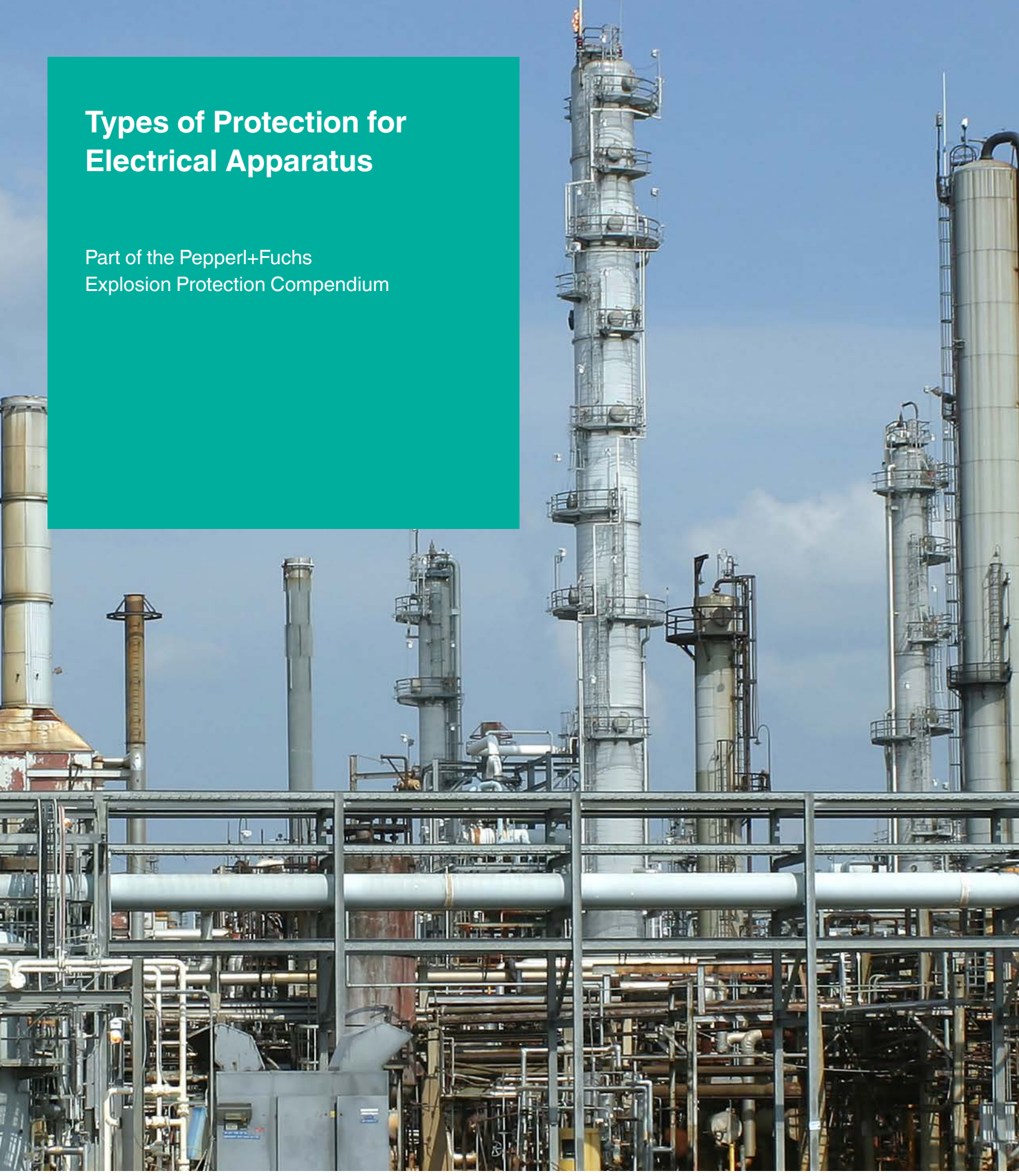
Types of Protection for Electrical Apparatus

Part of the Pepperl+Fuchs
Explosion Protection Compendium



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Disclaimer

The contents of this publication have been compiled by the editor with due and thorough regard for the legal regulations valid at the date of publication and of established technical measures. Nevertheless, incomplete, inaccurate, or ambiguous assertions cannot be excluded. The publication consists of several individual volumes that contain general information on explosion protection.

