FUNDAMENTAL OF Ex-d EQUIPMENT

This protection technique (Ex d) involves the use of a flameproof enclosure. It is governed by the Standard IEC 60079-1. Flameproof enclosures are among the protection techniques that are permitted in Zone 1 and Zone 2 locations. The letter “d” in the marking for flameproof comes from the German “druckfeste Kapselung”, which means pressurized encapsulation. In North America, the concept is known as ‘explosionproof’.

Note that flameproof equipment is not fireproof: Ex d equipment is able to withstand an internal flame for a few milliseconds but is not designed to withstand an external fire.

Cells and batteries in which the release of electrolytic gases (either due to natural ventilation or through a pressure-relief valve) is expected during normal operation are not permitted inside a flameproof enclosure. Such gases released inside could increase the internal pressure and mix with gases entering from outside the enclosure. The creation of a combustible mixture of gases must be prevented!

How does the flameproof protection technique work?

Those parts of an electrical device that are capable of igniting an explosive gas atmosphere are built into a flameproof enclosure that can withstand the pressure that results from an internal explosion within the ambient temperature range (-20 °C to +40 °C). If flameproof enclosures are used outside of the standard ambient temperature range, they must be proven to be suitable as per IEC 60079-1. Electrical equipment using this protection technique is allowed to have ignition sources such as sparks and hot spots internally. The role of the enclosure is to confine an explosion inside the enclosure and prevent it from spreading to the outer environment.

What is the role of the flamepath?

When the enclosure is constructed, there may be a gap between the mating surfaces (e.g., of the lid and the body of the enclosure). There are also other surfaces that are joined together to make the enclosure. In all cases, the mating surfaces must be of certain critical dimensions such that, if ignition occurs inside the box, the resultant flame cannot come out through the path left by the mating surfaces. This path is called a flamepath.

Created by the interface between different parts of the enclosure, the gap in the flamepath allows gases to exit and cool down so they cannot trigger an explosion in the environment outside the enclosure. Simply stated, the flamepath is the path that would be taken by the flame if allowed to escape from inside the enclosure to the outside.

Critical dimensions - the length and gap size of the flamepath, as well as the volume of the enclosure, are dictated by the Standards. The flamepath must be designed so that it quenches the flames of an explosion and prevents the flame from exiting. At the same time, the flamepath must allow the quick exit of the gases inside. Flameproof enclosures are designed with the smallest gaps that are possible, while still retaining the flamepath’s effectiveness.

Why are the joints of the enclosure significant?

There should be no way for a flame to exit the enclosure. The method by which the enclosure is held together is therefore critical to its effectiveness. Joints may be sealed; otherwise, they become a flamepath. A threaded joint that connects two parts of the enclosure for example, is a flamepath.

There are a few types of joints used: sinter, flanged, spigot, threaded and cylindrical, to name several. They differ in terms of their ease of construction, likelihood of emitting ignition-capable particles, tightness of fit, ease of maintenance, and efficiency in preventing flame transmission.

For each type, the Standards dictate the design and testing requirements.

What features impact the effectiveness of a flameproof enclosure?

Some of the features that impact the effectiveness of a flameproof enclosure are these:

a. The strength of materials used to construct the enclosure
b. The size and nature of the flamepath
c. The manner in which cable entry devices are connected to the enclosure
d. Internal compartment layout
e. The opportunity for pressure piling

a) Strength of Materials Used to Construct the Enclosure

Given that an explosive atmosphere is allowed to enter the enclosure, the enclosure must be strong enough to contain an explosion. Both the metallic and non-metallic materials that are part of the flamepath or constitute the enclosure walls must be strong enough to withstand the explosion pressure and impact. Similarly, the materials must be able to survive any naturally occurring physical damage to the exterior of the enclosure that could invalidate the integrity of the flamepath (if the enclosure is bumped, for example).

if any portion of the flamepath or walls of the enclosure is made of non-metallic material, these materials must be just as strong as metallic materials and similarly need to withstand the explosion pressure and impact.

b) The Size and Nature of the Flamepath

There are normally gaps in flameproof enclosures. Generally, there are two essential properties of a flamepath: the clearance (the size of the gap) and the length of the path. By design, gaps in the flamepath must be narrow enough to cool the hot , pressurized, burning gases before they can come into contact with the external atmosphere. The flamepath must quench any flame before it reaches the outside atmosphere. It is not possible or desirable to design an enclosure with no gaps between the various parts. An allowable gap between different parts is accepted, but strictly defined in the Standards. Gaps help to relieve the pressure inside the enclosure caused by an explosion.

The design of the enclosure must also ensure that the gaps are not damaged mechanically if an explosion does take place.

c) The Manner in which Cable Entry Devices are Connected to the Enclosure

Because cables enter enclosures through a cable entry hole (which is a flamepath) normally provided during the manufacturing, cable entries in Ex d enclosures must satisfy the requirements in the Standards for flameproof enclosures. Cable connections in a flameproof enclosure may be either "direct entry" or "indirect entry".

