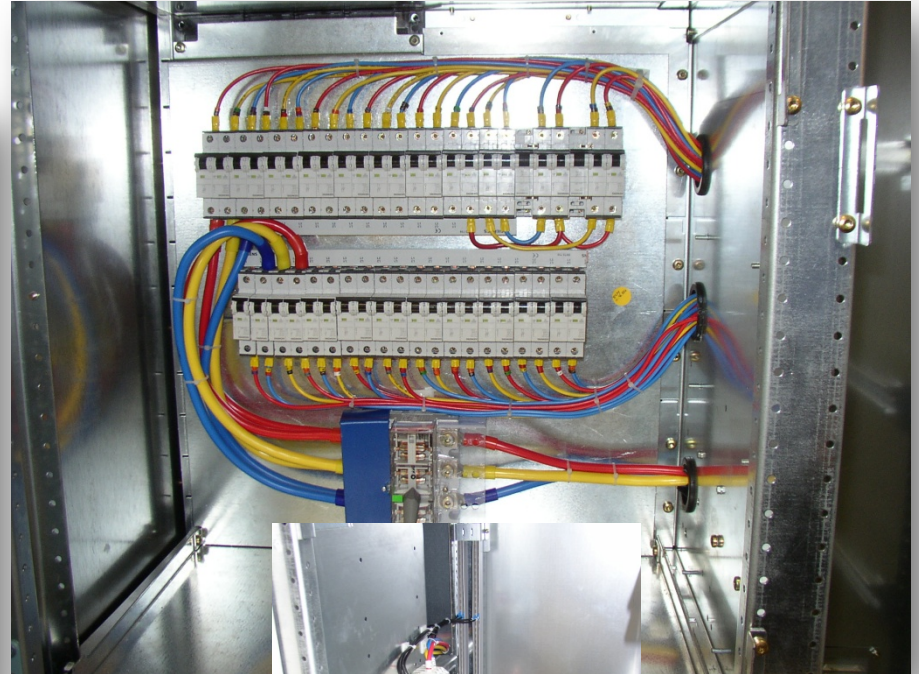
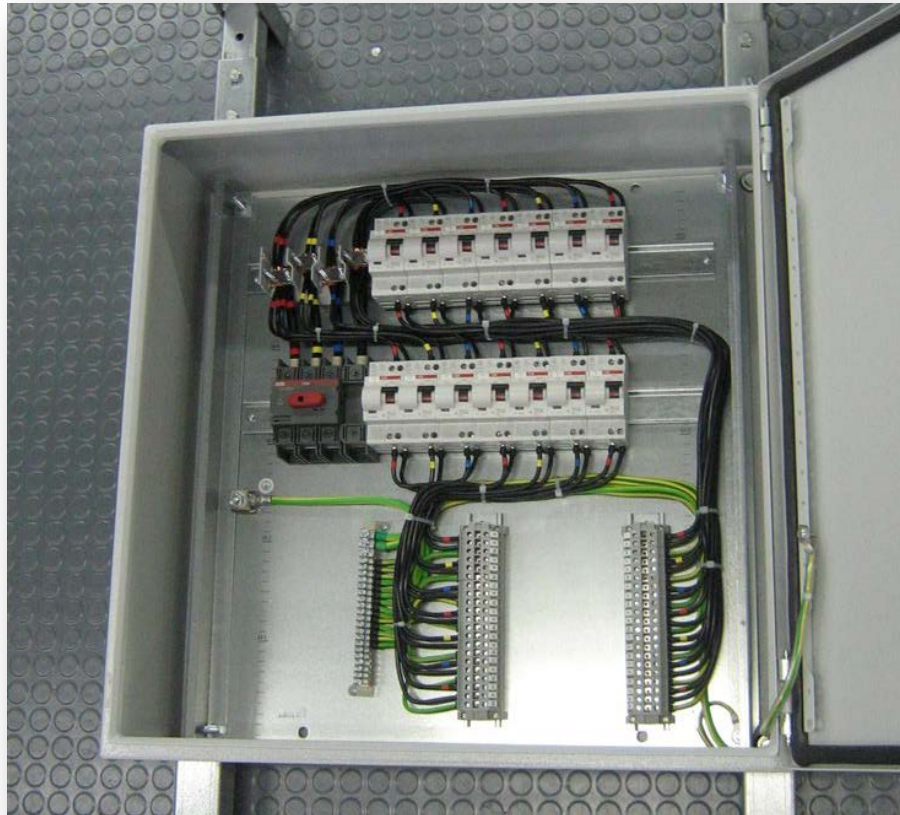
Most of Europe abides by IEC wiring color codes for AC branch circuits. The older color codes in the table reflect the previous style which did not account for proper phase rotation. The protective ground wire (listed as green-yellow) is green with yellow stripe.

Function	Label	Current Color IEC	Old Color IEC
Protective Earth	PE	Green-Yellow	Green-Yellow
Neutral	N	Blue	Blue
Line, single Phase	L	Brown	Brown or Black
Line, 3 phase	L1	Brown	Brown or Black
Line, 3 phase	L2	Black	Brown or Black
Line, 3 phase	L3	Grey	Brown or Black

The United Kingdom now follows the IEC AC wiring color codes. The table below lists these along with the obsolete domestic color codes.

Function	Label	Current Color UK	Old Color UK
Protective Earth	PE	Green-Yellow	Green-Yellow
Neutral	N	Blue	Black
Line, single Phase	L	Brown	Red
Line, 3 phase	L1	Brown	Red
Line, 3 phase	L2	Black	Yellow
Line, 3 phase	L3	Grey	Blue

Example of old UK wiring colors



The use of color coded ferrules or sleeves is typically left up to the client/user preference. Either practice is acceptable to relevant IEC standards.

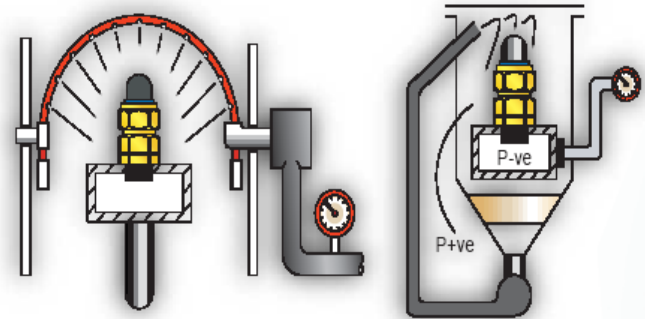
Cable Gland Selection Criteria

Cable glands used in enclosures intended for use in a hazardous area must meet with the same criteria as the enclosure to which they are connected. For example, cable glands used on an Ex'e' enclosure must meet the requirements for the enclosures of the Ex'e' standard i.e. must be capable of withstanding a 7Nm impact and capable of maintaining an ingress protection of at least IP54.

