Metallic cable glands in hazardous area installations

50 years of explosion protected cable glands according to British Standard

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Figure 1: Metallic cable gland according to British Standard

The use of cable glands in hazardous area installations around the world has evolved over the last fifty years or so, and due to an array of different national codes and standards, a general need for a globalisation approach was realised. This move towards a global approach coupled with product developments and initiatives from various manufacturers, could result in a long term benefit but how much common application knowledge does the industry share, and do we have more clarity in selection, installation and use as a result?

If the two main codes of installation in hazardous areas, NEC and IEC, and the alternative methods of Area Classification, i.e. Class/Divisions, versus the Zoning principals, are compared it can be seen that there are distinct differences and it is not possible to mix the equipment approved under the two systems.

Although similar types of metallic cable glands may be used under NEC as well as IEC installation standards, their selection and deployment under NEC follows a strict set of national rules. For example a cable gland, or cable connector as it is usually referred to in North America, must be approved for use with a specified cable type that is also approved for the specific application in the hazardous location. Cables in fact cannot be used in hazardous locations unless they are firstly permitted to be used in that location under the NEC rules and secondly approved for use in the specific hazardous location. This is not the case with IEC installations where there is no approval system for cables intended for use in hazardous areas.

With the introduction of the Class & Zone system into North America and the adoption of UL/ANSI 60079 standards, it has become possible to utilise IEC based concepts into what were traditional NEC stronghold areas. However in respect of cable, wiring and cable glands, the NEC code of installation rules must always be observed even when classification by zone has been adopted.

This means that major exceptions to IEC practices still prevail in respect of cable gland selection and installation, making for fewer possibilities than would usually be expected under a comprehensively globalised regime.

Focusing our attention on the development of metallic cable glands approved for hazardous areas under European standards, we could highlight two main types, those for unarmoured cables and those for armoured cables. With armoured cables, typically complying with British →

A1	for unarmoured cable with an elastomeric or plastic outer sheath, with sealing function between the cable sheath and the sealing ring of the gland (Ex d-prevention of flame transmission)
A2	as type A1, but with seal protection degree IP66
A3	as type A1, but with an electrical bind for the metallic inner screen

Table 1: Cable gland type designations for unarmoured cables

B	no seal
C	single outer seal
D	single inner seal
E	Double (inner and outer) seal suffix ›1‹ = normal suffix ›2‹ = lead sheathed

Table 2: Cable gland type designations for armoured cables

Standards, e.g. BS 5308, BS 5467, BS 6346 & BS 6724, the associated cable glands must be able to maintain a reliable earth path.

Although we are still in a state of transition as the European Standards and the IEC Standards (EN/IEC 60079 series) become fully harmonised and integrated there are some interesting aspects to note in respect of cable glands.

Under the CENELEC and IEC regime there is no construction standard for the cable which is intended to be used in hazardous areas. Similarly, there is no dedicated standard for cable glands, as the trend has been set to combine this item in with the various parts of the standard EN/IEC 60079 pertaining to General Requirements, types of protection Flameproof Enclosures ›d‹, Increased Safety ›e‹, and Non-Sparking ›n‹ for example.

These two facts are intriguing when you consider that this has not always been the case when national standards are taken into account. In terms of cable glands for hazardous areas there is a danger that in the implementation of the more globalised approach, the essence of the new standards may have become diluted whilst encouraging new and less experienced manufacturers to enter the market. Ultimately if the standard is not sufficiently robust, and leaves opportunity for ambiguous interpretation then it will come as no surprise when any such loop holes are exploited, causing concerns over long term safety.

Looking at the long established UK model, the design strategy has been adopted virtually all around the world for both the cable, in terms of its mechanical protection, and the impact on wiring and earthing principals, and the application purpose of the mating cable glands. Inevitably these two items are inexplicably linked, especially when it comes to armoured cables.

There was in fact a UK standard for cable glands established as far back as 1967, BS 4121 and this covered cable glands with imperial threads intended for industrial and hazardous areas situations. This ran alongside and complemented the existing flameproof equipment standard BS 229. BS 4121 was replaced in 1973 by BS 6121 which introduced metric threads, and again this standard covered both industrial and hazardous areas cable gland products. Events that have occurred subsequently in Europe have meant that the prevailing UK national standard, BS 6121, has been replaced in part with a new European Standard, EN 50262, established in 1998, but this does not address the subject as a whole and is only related to industrial products.