Adherence to local, national, and international explosion protection laws and standards is a fundamental obligation of plant designers and operators. The contents of this publication are not intended for and are not suitable for assessing the hazard situation ~~of~~ a specific plant.

Explosion protection regulations are subject to legal guidelines and can vary by country. Further, industrial plants can differ greatly from one another in their design, materials used, and methods of operation. The individual volumes of this compendium provide an overview of topics relating to explosion protection. With this in mind, the technical and organizational measures for explosion protection can only be detailed generally and thus incompletely. In a given specific case, each plant operator must determine the requirements and approach based on an individual hazard assessment, and implement and document these in a fashion verifiable in accordance with the national regulations.

International and European IEC/EN standards are generally referenced in this publication. In the United States and Canada, most IEC/EN standards have UL or CSA national harmonizations. The national harmonizations are based on the IEC/EN standards but are not exactly the same.

With regard to the supply of products, the current issue of the following document is applicable: The General Terms of Delivery for Products and Services of the Electrical Industry, published by the Central Association of the Electrical Industry (Zentralverband Elektrotechnik und Elektroindustrie (ZVEI) e.V.) in its most recent version as well as the supplementary clause: “Expanded reservation of proprietorship.”

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About the Explosion Protection Compendium

This booklet is one part of the Pepperl+Fuchs Explosion Protection Compendium. The goal of these volumes is to give plant operators a general overview of explosion protection. This volume provides an overview of types of protection in accordance with the IEC/EN 60079 series of standards and harmonized versions for the US and Canada. While the volume focuses mainly on the “Zone” concept, information about the “Division” concept is also covered where appropriate.

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Introduction

Causes of Explosion and Possible Precautions

Explosions always come about because three criteria are fulfilled simultaneously and in the same location:

- Combustible substance: gas, mist, vapor, or dust
- Oxidizing agent: oxygen, normally from the air
- Ignition energy: minimum ignition energy (e. g., through sparks or heating)

Ignition Triangle

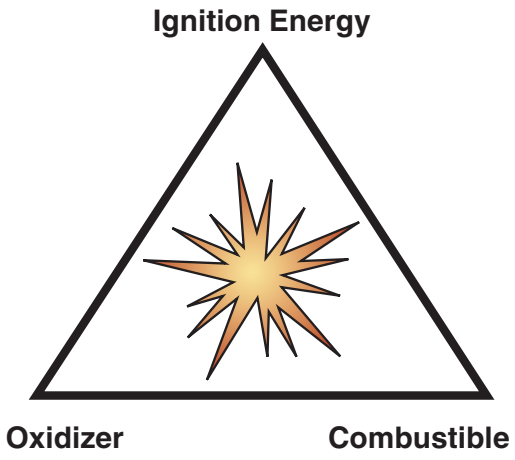

Figure 1. The ignition triangle consists of three components

If a combustible substance mixes sufficiently with air such that a concentration within the explosion limits is reached, we speak of a potentially explosive atmosphere or mixture.

Dust hazards also typically require suspension and containment to generate the needed conditions for explosion. However, the dust material itself may be a combustible substance. Evaluation of each application and the hazards present should be part of every risk assessment.

Hazardous Area Classification

Areas that can exhibit a potentially explosive atmosphere are particularly at risk. According to the frequency and duration of occurrence of the atmosphere, such areas are distinguished and categorized into Zones or Divisions/Classes.

Zone Model

The following Zone definitions are derived from the 2015 German Ordinance on Hazardous Substances, Annex I, 1.7, and are based on the Directive 1999/99/EG (ATEX 137).

Zone 0	Area in which a dangerous potentially explosive atmosphere is constantly, persistently, or frequently present as a mixture of air and combustible gases, vapors, or mists.
Zone 1	Area in which a dangerous potentially explosive atmosphere can occasionally form as a mixture of air and combustible gases, vapors, or mists during normal operation.
Zone 2	Area in which a dangerous potentially explosive atmosphere as a mixture of air and combustible gases, vapors, or mists does not normally arise and, if so, only rarely and for a short period of time.

Table 1. For definitions of Zones 0 ... 2 see also IEC/EN 60079-10-1.