Direct Entry

Direct entry connection means that the connection facilities (the terminal block) are inside the enclosure for connection outside. For direct entry, cables enter flameproof enclosures via a cable gland (made of metallic or non-metallic materials) or conduit. Cable glands of a given pressure rating are basically mechanical cable entry devices. They are sealed onto the cable. Flames and sparks are prevented from travelling from the electrical equipment to the environment outside the enclosure. Cable glands allow cables to be safely passed into the enclosure.

The threaded hole must satisfy the requirements for threaded joints that are in the Standards. The word "direct" is used to describe them because the external circuit (power supply) is directly connected to the terminal block of the enclosure to energize the circuit within the enclosure. Cable glands offer a safe and secure connection between the electrical device and the cable to which it's connected.

Cable glands must not be opened when a circuit is energized.

Indirect Entry

An indirect entry cable connection has a separate terminal box, which may be connected to the main enclosure by bushing or a sealed flying lead. The advantage of an indirect entry is that wiring does not directly enter the flameproof enclosure. The cable bushings are installed by the manufacturer of the enclosure, which can therefore be tested at the factory. The installer needs only to have access to the bushing or a sealed flying lead for wiring termination externally, but not the flameproof enclosure itself, in order to connect the wires.

d) Internal compartment layout

The internal geometry, dimensions and volume of the enclosure are all critical to its effectiveness. The amount of heat and pressure produced by an explosion are directly proportional to the free internal volume of the enclosure. The enclosure's volume must therefore be taken into account when designing the flamepath. The larger the volume, the longer the flamepath needs to be and the smaller the gap needs to be.

e) The Opportunity for Pressure Piling

Pressure piling involves, as the name implies, the build-up of pressure that is higher than the expected peak pressure. Pressure piling can happen when explosion proof enclosures are not designed and installed properly for use in a hazardous area. The result of pressure piling can lead to a catastrophic event. (See our article "Pressure Piling")

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What levels of protection can be provided by a flameproof enclosure?

Electrical equipment within a flameproof enclosure "d" can be designed with various levels of protection, which determine the overall equipment protection level:

- a) Level of Protection "da" (EPL "Ma" or "Ga") - The marking Ex da EPL Ga means the equipment is certified for zone 0, but only applies to catalytic gas sensors, not general equipment. The maximum free internal volume cannot exceed 5 cm^3.
- b) Level of Protection "db" (EPL "Mb" or "Gb") -Ex db, EPL Gb, certified for Zone 1 – this is the new marking for Ex d and will remain the most common flameproof version by far.
- c) Level of Protection "dc" (EPL "Gc") - Ex dc, EPL Gc, certified for Zone 2 – this replaces 'enclosed break' devices, previously certified Ex nC. However, Ex dc (and nC) devices are limited to a free internal volume of 20 cm3, so have limited application. The most common device with a small internal volume is the micro-switch, but, for commercial reasons, this is much more likely to be certified "db".

How is the effectiveness of flameproof enclosures maintained during installation and monitoring?

Proper installation and maintenance play an important role in safety of the flameproof enclosures.

Because of the critical safety function that they serve, flameproof enclosures must be properly installed, monitored and maintained in order to remain effective. Grease used to prevent corrosion must not be wiped off during installation, for example. Screws that hold the lid on the enclosure must be checked in case they have loosened. The flameproof characteristics can easily be damaged or destroyed as a result of corrosion, careless handling, and misuse. Tools used to address corrosion must not damage the surface of the enclosure. Attention must be paid any time something happens such that the condition and size of the flamepath are affected. Corrosion of the mating surfaces, and physical damage through careless handling when the housing is opened for inspection and repair, can increase the gap dimensions of jointed surfaces above the maximum safe gap and destroy the flameproof characteristics. The Code of Practice, maintenance guidelines, and manufacturer's recommendations should be followed for effective maintenance, in order to maintain the integrity of the flamepath.

Minor damage to the flamepath is acceptable, requiring an engineering judgement. If the surface becomes deeply pitted with rust or has a deep scratch across the entire flamepath, then replacing the equipment should be considered. For larger, more expensive items, repair (as per IEC 60079-19) may be a cheaper option. If serious damage to a flameproof joint requires welding or machining, such a repair is beyond the scope of a maintenance electrician. The part should be replaced. The manufacturer must be contacted to obtain the original flamepath dimensions: the size of the gap and the length of the flamepath so the repair can reproduce them.

What are some examples of electrical devices that use the flameproof protection technique?

The following are examples of equipment to which the flameproof protection technique is typically applied. Each of these examples has make/break components that can result in arcing or heated surfaces:

- Motors with slip rings and commutators
- Three-phase cage induction motors
- Switchgear with N/C and N/O contacts such as manual motors
- Starters, circuit breakers and air-break contactors
- Control devices
- Plugs and sockets
- Luminaires