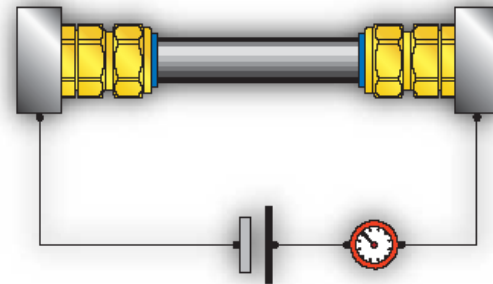


Testing Procedures for Cable Glands

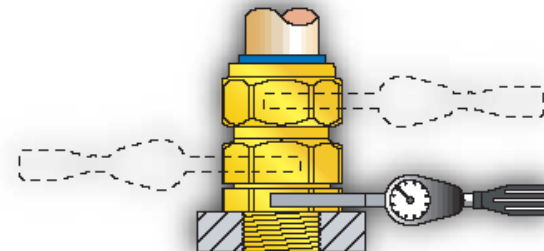
IP 66 Testing – 100 liters of water for 3 minutes from 2.5 to 3 meters



Continuity Testing of Armor – Gland is heated and cooled over time and resistivity should not change more than 10%

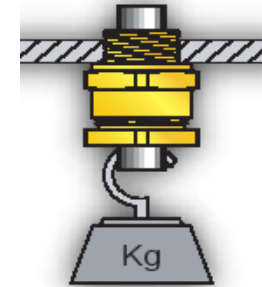


Tork Test – Multiple spanners to prescribed tension with no damage on disassembly

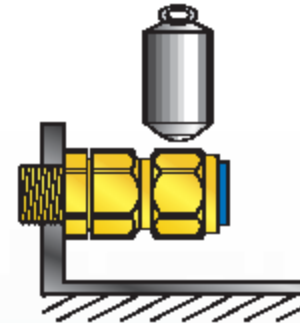


Testing Procedures for Cable Glands

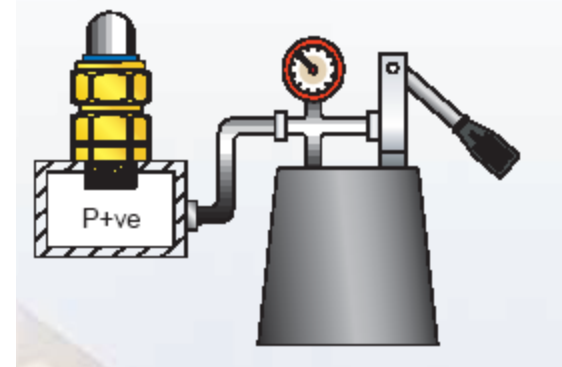
Load Test – Unarmored cable gland with mandrel to not slip more than 6 mm over 6 hrs.



Impact Test – 1 kg falling from 70cm or 7 joules. No damage to gland



Pressure Test – Minimum of 450 psi without leakage for Ex 'd', 2000 psi for UL2225 requirements



Wiring Methods

Wiring concepts Offshore follow the established & prevailing Marine standards, e.g. IEC 60092-352

Metallic parts (including armour) shall be earthed effectively to prevent them from becoming live.

Cable Armour/Braid provides a means of good earth continuity as well as mechanical protection.

Normal practice has been to use external grounding as the most direct route to earth.

This is easily achieved with metallic cable glands in non metallic enclosures by the use of an earth tag

Shrouds have been found to be an ineffective means of keeping water out of enclosures and glands are typically not used for North Sea applications any more



Wiring Methods – Shielding EMI Protection

Two forms of EMI/RFI to consider

- Conducted Emissions (Generated & Susceptibility)
- Radiated Emissions (Generated & Susceptibility)

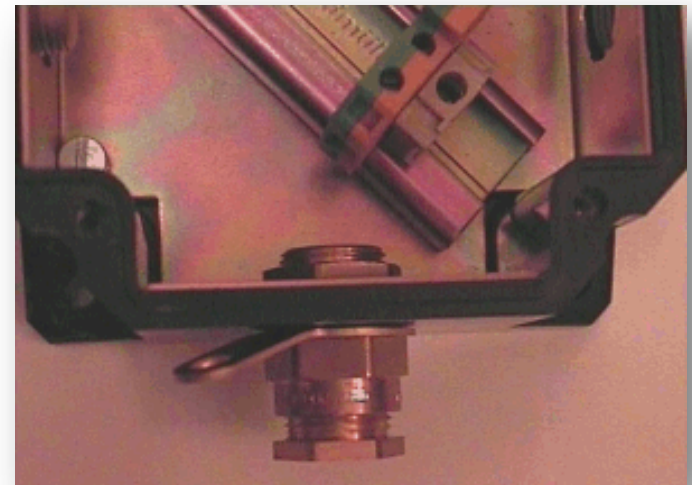
A Screened Cable entering shielded enclosure

- Assists in protection against Radiated Emissions

Metallic glands are an essential part of the system design in respect of Electromagnet protection.

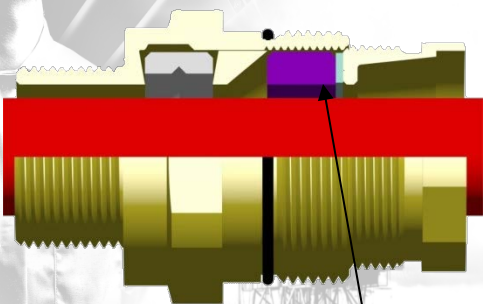
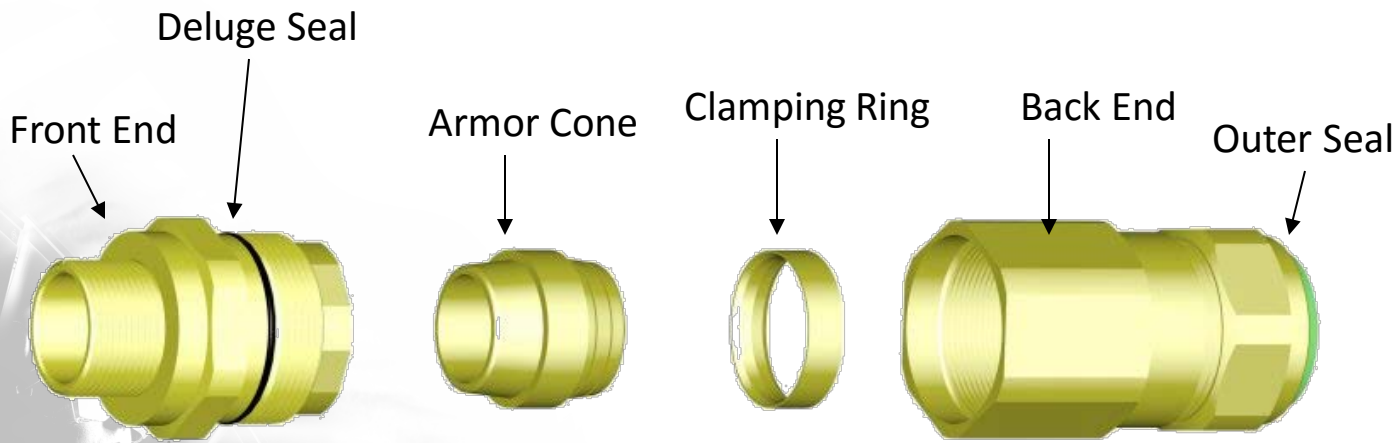
360° Cable shielding provides optimum performance for EMC as opposed to 'pig tail' techniques.