Zone 20	Area in which a dangerous potentially explosive atmosphere in the form of combustible dust contained in the air is present frequently or for long periods of time.
Zone 21	Area in which a dangerous potentially explosive atmosphere can occasionally form during normal operation in the form of combustible dust contained in the air.
Zone 22	Area in which a dangerous potentially explosive atmosphere in the form combustible dust contained in the air does not normally arise and, if so, only rarely and for a short period of time.

Table 2. For definitions of Zones 20 ... 22 see also IEC/EN 60079-10-2.

In the reissues of the standards series IEC/EN 60079, the designation “Zone” is avoided and “equipment protection level” (EPL) is introduced instead.

Example: “Zone 1” is now “an area of the equipment of level of protection Gb”.

Division Model

The following definitions are derived from the National Electrical Code® (NEC, NFPA 70® for the US) and the Canadian Electrical Code (CE Code, CSA C22.1 for Canada).

Division 1	Area in which explosive atmospheres are likely to be present continuously,
Division 2	Area in which explosive atmospheres are not likely to occur or, if they do occur, only exist for a short time.

Table 3. Definition of North American Divisions

Class I	Area in which flammable gas or vapors may be present.
Class II	Area in which combustible dust may be found.
Class III	Area in which easily ignitable fibers or flyings may be found, not suspended in the air.

Table 4. Definition of North American Classes

Comparison of Zones and Divisions

Hazard Occurrence	Zone	Class/Division
Continuous gas hazard is normal	0	Class I, Division 1
Intermittent gas hazard is normal	1	Class I, Division 1
Gas hazard in abnormal condition	2	Class I, Division 2
Continuous dust hazard is normal	20	Class II, Division 1
Intermittent dust hazard is normal	21	Class II, Division 1
Dust hazard in abnormal condition	22	Class II, Division 2

Table 5. Comparison of the IEC “Zone” and the North American “Division” classification of explosion-hazardous locations.

Normal Operation

Normal operation is the state whereby plants are operated within their design parameters. If in doubt, the stricter Zone/Division is to be selected. Layers, deposits, and accumulations of combustible dust are to be considered like any other cause that can form a potentially explosive atmosphere. The classification is to be documented in the documentation of the hazard assessment (explosion protection document).

Permissible Equipment Categories According to IEC/EN 60079-14

Alongside the existing ATEX device categories, in the standard IEC/EN 60079-14 the “equipment protection level” (EPL) has been introduced in the device marking. Equipment that is intended for use in hazardous areas must bear this marking.

The equipment protection level provides information as to which equipment may be used in which Zone of the hazardous area.

Assignment of Explosion Hazard Zone, Equipment Category, Equipment Protection Level (EPL)

Zone (ATEX/IEC)	Equipment category (ATEX Directive)	EPL (IEC/EN)
0	1G	Ga
1	2G, 1G	Gb, Ga
2	3G, 2G, 1G	Gc, Gb, Ga

Table 6. Equipment of the category 1G (EPL Ga) may be used in all gas zones.

Zone (ATEX/IEC)	Equipment category (ATEX Directive)	EPL (IEC/EN)
20	1D	Da
21	2D, 1D	Db, Da
22	3D, 2D, 1D	Dc, Db, Da

Table 7. Equipment of the category 1D (EPL Da) may be used in all dust zones.

Basic Principles of the Types of Protection

Types of protection are explosion protection measures that prevent a device from becoming an ignition source or prevent an explosion from being propagated.

Hazard Posed by Electrical Apparatus

For electrical apparatus, ignition hazards are predominantly due to sparks and heat generation.

The following fundamental protective measures are possible against the ignition of a surrounding potentially explosive atmosphere:

- **Prevention of explosion propagation:** This method enables explosions under controlled conditions. To prevent the explosion from propagating to the surrounding atmosphere, this method specifies exactly which areas to limit the effects of the explosions to. The “flameproof enclosure” is an example of this type of protection.
- **Spatial separation between the ignition source and potentially explosive atmosphere:** This method maintains spatial separation between possible ignition sources—electrical component and hot surfaces—and the potentially explosive mixture. “Purge and pressurization,” “powder filling,” “equipment protection by encapsulation,” “oil filled,” and “protection by enclosure” (for dusts only) are types of protection based on this method.
- **Prevention of an effective ignition source:** This method prevents thermal effects such as hot surfaces and electrical sparks altogether. This corresponds to the type of protection “increased safety.” Alternatively, this method limits the electrical energy of a spark—also under certain fault conditions—to a safe level. This corresponds to the type of protection “intrinsic safety.”