Although many manufacturers of cable glands do not, and perhaps never did, adhere to the last complete edition of BS 6121:1989, instead favouring the lesser requirements of EN 50262, it is worthy of note that this 1989 edition of BS 6121 is still used by some manufacturers as the basis of their design. In practical terms there is a huge proportion of the developing world that has built its facilities and electrical infrastructure using BS 6121 as its main reference for cable gland specification. Because of the construction principals laid down perhaps 30 years ago under what could be construed as a more comprehensive document, to this day users still continue to call for product compliance in line with this well rounded and respected standard. EN 50262 on the other hand now offers manufacturers a broader range of options as to how they can choose to comply, so cable glands produced by different manufacturers to this standard may perform very differently from each other.

This may benefit a range of European cable gland suppliers, and also suit the needs of the majority of the user base in mainland Europe, but it will not always help the overseas user who has established facilities based upon the original British Standard and who wishes to continue maintaining these facilities to the same high standards.

Basic requirements of the national specific British Standards

Being the fore runner to later IEC requirements the BS 4121/BS 6121 standards established a variety of ground rules including the pull tests, impact tests, hydrostatic pressure tests, but also included maximum cable acceptance through the bore of the cable gland components which ultimately controlled the wall thickness of the cable gland to an acceptable level. Another very important factor covered by BS 6121 was the earth fault short circuit withstand capabilities of the cable gland and any associated earth connection tags, not to be overlooked particularly when armoured or lead sheathed cables are used.

What part of the BS 6121 standard is still retained by the IEC Standards?

In fact BS 6121 also established the industry standard cable gland type designations that still prevail today for cable and cable glands (Table 1 – 4).

In order to examine closer the particulars of the cable glands, we should first consider the variation in the cables used. Whilst currently there is no construction standard for the cable which is intended to be used in hazardous areas, examples could be shown as follows :

Armoured Cables

- Cables with single wire armour (W) – used extensively in onshore plant both above ground and directly buried in the ground, and is probably the most common type of armoured cable used in the world.
- Cables with pliable wire armour (T) – used extensively in the mining and quarrying industry particularly in underground deep coal mines, as it offers high level of mechanical protection but added flexibility compared with SWA.
- Cable with braid armour (X) – used onshore and offshore and comes in a wide variety of types, including galvanised steel wire, tinned copper wire, bronze wire, and is the standard for Marine shipboard cables, and the offshore oil and gas industry around the world, because of its high level of flexibility.
- Cable with strip armour (Y) – used onshore, offering heavy duty service, high level of mechanical protection but is probably the least common type of armoured cable.
- Cable with steel tape armour (Z) – primarily used onshore, often referred to as STA or DSTA, and the tape armour is manufactured in either steel or aluminium (ATA). This can mean a lighter, leaner and smaller diameter alternative to SWA, but may not be available from all cable makers.

IEE Wiring and Earthing Regulations and Requirements

When using armoured cables (or conduit), both in onshore and offshore or marine situations, any metallic parts of the cable (or conduit) must be earthed, and this also applies to the lead covering used in lead sheathed cables. Wherever armoured cables are used it is normal practice to terminate the metallic armour, and/or lead cover (lead sheath) in the body of a metallic cable gland.

In accordance with BS 7671:1992, the IEE Wiring Regulations 16th Edition, both the cable and the accessories used for its connection must be tested to ensure compliance with the required safety levels. Cable glands and their fixing accessories and earth tags must be selected correctly to ensure that any risk of electric shock to personnel from coming into contact with live parts due to inferior earth connection is avoided. These earthing components must therefore be able to meet the minimum short circuit fault current withstand tests of the associated cable, and also be installed by competent personnel in line with good engineering practices

The cable armour is primarily for mechanical protection, and as already stated, this metallic armour must be effectively earthed. In general, the armour wire current carrying capacity must be equal to 50 % of that of the largest current carrying conductor in the cable. The cable must be tested to determine its short circuit earth fault current rating, with the earth fault current being carried by the cable armour wires. Users should refer to the cable manufacturers design data for the short circuit fault current carrying capacity of the armour wires of each cable.

- SWA cables
  Cable glands connected to SWA cables must be able to provide earth continuity from the termination point of the armour in the cable gland body through to the equipment, if the enclosure is metallic, or via a metallic gland plate that is bonded to an external earth point, and/or directly to an external earth point via an earth tag. In the interests of safety most earthing systems associated with armoured cables will utilise a number of directly grounded external earth link cables connected to the earth tag which is in contact with the cable gland. Usually the cable would be earthed at one of its two ends as a minimum, and this approach ensures that in the event of a short circuit or earth fault in the cable, the quickest and most →

F	Flameproof enclosures ›d‹
e	Increased safety ›e‹
N	Non-sparking ›n‹

Table 3: Designation of type of protection

T	Pliable wire armour
U	Unarmoured
W	Single wire armour
X	Braid
Y	Strip armour
Z	Tape armour

Table 4: Designation of of cable armouring

direct route to ground will be achieved as a result of the design philosophy adopted. When multiple cable entries are required in non-metallic enclosures (e.g. GRP terminal box) that do not have an external earth point, the user may prefer to engage an external earth cable between each metallic cable gland via an earth tag. At least one of the earth tags would also be used to connect an earth cable directly to ground. This method of providing earth continuity is sometimes referred to as a ›daisy-chain‹ arrangement. The earth tag described above must also be tested to ensure that it can withstand the equivalent short circuit earth fault current test rating of the cable and cable gland, otherwise the system will not have adequate (safety) earth protection.