Non metallic glands create the weak link in the system between shielded cable and enclosure.



Typical Ex d & e armored cable gland

Components of Typical Ex e & d cable gland....



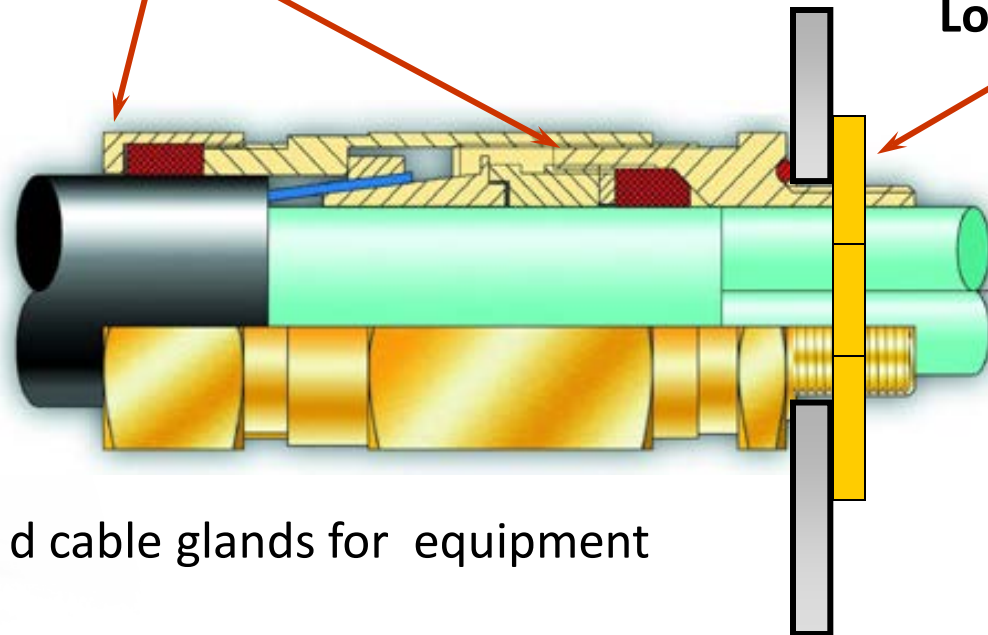
Inner Seal



Installation of Ex 'ed' gland

Inner & Outer Seals

Locknut



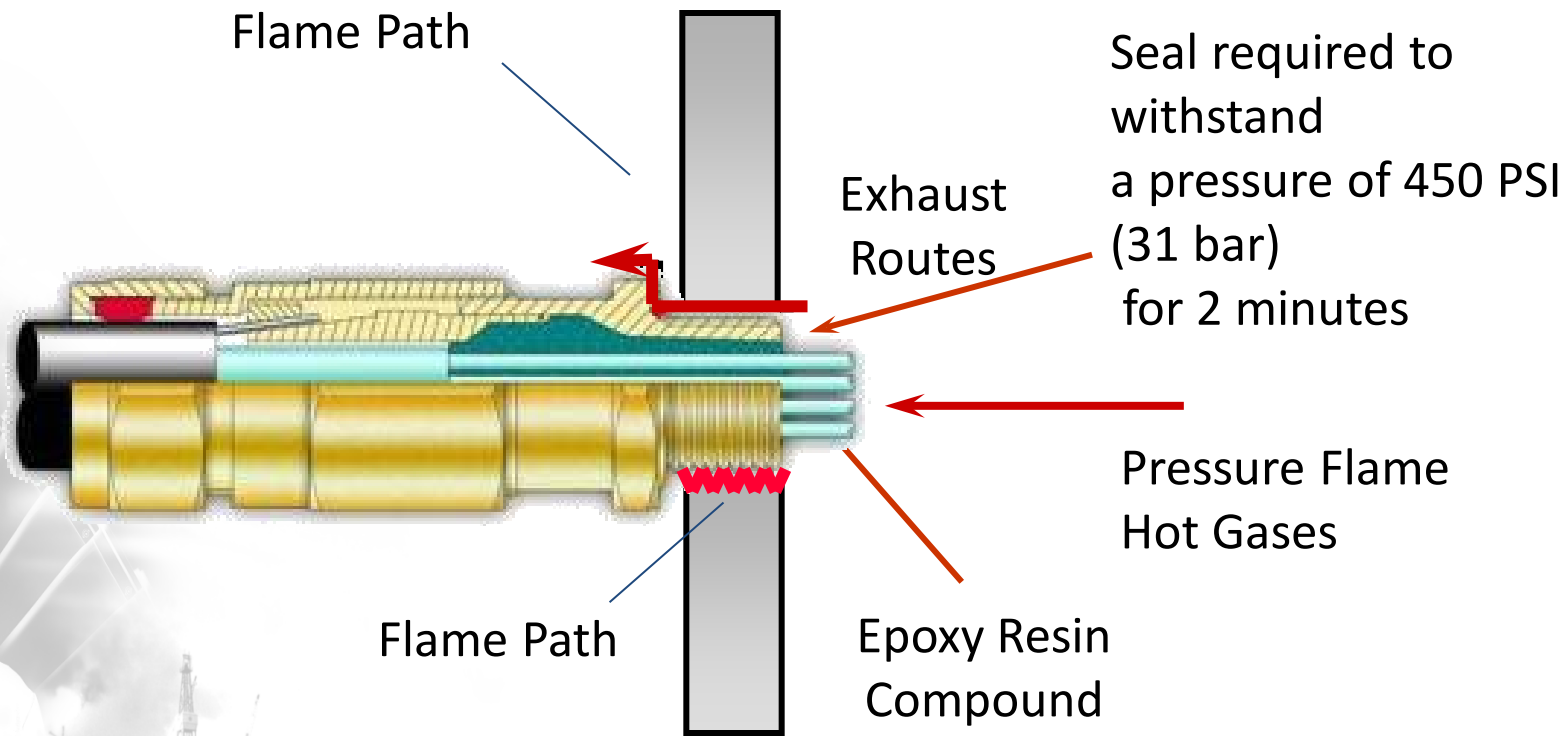
Ex d & Ex e

Requirement for Ex d cable glands for equipment < 2 litres

- Screwed entry threads must maintain flame path
- Inner seal must be explosion proof and gas tight
- Trend is to use dual certified Ex d & Ex e

Not unusual to use the identical gland for both Ex d and Ex e applications for less confusion in installation in the field....

Installation of Ex 'd' barrier gland



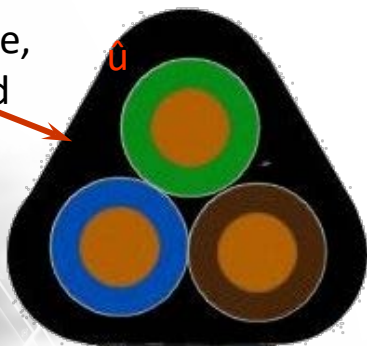
Direct Entry into Zone 1, Ex 'd' enclosure over 2 liters volume
With Arcing Sparking Devices...