Explosion Protection through Protected Apparatus

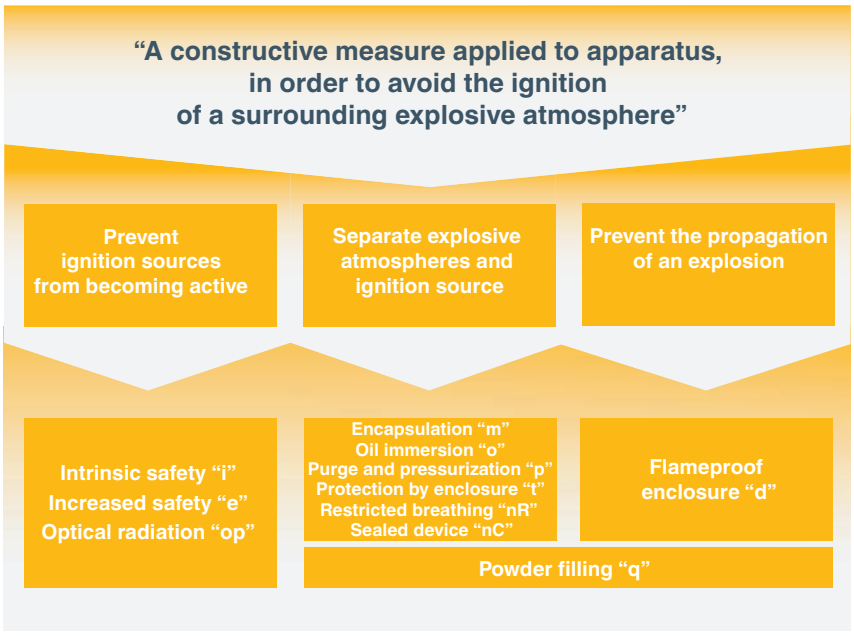

Figure 2. Types of Protection Overview

Increased Safety (Ex e)

Increased safety (Ex e) is applicable to Zone-classified ares. It is applied to electrical devices and includes additional measures with an increased degree of safety to prevent the possibility for exceedingly high temperatures and the generation of sparks or arcs. This applies for intended operation and under determined improper operating conditions, depending on the Zone of application.

Figure 3. Ex e terminal box

Fundamentals

Potential ignition sources are located in the enclosure, into which a potentially explosive atmosphere can penetrate.

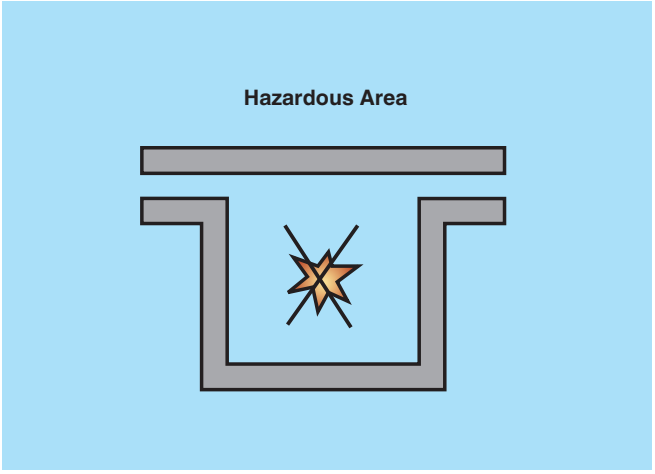

Figure 4. Illustration of “increased safety”

An overdimensioning (e. g., an increased measure of the insulation) plus particular measures for the mechanical strength of the enclosure and for the fixing of connection cables (protection against self-loosening) and other constructional performance criteria prevent sparks from being generated or the device from becoming exceedingly hot. Additional possibilities include an increased degree of protection (IP) of the device and overload protection through thermal monitoring.

Level of Protection and Equipment Protection Level

In accordance with IEC/EN 60079-7:2015, Ex e is subdivided into two levels of protection: “eb” and “ec.”

The protection method “eb” is limited to terminals, terminal connections, motors, and lights. The protection method “nA” was recently moved to this standard and renamed “ec.” Therefore, “ec” allows additional items, such as more complex electronics that are not permitted under “eb.”

An equipment protection level is assigned to every level of protection. This EPL is based on the likelihood of the device becoming an ignition source in a potentially explosive atmosphere. The EPLs available for this type of protection are Gb and Gc.

