

Considerations regarding the choice of cable glands for electrical equipment used in potentially explosive atmospheres

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Abstract. The evaluation of explosion-proof electrical equipment for certification is particularly important given the risk of explosion and must be minimized. This in order to ensure the safety of life, health of workers, to prevent damage to goods and the environment when they meet the essential security requirements at European level. Directive 2014/34 / EU states that equipment used in explosive atmospheres must be designed to operate without endangering the environment for which it is intended. This paper presents a comparison between the different types of cable glands for electrical apparatus by comparing some common characteristics that are important for maintaining the integrity of explosion protection. Consequently, this paper intends to be the precursor of a practical guide for the selection and implementation of different types of protection on the apparatus intended for use in areas with hazard of explosive atmospheres, both for designers and manufactures. This state of fact is negatively more emphatic because, lately, the groups of standards from this field in the world, Europe and Romania have a peculiar dynamic caused especially by the homogenisation and generalisation process opened and maintained by IEC.

1 Introduction

Generally speaking, designing and manufacturing of electrical apparatus benefits lately of special advantages, offered by the appearance of new components (integrated) and technologies, which makes the time that passes from enouncing the idea until physical achievement of the apparatus to be relatively short, and the process involved by that to be a monotonous one.

But, when the problem of adapting this apparatus to the particularities of use them in atmospheres with explosion hazard, the above mentioned process is considerably slowed, not by the missing of consecrated components for such processes, but especially by the leak of experience and knowledge regarding the standard requirements, referring to construction and using of electrical apparatus in areas with hazard of explosive atmosphere.[2]

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This state of fact is negatively more emphatic because, lately, the groups of standards from this field in the world, Europe and Romania have a peculiar dynamic caused especially by the homogenisation and generalisation process opened and maintained by SR-EN.

Evaluation and testing of equipments that compose an explosion-proof system, in purpose of certification, is very important considering the existing explosion risk which has to be minimized to ensure peoples health and security, as well as to prevent goods damage and, not in the last instance, to protect the environment.

Using electric energy in potentially explosive atmospheres brings forward several particularities therefore the problems that appear during the design, construction and operation of electrical devices and installations brings forward numerous difficulties, their approach requiring special attention considering all the technical, economical and labour safety aspects. [1] [2]

The risk of explosion may appear in all the fields of activity in which flammable substances are involved, such as gases, vapours, dusts, mists, which mixed with air may result in potentially explosive atmospheres. [1], [2]

To prevent the ignition of explosive atmospheres, the electrical equipment used in such areas must be made with different types of protection so that it can not ignite the explosive mixture surrounding the electrical equipment. [1], [2]

The type of protection means the specific measures applied to electrical equipment to avoid ignition of a surrounding explosive atmosphere. [2]

For each type of protection applied to electrical equipment used in potentially explosive atmosphere, a wide range of type tests have been developed so that they can be used safely [2]

In addition to type tests, on the cable glands and blanking elements, specific tests are carried out to determine whether these components are in compliance with specific standards

The tests to which explosion-proof cable glands have to be submitted include the tensile test, the mechanical strength, and the sealing test (specific to flameproof enclosure protection type cable entries) [3], [4]

2 Cable glands for equipment with protection type “d” and “e”

Cable glands for equipment with protection type “d”, integral or separate, shall meet the requirements of SREN standard 60079-1. Where cable glands are integral with the enclosure or specific to enclosure, they shall be tested as part of the enclosure concerned.

Where cable glands are separate:

- a) Threaded Ex cable glands and non-threaded Ex cable glands (for Group I only) can be evaluated as equipment. Such cable glands do not have to be submitted to the type tests nor to the routine test
- b) Other cable glands can only be evaluated as an Ex component
- c) Sufficient information shall be provided in the documentation to facilitate the mounting in holes

When installed in accordance with the instructions in SR-EN 60079-0, the cable glands shall not invalidate the characteristics specific to the type of protection of the electrical equipment on which they are mounted. This applies to the full range of cable sizes specified by the cable glands manufacturer as suitable for use with those cable glands. The cable glands may form an integral part of the equipment, ie they may be considered to be elements or parts of major importance, inseparable from the equipment housing. In such cases, the cable glands must be tested together with the equipment. [3]

Unwired cable glands must be certified as Ex components or certified with the complete equipment.

Threaded cable glands and cable trays must be certified as Ex cable glands, certified as Ex components or certified together with the complete equipment.