Sample of Cable Types

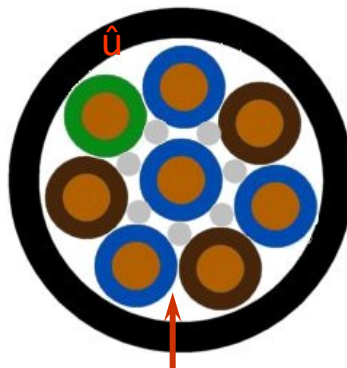
Which type is suitable for use with Flameproof Ex d equipment using a gland with an **ELASTOMERIC** seal?

Cable A

Incorrect Shape, Cables Should be Round

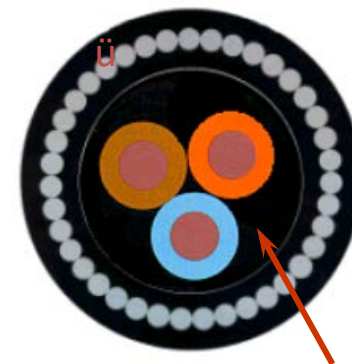


Cable B

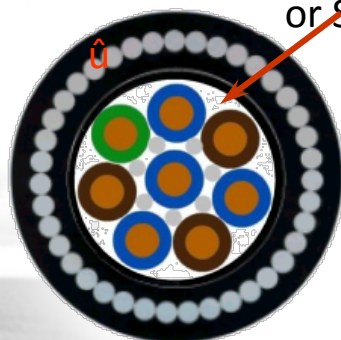


No Inner Sheath, Extruded Bedding or Suitable Fillers

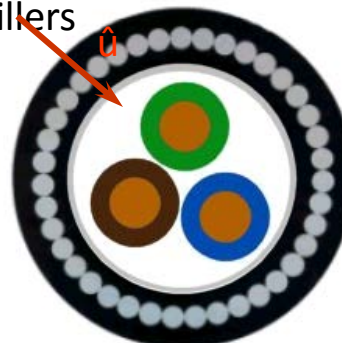
Cable C



Correct Cable, e.g. has an extruded inner bedding



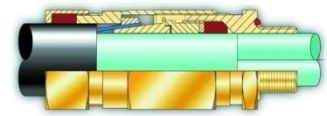
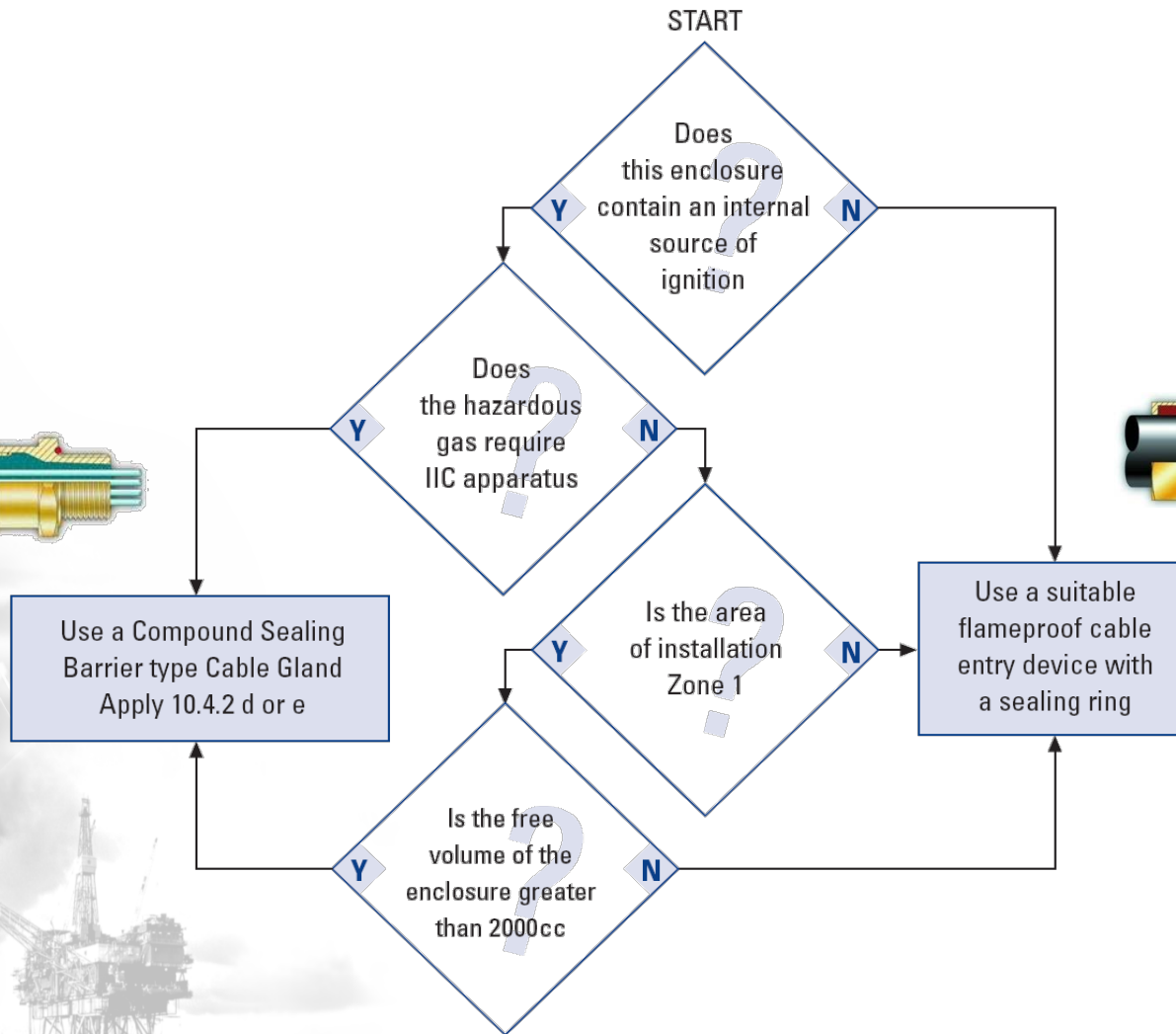
Cable D