Main Applications

Enclosure for control units with components that are separately U certified.

- Connection enclosure of Ex de control panels
- Terminal boxes
- Measuring instruments
- Transformers
- Motors
- Hand lights and cap lights
- Zone 2 devices that were previously handled under non-sparking “nA”

Product Marking

Examples of Markings for ATEX
II 2 G Ex eb IIC T4 Gb
II 3 G Ex ec IIC T4 Gc

Flameproof Enclosure (Ex d)

Flameproof enclosure (Ex d), similar in principle to “explosionproof” for Division applications, entails installing parts that can ignite a potentially explosive atmosphere in a special enclosure. This enclosure withstands the pressure that can be produced by an internal explosion and prevents the explosion from spreading to a potentially explosive atmosphere that surrounds the enclosure.

Figure 5. Ex d enclosure solution

Fundamentals

The potential ignition sources are located in an enclosure into which a potentially explosive atmosphere can penetrate. An interior explosion does not result in the destruction of the enclosure, meaning it can withstand the maximum explosion pressure of the permitted gases. The pressure is relieved by means of a flameproof joint. These enclosures typically require third-party verification from a certification agency or a “notified body.”

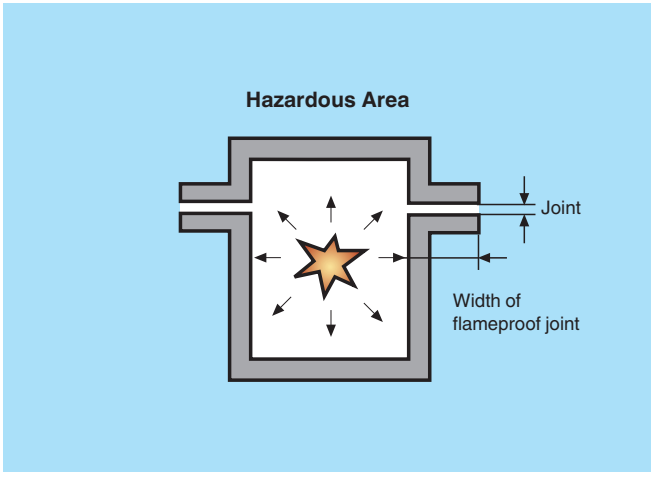

Figure 6. Illustration of a flameproof enclosure

The user is responsible for suitable cable entries and sealing plugs. In accordance with IEC/EN 60079-14, a cable entry is possible in three ways:
- Proper seals from the Ex d enclosure leading into a terminal compartment of increased safety
- Direct cable entry with Ex d cable glands or seals
- A conduit installation and, depending on the permitted length of the conduit, additional seals

In accordance with NEC® and CE Code for Class/Division classification, a cable entry is possible in two ways:
- Direct cable entry with flameproof cable glands or seals
- A conduit and, depending on the permitted length of the conduit, additional seals

A modification of the flameproof enclosure and the content is permitted only if this is intended and described in the instruction manual. The user is not permitted to perform any modification or overhaul of the flameproof joint whatsoever.

For motors in inverter operation, there are two possibilities:
- Motor and electrical drive inverter are examined as a unit and the results are considered during the type examination of the motor.
- The outside temperature of the enclosure surrounding the motor and electrical drive inverter is monitored effectively and protected with a protective switch.

Level of Protection and Equipment Protection Level

In accordance with IEC/EN 60079-1:2014, Ex d is subdivided into three levels of protection: “da,” “db,” and “dc.” An equipment protection level is assigned to every level of protection. This EPL is based on the likelihood of the device becoming an ignition source in a potentially explosive atmosphere. Equipment of the type of protection “d” is protected by the level of protection “da” (EPL “Ga”) or “db” (EPL “Gb”), or “dc” (EPL “Gc”).

One way of achieving the level of protection “da” is to combine two independent types of protection with level of protection “db.” The level of protection “da” can only be used for catalytic sensors and portable sensors for combustible gases. Alongside other conditions, the free internal volume must not exceed 5 cm^3.

The type of protection “explosionproof” for Class/Division classifications is covered by several standards, including UL 1203 and CSA 22.2 No. 30 for enclosures. UL 2225 and CSA 22.2 No. 174 cover cable glands and fittings.