- LC/SWA or LC/PVC/SWA cables
  In addition to the standard requirements for SWA cables, there is a set of special guidelines for lead covered cables intended for direct burial in the ground of hydrocarbons processing and refinery sites. These guidelines were introduced in the UK by the Oil Companies Material Association (OCMA) and responsibility for these was subsequently transferred to EEMUA, the Engineering Equipment and Material Users Association. The EEMUA Publication 133 ›Specification for Underground Armoured Cable Protected Against Solvent Penetration and Corrosive Attack‹ defines the requirements of the petroleum industry for underground lead-sheathed cables for use where protection against solvent penetration or corrosive attack is required.
- When the cable is LC/PVC/SWA the addition of the lead sheath introduces another metallic part of the cable that could effectively become live in the event of an earth fault or induced voltage and this must also be earthed. Any metallic parts used to terminate the lead sheath as part of the earth path must also be tested and documented to demonstrate that adequate levels of protection are maintained. In the case of LC/SWA cables the earth fault short circuit levels will be increased due to the parallel earth path existing between the armour wires and the lead sheath. It is important therefore that the whole cable gland and earth tag arrangement is tested on lead sheathed cable to ensure that the arrangement can withstand the overall affects resulting from short circuit in the cable armour/lead sheath.

If the cable glands and accessories chosen have not been tested, and are incorrect the connection of the earth circuit via the cable armour will become the weakest link in the system, and could result in potential fatality, lost time incident (LTI) or other accident.

Cable Gland Selection according to IEC 60079-14

Concerning the subject of cable glands to maintain integrity of type of protection Flameproof Enclosures ›d‹ using direct cable entry into the flameproof enclosures, special selection criterions have to be considered as defined in Section 10 of IEC Standard IEC 60079-14 ›Electrical apparatus for explosive gas atmospheres Part 14: Electrical installations in hazardous areas (other than mines)‹

In order to achieve compliance with the prevailing Installation Code of Practice and in particular IEC 60079-14, it is necessary to evaluate the function of the equipment, the cable gland, and the cable, and in order to satisfy the conditions of the applicable standards compatibility of all three with each other must be verified. Section 10 of IEC 60079-14 ›Additional requirements for type of protection ›d‹-Flameproof enclosures‹ for the selection of cable glands is required to be followed, and this sets out some specific rules to ensure integrity and safe operation of the installed equipment.

The cable entry system shall comply with the following:

- Cable entry device in compliance with IEC 60079-1 ›Flameproof enclosures and certified as part of the apparatus when tested with a sample of the particular type of cable‹
- Thermoplastic, thermosetting or elastomeric cable which is substantially compact and circular, has extruded bedding and fillers, if any, are non-hygroscopic; may utilize flameproof cable entry devices, incorporating a sealing ring selected in accordance with Figure 2.