Cable E

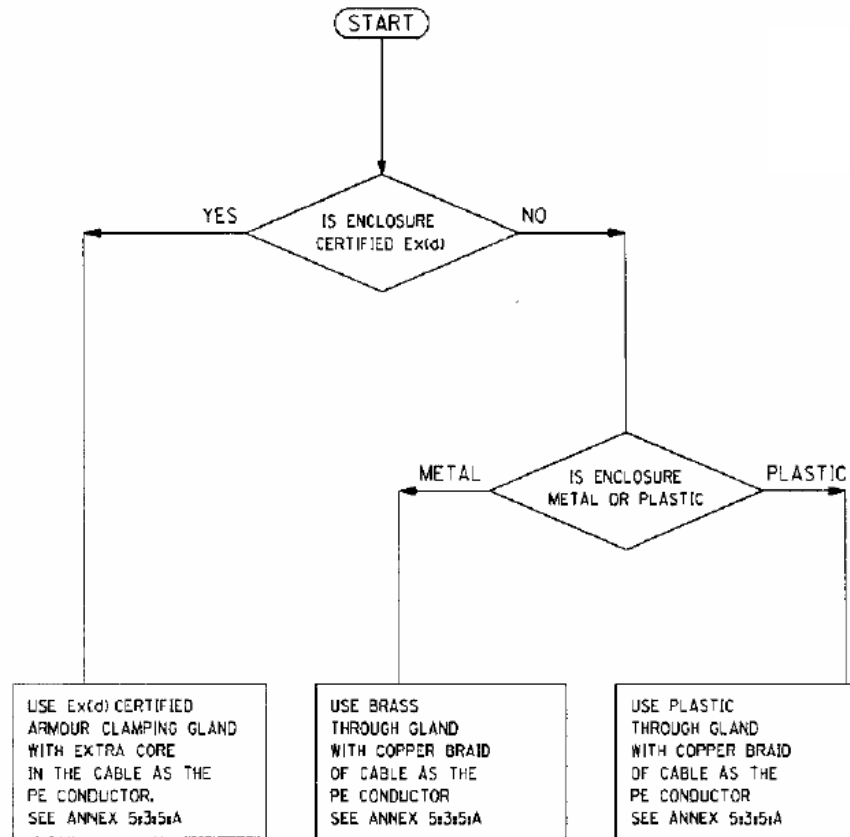
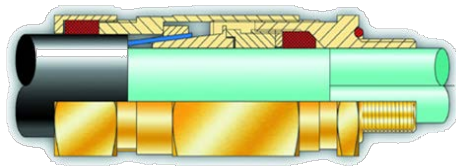


IEC60079-14:2007 Cable Gland Selection Chart



In general, about 90% of the application for hazardous location cable glands can be fulfilled with the use of a non-barrier compound gland...

Wiring Methods – Typical Norwegian Installation Practice



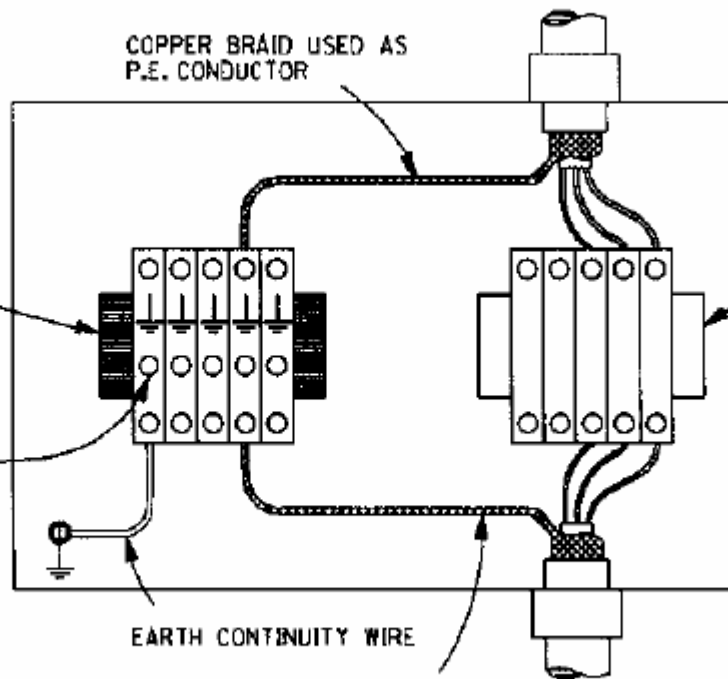
Wiring Methods – Typical Norwegian Installation Practice

GLANDING & EARTHING MISCELLANEOUS DETAILS 'A' & 'B'

GREEN/YELLOW COLOURED EARTH TERMINALS (E.G. KLIPPPON TYPE EK) MOUNTED ON COPPER DIN RAIL. STEEL IS NOT ACCEPTABLE. POWER, SIGNAL OR SCREEN TERMINALS MUST BE MOUNTED ON A SEPARATE RAIL.

MIDDLE SCREW CLAMP TERMINAL TO DIN RAIL. THIS CLAMP PROVIDES THE CONTINUITY REQUIRED BETWEEN THE TERMINALS VIA THE DIN RAIL.

COPPER BRAID USED AS P.E. CONDUCTOR

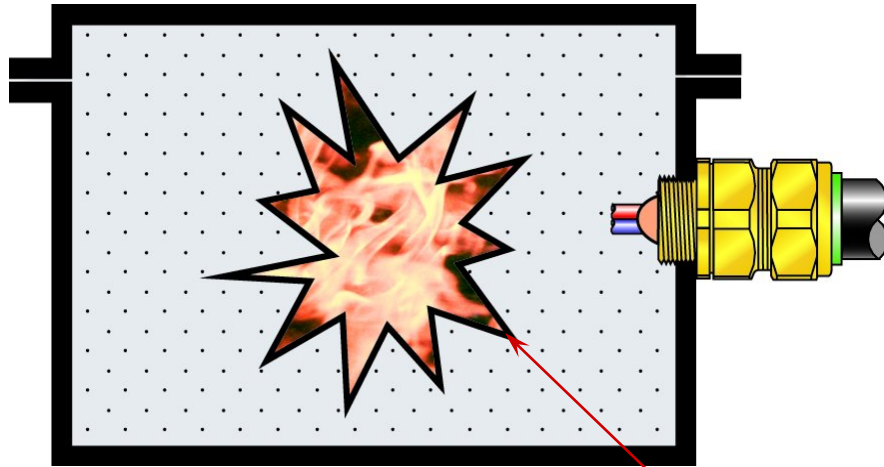


POWER OR SIGNAL OR SCREEN TERMINALS MOUNTED ON A SEPARATE RAIL FROM THE EARTH TERMINALS

EARTH CONTINUITY WIRE

ONLY ONE P.E. CONDUCTOR IS TO BE TERMINATED IN EACH SIDE OF EACH TERMINAL.