Cable glands, whether integrated or separate, must meet the following relevant requirements: Cable sealing, filling compounds, clamping, lead-in of cable, release by a tool, fixing, degree of protection.

The ingress protection between the cable and the cable gland shall be ensured by one or more of the following means:

- a) an elastomeric sealing ring;
- b) a metallic or composites sealing ring;
- c) a filling compound;
- d) other suitable means.

The cable sealing may be made of a single material or a combination of materials and shall be appropriate to the shape of the cable concerned.

Cable glands shall provide clamping of the cable in order to prevent pulling applied to it from being transmitted to the connections. Such clamping can be provided by the cable sealing means or by an integral clamping device. It shall be capable of meeting the relevant type tests.[4]

Cable glands for Group II or III Ex equipment, without a clamping device shall also be accepted as complying with SR-EN 60079-0 if they are capable of passing the clamping tests with values reduced to 25% of those required. Such cable glands shall be marked with the symbol „X” and the specific condition of use shall specify that the user shall provide additional clamping of the cable to ensure that pulling is not transmitted to the terminations.

Cable glands shall not have sharp edges capable of damaging the cable. In the case of flexible cables, the point of entry shall include a rounded at an angle of at least 75 °, the radius R of which is at least equal to one-quarter of the diameter of the maximum admissible cable in the entry but with need not exceed 3 mm.

Cable glands shall be designed so that after installation they are only capable of being released or dismantled by means of a tool.

The means of fixing cable glands to enclosures of equipment shall be capable of retaining the cable gland when subjected to the mechanical tests of clamping and resistance to impact.[3]

The type tests for cable glands are: tests for tightening unarmored cables, insert cables and reinforced cables, clamping test, mechanical strength test, test for impact resistance, test for the degree of protection of cable glands.

The tests shall be performed using for each type and size of input a sample of the reinforced cable having the smallest specified size. The reinforced cable sample must be mounted in the cable glands clamp. Then apply torque to the screws (in the case of the flange clamp), or to the nut (in the case of the threaded clamp), in order to press the clamp and prevent the reinforcement from slipping. The torque thus determined must be used as the reference torque.

The clamping device must prevent the reinforcement from slipping when the force applied to the reinforcement has a value, in newtons, equal to:

- 80 times the value in millimeters of the cable diameter over the armature for Group I equipment, or
- 20 times the value in millimeters of the cable diameter over the armature for Group II or Group III equipment.

For sealing tests, each sealing ring must be mounted on a clean, dry cable sample; or a clean, dry, smooth metal mandrel with a maximum surface roughness Ra of 1.6 µm, with a diameter equal to the smallest allowable cable diameter in the ring as specified by the cable entry manufacturer. For this test, the cable glands with the cable or mandrel shall be tested after it has been secured to a suitable housing, ensuring that the method of sealing at the point

of contact between the entrance and the housing does not compromise the test result. Before performing the required IP tests, the samples shall be subjected to thermal endurance tests and impact resistance tests. [3]

Cable glands sealed with setting compound

For each size of cable gland, the test shall be carried out using metal mandrels, the number and diameter of which equate to the maximum diameter over cores with the maximum number of cores specified by the manufacturer in accordance with the SR-EN 60079-0.

The setting compound is prepared following the manufacturer's instructions and then introduced into the appropriate volume. It is allowed to harden for the appropriate time.

The assembly is then mounted into the hydraulic testing device, defined in **Error! Reference source not found.** and the same procedure is applied. The acceptance criteria are also the same.

For each size of conduit sealing device, the test shall be carried out using metal mandrels, the number and diameter of which equate to the maximum number of cores specified by the manufacturer in accordance with the requirements of SR-EN 60079-0.

The setting compound is prepared following the manufacturer's instructions and then introduced into the appropriate volume. It is allowed to harden for the appropriate time.

The assembly is then mounted into the hydraulic testing device, defined in **Error! Reference source not found.** and the same procedure is applied. The acceptance criteria are also the same.

A torque of twice that required in the sealing test shall be applied to the compression element; however, the value of this torque, expressed in Nm, shall always be at least three times the value in millimetres of the maximum permissible cable diameter when the cable gland is designed for circular cables or equal to the value in millimetres of the maximum permissible cable perimeter when the cable gland is designed for non-circular cables.

The cable gland is then dismantled and its parts are examined.