Main Applications

- Switching devices and control panels
- Control units, e. g., as control interface for sensors
- Motor protective switches and protective switches for lines
- Transformers
- Motors
- Light fittings

Product Marking

Examples of Markings for ATEX
II 1 G Ex da IIC T4 Ga
II 2 G Ex db IIC T4 Gb
II 3 G Ex dc IIC T4 Gc

Intrinsic Safety (Ex i)

Intrinsic safety (Ex i) is based on limiting the electrical energy to a defined value. This value lies below the limit value that can trigger an ignition by spark generation or thermal effect. These parameters apply within the devices and for all connecting cables and lines that are exposed to a potentially explosive atmosphere.

Figure 7. Valve position monitoring with an intrinsically safe sensor

Fundamentals

In intrinsically safe circuits, currents and voltages are safely limited and power and thermal considerations are taken into account. Further, the energy storage is limited safely—e. g., coils and capacitors. This also takes into account distributed reactance values of cables and lines.

A typical configuration includes the following two elements:

- An associated apparatus (or “barrier”) that provides energy limitation into the explosion hazardous area
- An apparatus (or “device”) that is designed with certain limitations to comply with the type of protection

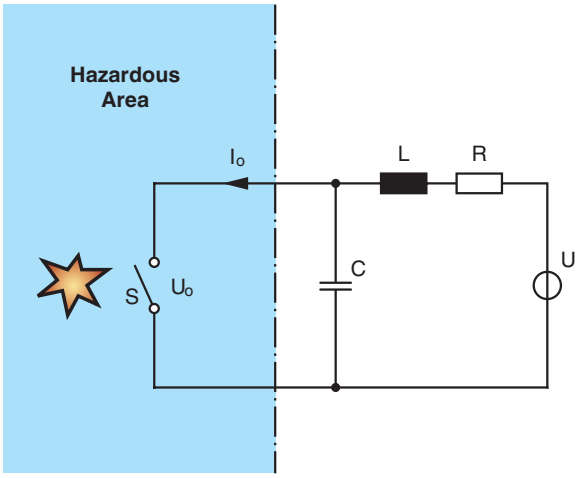

Figure 8. Illustration of an intrinsically safe circuit

The user undertakes the verification of intrinsic safety and documents this verification in the plant documentation. In accordance with IEC/EN 60079-14:2013 (sections 4.2 and 16.2.4), NEC® Article 504, or CE Code Section 18, the verification is required as part of the plant documentation.

Intrinsically safe circuits must be protected from any kind of coupling. To achieve this, minimum distances are observed on the terminals—for example, 50 mm from intrinsically safe terminals to non-intrinsically safe terminals. Cables and lines must be marked and protected.

Level of Protection and Equipment Protection Level

Ex i is subdivided into three levels of protection: “ia,” “ib,” and “ic.” An equipment protection level is assigned to every level of protection. This EPL is based on the likelihood of the device becoming an ignition source in a potentially explosive atmosphere.

EPL	Equipment Category Gas	Degree of Safety
ia	1G	Safe if two independent errors occur.
ib	2G	Safe if one error occurs.
ic	3G	Safe in normal operation.
[ia Ga]	Associated apparatus	Installation outside of the hazardous area. Supply possible for field devices in Zones 0, 1, or 2.
[ib Gb]	Associated apparatus	Installation outside of the hazardous area. Supply possible for field devices in Zones 1 or 2.
[ic Gc]	Associated apparatus	Installation outside of the hazardous area. Supply possible for field devices in Zone 2.

Table 8. Ex i levels of protection in gas-hazardous areas

EPL	Equipment Category Dust	Degree of Safety
ia	1D	Safe if two independent errors occur.
ib	2D	Safe if one error occurs.
ic	3D	Safe in normal operation.
[ia Da]	Associated apparatus	Installation outside of the hazardous area. Supply possible for field device in Zones 20, 21 and 22.
[ia Db]	Associated apparatus	Installation outside of the hazardous area. Supply possible for field devices in Zones 21 or 22.
[ic Dc]	Associated apparatus	Installation outside of the hazardous area. Supply possible for field devices in Zone 22.

Table 9. Ex i levels of protection in dust-hazardous areas

Main Applications

- Measurement and control engineering
- Sensors and actuators
- Fieldbus technology
- Instrumentation

Product Marking

Examples of Markings for ATEX
II 1 G Ex ia IIC T6 Ga
II (1) G [Ex ia Ga] IIC

Purge and Pressurization (Ex p)

Purge and pressurization (Ex p) prevents a surrounding atmosphere from penetrating into an enclosure through the use of a protective gas under overpressure.