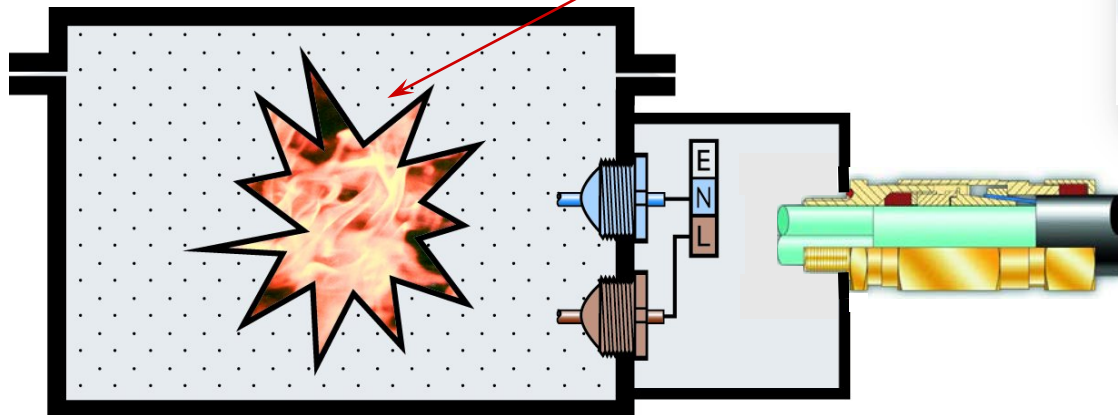
Direct and Indirect Entry Ex e & Ex d Enclosures



Direct Entry, Gland Type
Ex d Barrier Type if
volume > 2 litres and all
IIC applications

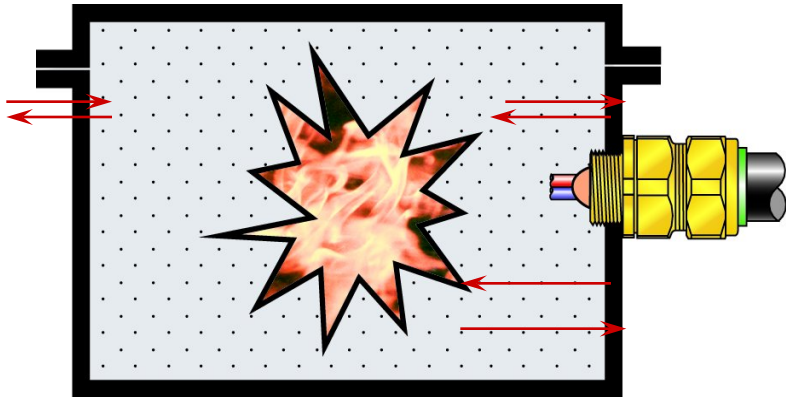


Ignition Source

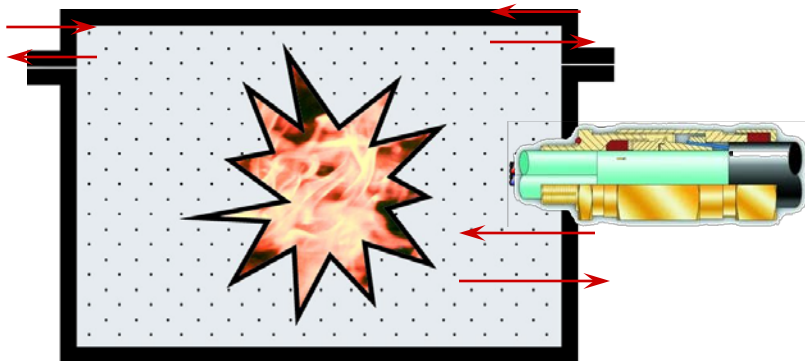


Indirect Entry, Gland Type Ex e
or Dual Certified Ex e/Ex d
gland

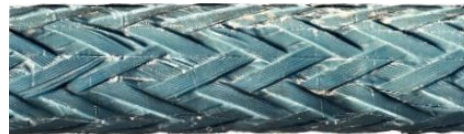
Direct Entry Ex nR Equipment



Gland Type Ex d Barrier Type providing gas tight Bi-Directional seal. Must be certified for Ex nR

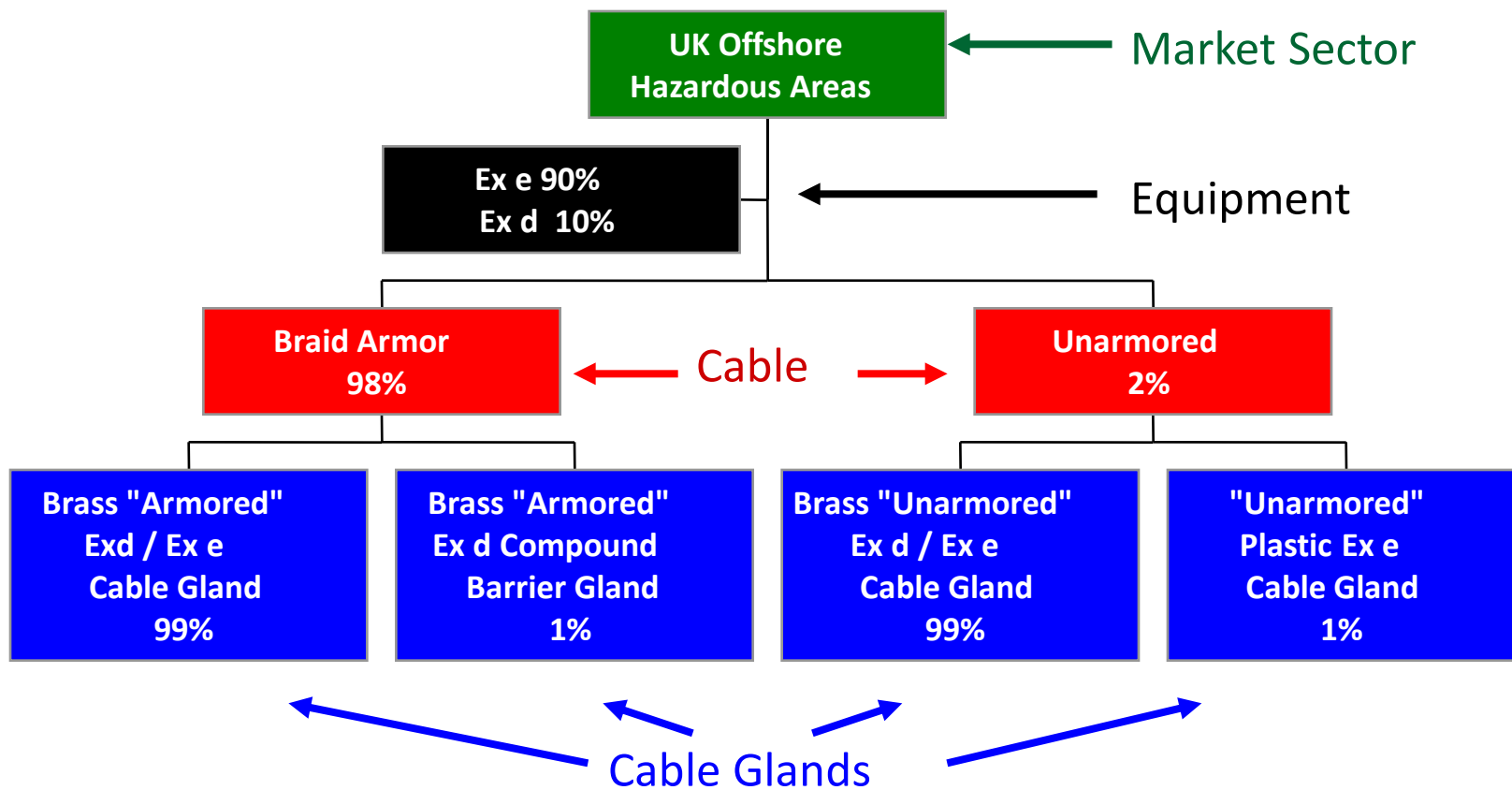


Gland Type Ex d/Ex e incorporating internal seal that provides Bi-Directional Gas-tight seal. Diaphragm Seals or compression seals not recommended. Gland must be Ex nR



← Due to this...