A torque of twice that required in the sealing test shall be applied to the compression element screws; however, the value of this torque shall always be at least equal to the following values:

M6: 10 Nm	M12: 60 Nm
M8: 20 Nm	M14: 100 Nm
M10: 40 Nm	M16: 150 Nm

The cable gland is then dismantled and its parts are examined.

Marking cable glands

Cable glands shall be marked in accordance with SR-EN 60079-0 and, unless otherwise specified by the manufacturer, shall include marking for protection type "e" in addition to marking for any other relevant type of protection; and, if it is a threaded inlet, with the type and size of the thread. [5]

MARKING OF CABLE SEALING RINGS

Cable sealing rings, for cable entries that allow more sizes for the rings, must be marked with the minimum and maximum diameters, in millimeters, of the permitted cables.

If the sealing ring is secured to a metal washer, marking can be performed on the washer.

The cable sealing rings must be identified allowing the user to determine if the ring is suitable for cable entry.

If the inlet and ring are intended to be used at temperatures outside the range of -20°C to $+80^{\circ}\text{C}$, they must be marked with the temperature range. [3]

Cable glands for equipment with protection type "d", integral or separate, shall meet the requirements of SREN standard 60079-1. Where cable glands are integral with the enclosure or specific to enclosure, they shall be tested as part of the enclosure concerned.

Where cable glands are separate:

- d) Threaded Ex cable glands and non-threaded Ex cable glands (for Group I only) can be evaluated as equipment. Such cable glands do not have to be submitted to the type tests nor to the routine test
- e) Other cable glands can only be evaluated as an Ex component
- f) Sufficient information shall be provided in the documentation to facilitate the mounting in holes

3 The sealing test for cable glands [1]

The sealing test for the cable glands shall be carried out using, for each type of cable gland or conduit sealing device, one sealing ring from each of the different permitted sizes. In case of elastomeric sealing rings, each ring is mounted on a clean, dry, polished mild steel cylindrical mandrel of diameter, equal to the smallest cable diameter permissible in the ring, as specified by the manufacturer of the cable gland or conduit sealing device.

In case of metallic or composite sealing rings, each ring is mounted on the metal sheath of a clean dry sample of cable, of diameter equal to the smallest value permissible in the ring, as specified by the manufacturer of the cable gland or conduit sealing device. [4]

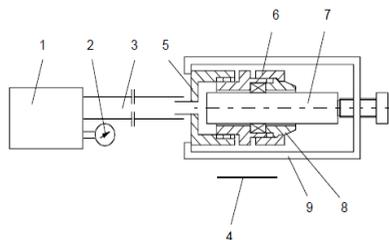
In the case of sealing rings for non-circular cables, each ring is mounted on a clean dry sample of cable, of perimeter equal to the smallest value permitted in the ring, as specified by the manufacturer of the cable gland or conduit sealing device.

The assembly is then fitted into the entry and a torque is applied to the screws (in case of a flanged compression device) or the nut (in case of a screwed compression device) to obtain a seal under a hydraulic pressure of 2000 kPa for group I and 3000 kPa for group II. [4] The torque values may be determined experimentally prior the tests, or they may be supplied by the manufacturer of the cable gland or conduit sealing device.

The assembly is then mounted into a hydraulic testing device using coloured water or oil as the liquid, the principle illustrated in Figure 1. The hydraulic circuit is then purged. The hydraulic pressure is then gradually increased.

The sealing is considered satisfactory if the blotting paper is free from any trace of leakage when the pressure has been maintained at 2000 kPa for group I and 3000 kPa for group II at least 10 s. [3]

It may be necessary to seal all the joints of the cable gland or conduit sealing device mounted in the test device, other than those associated with the sealing ring under test. When a sample of metal-sheathed cable is used, it may be necessary to avoid the application of a pressure to the ends of the conductors or to the interior of the cable.



Components
 1 hydraulic pump
 2 pressure gauge
 3 hose
 4 blotting paper
 5 adapter

6 sealing ring
 7 mandrel metal-sheathed cable
 8 compression component
 9 retaining clamp

Fig. 1. The standard design of the device for the sealing tests for cable glands

4 Conclusions

According to the requirements in force, in the process of certification of Ex equipment cable entries must be tested in order to verify if the explosion protection characteristics are maintained at their level. In this paper were revealed the tests to be carried out: Tensile test for cable glands; sealing test for cable glands. Also it must be determined the mechanical strength of the cable glands and the tensile test for cable glands shall be performed.

To protect people who work in explosive environments, it is important that equipment operating in such areas to comply with the requirements in force, and be properly maintained.

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