Figure 9. Control unit for a pressurization system

Fundamentals

The potential ignition sources are located in a robust enclosure under a low overpressure: 25 Pa ... 50 Pa, or 0.25 mbar ... 0.5 mbar. If air is used as a protective gas, this air must be drawn from the non-hazardous area. If the overpressure fails, an alarm signal is necessary.

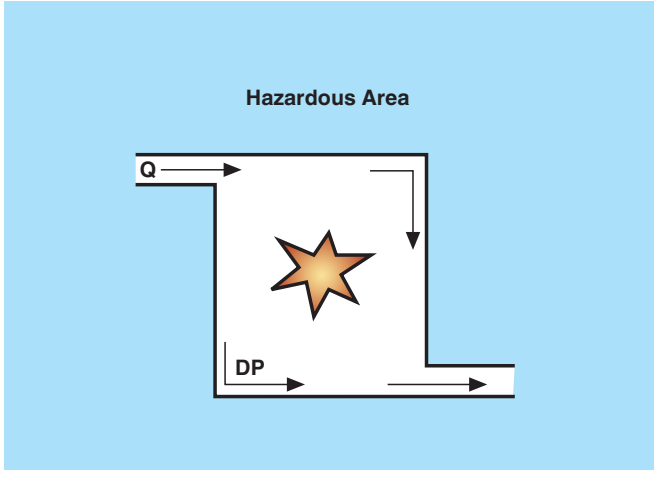

Figure 10. Illustration of a pressurizing system

Level of Protection and Equipment Protection Level

Ex p is subdivided into three levels of protection: “pxb,” “pyb,” and “pzc.” An equipment protection level is assigned to every level of protection. This EPL is based on the likelihood of the device becoming an ignition source in a potentially explosive atmosphere.

EPL	Equipment Category Gas/Dust	Degree of Safety
pxb	2G, 2D	Installation of the device in Zone 1 or Zone 21: no explosion hazard in interior. Use of standard devices safe.
pyb	2G, 2D	Installation of the device in Zone 1 or Zone 21: interior of the device Zone 2 or Zone 22. Use of devices from Zone 2 or Zone 22 and EPL Gc or Dc safe.
pzc	3G, 3D	Installation of the device in Zone 2 or Zone 22: no explosion hazard in interior. Use of standard devices safe.

Table 10. Ex p levels of protection in gas- or dust-hazardous areas

For type of protection Ex pxb in Zone 1 or Zone 21 with internal devices that do not fulfill the EPL Gc or Dc, the unprotected device in the interior of the enclosure must also be shut down.

For Zone 1 and Zone 2 applications, the enclosure must be purged prior to power being applied. The purge cycle depends on several factors. Typically, a purge cycle is made up of four volume exchanges for applications that follow NFPA 496 for Class/Division applications or five volume exchanges for applications that are based on IEC/EN 60079-2 series standard. Depending on the application, the number of required volume exchanges may be higher or lower.

Main Applications

- Switch cabinets
- Large motors
- Measuring instruments and analysis equipment

Product Marking

Examples of Markings for ATEX
II 2 G Ex pxb IIB T4 Gb
II 3 G Ex pzc IIC T4 Gc
II 2 D Ex pxb IIIC T80 ˚C Db

Encapsulation (Ex m)

Type of protection Ex m encapsulates in a casting compound parts that are capable of igniting a potentially explosive gas atmosphere through the generation of sparks or heating. This prevents the surrounding potentially explosive atmosphere from being ignited under conditions of operation or installation.

Fundamentals

The enclosure has sufficient mechanical strength and is chemically resistant to the materials in the vicinity of which it is to be used. The filling material must not come away from the enclosure wall during permitted temperature fluctuations. The user is responsible for following the manufacturer's instruction manual to install, bring into service, and operate the apparatus.