Wiring Methods – Cable Gland usage UK



Thread Information and Accessories

The standardization of thread type in the international world is typically around the Metric straight thread. However, other thread types do exist in the IEC world and if not Metric or a variation of, are a PG, BSP or BST thread type.

Accessories that are commonly used are:

Cable Shrouds – Becoming increasingly less used as they have a tendency to hold water in and cover up potential corrosion with glands.

Earth Tags – Otherwise known as “Banjos” or “Frying Pans”. Used to provide a means to ground the cable gland typically when used in non-metallic enclosures.

Locknuts – Typically used to secure the cable gland to the enclosure.



Thread Information and Accessories (Cont.)

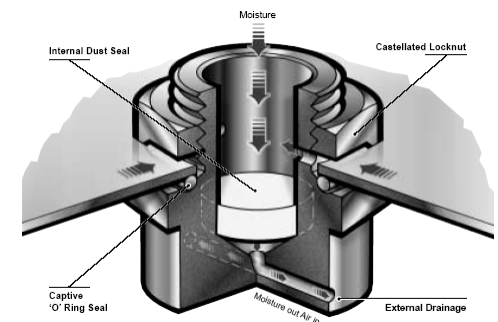
With the various threads used, thread adaptors and reducers are a common accessory widely used. One key point is that it is not allowed to reduce a reducer...

Shaker Washers – Typically used between the locknut and inside of an enclosure, shaker washers are used to provide a means to keep vibrations from loosening the cable gland to the enclosure.

IP washers – As the name implies, IP washers help maintain the IP rating between the cable gland and the enclosure...

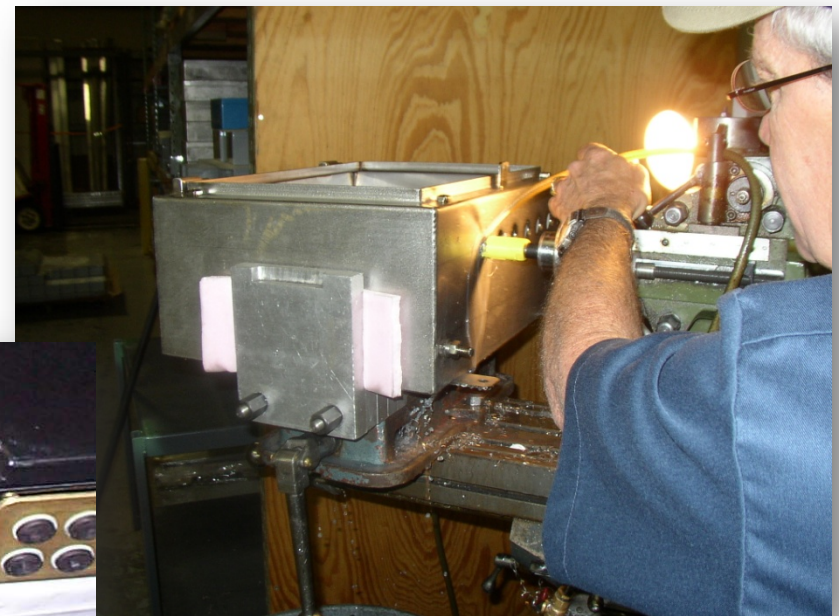
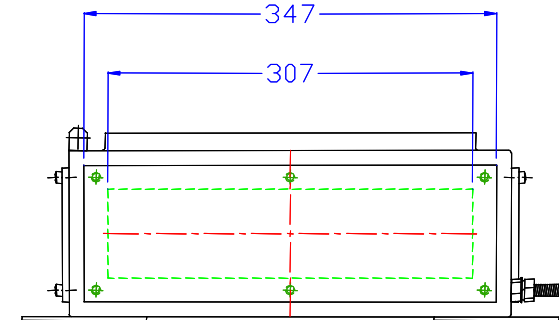
If you have a cable gland in a clearance hole, you have a metal to metal (or plastic) surface that provides no better than IP54 protection. IP washers go between the face of the gland and the outside of the enclosure.

Drains – Ex e drains that allow condensation to drain from the inside of enclosures due to moisture buildup during the normal heating and cooling process during the day and night.



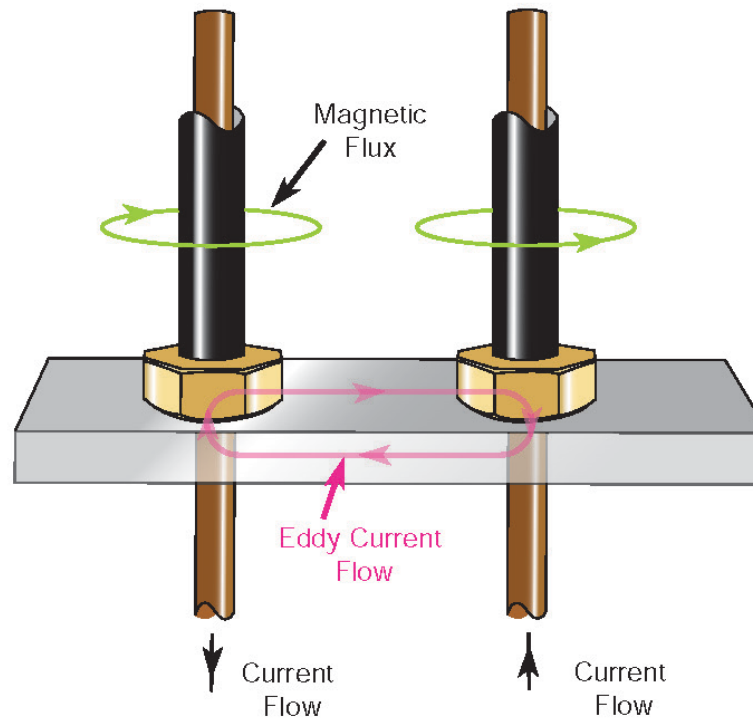
Cable gland spacing on enclosures

Cable glands clearance holes need to be considered when determining number and sizes of glands installed in enclosures. Always confirm gland cross corner clearance with manufacturer and template size of enclosure to confirm whether enough space exists for gland entries...



A note on single core cables entering enclosures

Eddy currents can overheat iron or steel cabinets, locknuts or bushings or any ferrous metal that completely encircles the single conductor cables. This presents no problem in multi-conductor cables, where the magnetic fields tend to cancel each other out. For single core cables, it is recommended that these cables enter metal enclosures through a non-ferrous plate such as aluminum....