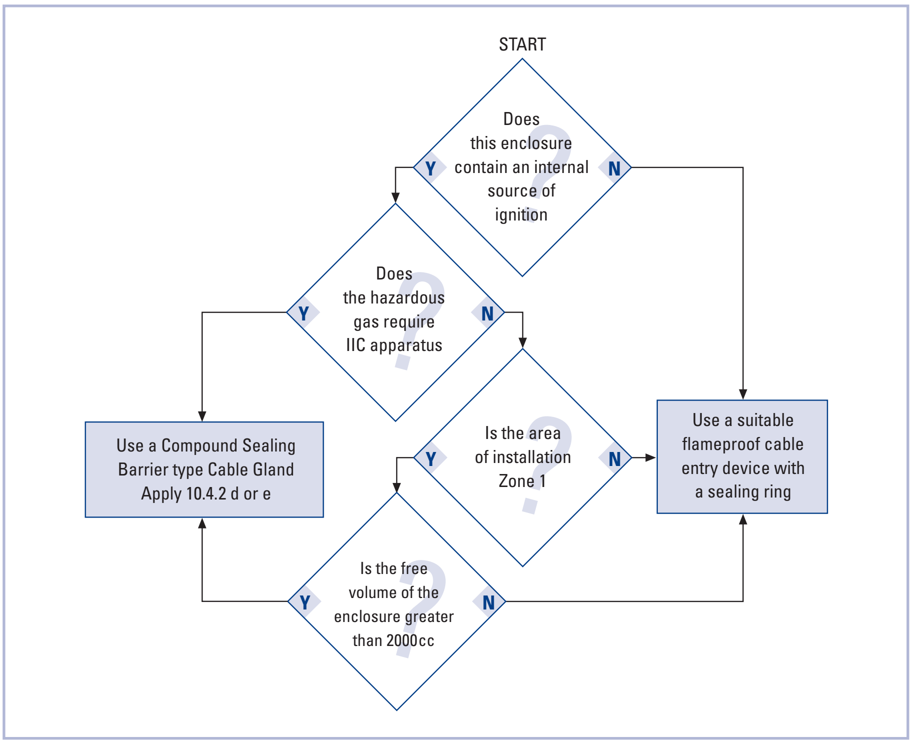
On condition the cable gland is not certified as part of the equipment but tested and certified as a separate component and the used cable is substantially compact and circular the selection chart in section 10 can be used.

If the cable is not round in appearance, or visually appears to allow air to be passed through its interstices due to the fact that the cable construction is not adequately filled, then this would give cause to select a compound barrier type cable gland.

In the case of flameproof enclosures type ›d‹, the function of the elastomeric sealing ring that is applied to the part of the cable entering the equipment is to provide a gas tight seal around the cable bedding and prevent explosion from penetrating this cable sealing point so that the explosion cannot be transmitted to the external atmosphere.

If the cable is not round, this means that it is not possible to rely upon an elastomeric seal to perform a sealing function around the cable sheath. An example of a cable that fits this scenario is a twisted pair instrument

Figure 2:
Selection chart for cable entry devices into flameproof enclosures for cable complying with EN/IEC 60079-14 Section 10.4.2.b



cable where the insulated conductors beneath the inner cable bedding do not usually offer a round (circular) surface on which to seal. If the inner bedding follows the same shape, then an elastomeric seal may struggle to seal effectively around the cable circumference. The effect is often more noticeable with single pair cables, and it may be necessary to fit a compound sealing barrier type cable gland to overcome the situation, depending upon the form of protection and cable entry configuration of the apparatus enclosure.

Equally, if the cable is not adequately filled, and allows the passage of air or gas to flow along the cable length then there would be no protection to the inner part of the cable when an elastomeric sealing ring is used. In this case a compound barrier type cable gland is the only safe solution and this is needed to maintain the integrity of the equipment as explained above, and prevent gas migration from equipment to equipment, or hazardous areas to safe areas.

In conclusion it should be acknowledged that when it comes to the correct selection, deployment or installation and maintenance of cable glands in hazardous areas, referring merely to the product certification is not enough, and the guidelines laid down in the available installation code(s) of practice should be strictly observed. The code of practice for any installation will play a vital part in the overall safety of the plant and failure to comply with it will usually lead to non-conformities and incompatibilities taking place that will inevitably compromise some aspect of safety in the ongoing operations.

A2	Cable gland for unarmoured cable with outer seal
BW	Cable gland for SWA cable without seal
CW	Single seal cable gland for SWA cable
E1W	Double seal cable gland for SWA cable
CX	Single seal cable gland for braided cable
E1X	Double seal cable gland for braided cable
CWe	Single seal cable gland for SWA cable, type of protection Increased Safety ›e‹
E1We	Double seal cable gland for SWA cable, type of protection Increased Safety ›e‹ (*)
CXe	Single seal cable gland for braided cable, type of protection Increased Safety ›e‹
E1FW	Double seal cable gland for SWA cable, type of protection Flameproof Enclosures ›d‹ (*)
E1FXZ	Double seal cable gland for braided or steel type armour cable, type of protection Flameproof Enclosures ›d‹ (*)
E2FW	Double seal cable gland for lead covered SWA cable, type of protection Flameproof Enclosures ›d‹ (*)
A2F	Cable gland for unarmoured cable with outer seal, type of protection Flameproof Enclosures ›d‹ (*)

Note (*): Recent trends have led several manufacturers to offer cable glands that conform with the requirements of the types of protection Flameproof Enclosures ›d‹ and Increased Safety ›e‹ and are approved for both, thereby making the designation E1FW/e (or simply E1FW) a single product applicable for Ex d and Ex e equipment, resulting in the withdrawal of the increased safety version, e.g. E1We (reduction of number of types on stock)

Table 3: Cable type designations