Cable gland spacing on enclosures

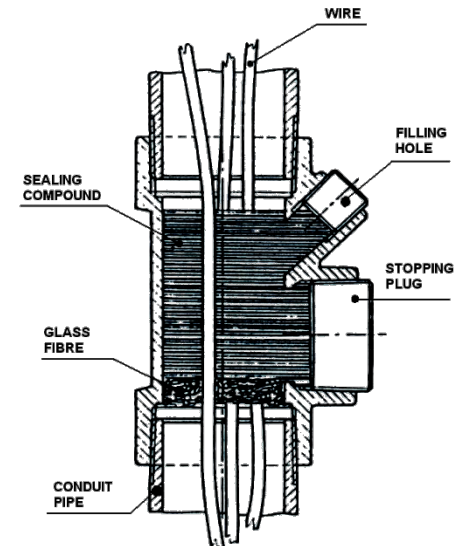
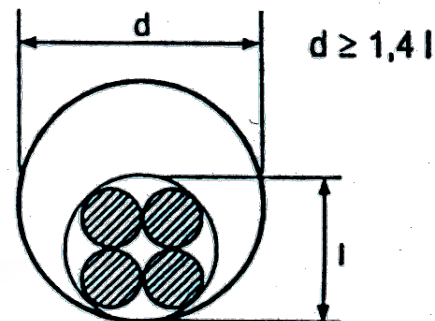
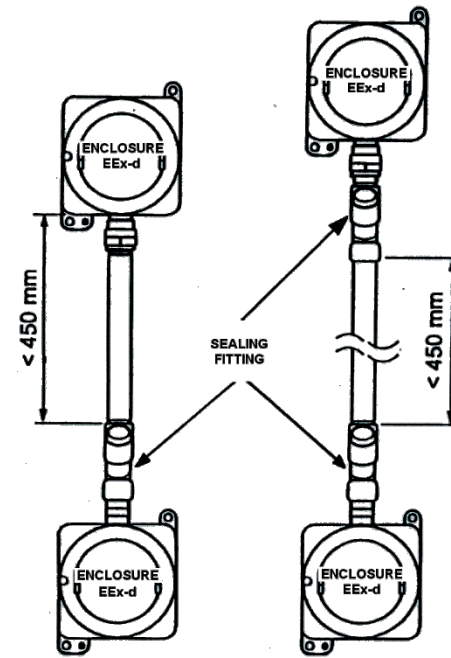
Traditional use of cable glands entering into an Ex e enclosure need a significant amount of excess space to allow for the use of a spanner or wrench to tighten the gland. The use of cabinet seals certified to Ex e can reduce the footprint of the enclosure required by as much as 50% or allow a doubling of cables to enter in the same space as traditional cable glands.



Ex 'd' Seals and Conduit Systems

Conduit Seals are commonly used with conduit systems for direct entry into Ex d enclosures. The maximum allowed distance from enclosure is 450mm. Like the US, installations also require seal fittings at boundaries. Also, all Ex d conduit bodies must be sealed when entries are 50mm or larger housing taps, splices, joints or terminals.

Conduit systems have a slightly different requirement in that countries typically mandate max. fill. In the case of most of the southern European countries, a max. fill of 60% is allowed. This differs with US regulations of typically 40% maximum conduit fill. Conduit systems are usually limited to 3000V or less. Above 3000V, cable systems are required...



Typical Wiring Practices with Conduit

All switching mechanisms should be omni polar where the neutral wire is always cut

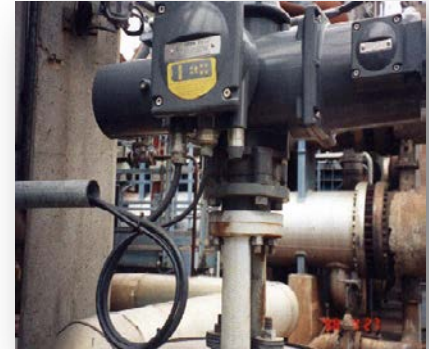
- MINIMUM allowed wire sizes : - Auxiliary Circuits (Controls) 1.5 mm/sq. - Power Circuits 2.5 mm/sq.
- Cables should be 3000V min. and “**flame-retardant**” type

Cables MUST protected against insulation damage generally due to :

- Impact damage
- Heat sources that could damage cables insulation
- Chemical substances that could cause insulation cables corrosion

In order to comply with above mentioned requirements, a proper choice of cables and cable routing is very important.

If “Cables Pass” far away from any place with risk of corrosion or accidental damage (i.e. cables for ceiling mounted lighting fixtures) a standard PVC insulated cables in proper cable trays are allowed. When cables come down to working areas, or pass beside to valves or other equipment that might release heat or corrosive substances that might damage cables insulation, it is recommended to pass relevant cables inside a galvanized steel pipes. If cables go to vibrating machines (example: electrical motors) pipes should be flexible hoses, for the last 500mm approx. connected to special cable glands with female threaded head which allow for flexible hoses direct connection to the gland nut, without leaving any part of cables uncovered.



Typical Wiring Practices with Conduit

Flexible Conduit for vibration and mechanical protection



Conduit for mechanical protection



Typical Wiring Practices with Conduit

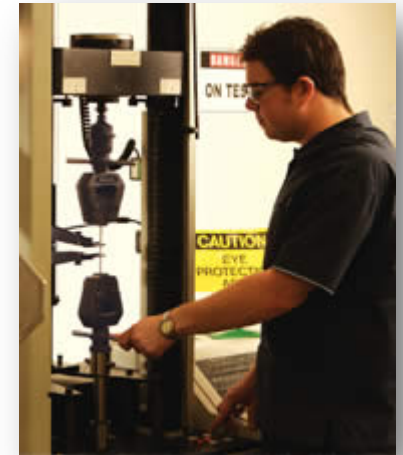
IEC 61386 is the new European standard governing the performance of flexible conduit (and rigid) systems in electrical installations.

Superseding the current European flexible conduit systems standards, EN 50086, IEC 61386 covers performance requirements for use of such products in electrical installation applications. The performance requirements covered include fatigue life, bend radius, operating temperature, non-flame propagation, IP ratings, impact resistance and pull-off strength

Tests to be carried out under IEC 61386:

The new IEC 61386 standard requires a number of tests to be carried out on specimen conduit materials. These include:

The Impact Strength Test - This is carried out on conduits over a range of different temperatures. The test is made on each specimen using an impact head with a defined profile. Conventionally, fracture behavior is studied, but under this test, it is the deformation (buckling) behavior that is also determined. The specimen passes the test if no fracture occurs after impact, and there is also no excessive permanent deformation.



Typical Wiring Practices with Conduit

The Peak Load Test - Under the requirements of this test, carried out on conduit specimens under standard ambient conditions (which is specified as 23°C at 50% relative humidity), the conduit is deformed by a defined amount between two plates.

The Reverse Bending Test (With Swinging Movements) - This test is based on a cyclic reversed bending of conduits under various temperatures. Under the requirements for the test, conduits are dynamically loaded and evaluated over the temperature limits. The number of bending cycles taken to fracture the conduit determines its strength.

The Self-Extinguishing Test - Under the requirements for this test, the conduit is exposed to a flame (from a standard burner). The time to ignition (if any), the flame propagation, and the time to self-extinguishing after flame removal are all parameters measured.



Typical Wiring Practices with Cable

A typical method of making final terminations to enclosures is to leave excess cable in a loop configuration to relieve any potential undue strain on the cable gland, and allow easier modifications if equipment needs to be replaced or repaired..



Typical Wiring Practices with Cable