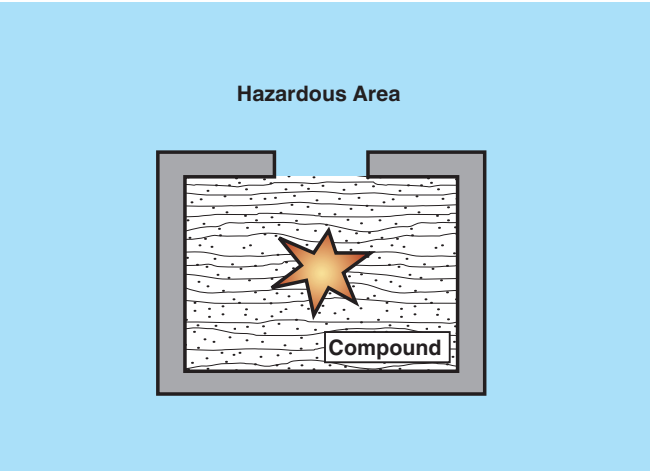

Figure 11. Illustration of encapsulation

Level of Protection and Equipment Protection Level

In accordance with IEC/EN 60079-18:2014, Ex m is subdivided into three levels of protection: “ma,” “mb,” and “mc.”

An equipment protection level is assigned to every level of protection. This EPL is based on the likelihood of the device becoming an ignition source in a potentially explosive atmosphere.

Encapsulated equipment is protected by the levels of protection “ma” (EPL “Ga” or “Da”), “mb” (EPL “Gb” or “Db”), or “mc” (EPL “Gc” or “Dc”).

Main Applications

- Display devices
- Sensors
- Switching devices for low power
- Control units

Product Marking

Examples of Markings for ATEX
II 1 G Ex ma IIC T4 Ga
II 2 G Ex mb IIC T4 Gb
II 2 D Ex mb IIIC T90 ˚C Db
II 3 D Ex mc IIIC T90 ˚C Dc

Liquid Immersion (Ex o)

Liquid immersion (Ex o) protects electrical equipment or components by immersing them in a protective liquid. This prevents a potentially explosive gas atmosphere above the liquid level or external to the enclosure from being ignited.

Fundamentals

Potential ignition sources are located in the enclosure. The potentially explosive atmosphere is kept away from the ignition source.

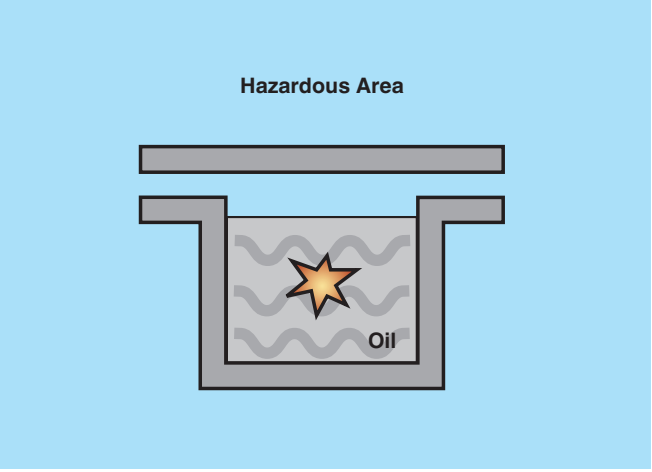

Figure 12. Illustration of liquid immersion

The fill level of the protective liquid must be monitored. The mounting position must also ensure that the ignition sources are permanently located beneath the liquid level.

The user is responsible for following the manufacturer's instruction manual to install, bring into service, and operate the apparatus.

Level of Protection and Equipment Protection Level

In accordance with IEC/EN 60079-6:2015, Ex o is subdivided into two levels of protection: “ob” and “oc.”

An equipment protection level is assigned to every level of protection. This EPL is based on the likelihood of the device becoming an ignition source in a potentially explosive atmosphere.

Equipment of the type of protection “o” is protected by the level of protection “ob” (EPL “Gb”) or “oc” (EPL “Gc”).

Main Applications

- Transformers
- Starting resistors
- Switching devices

Product Marking

Examples of Markings for ATEX
II 2 G Ex ob IIB T4 Gb
II 3 G Ex oc IIC T4 Gc

Powder Filling (Ex q)

In powder filling (Ex q), fixed installed parts that are able to ignite a potentially explosive gas atmosphere are completely surrounded by filling material. This prevents the ignition of a surrounding potentially explosive atmosphere.

Figure 13. Powder-filled operator workstation

Fundamentals

By using very fine-grain glass or silica (quartz) beads, free enclosure space is filled and the likelihood for penetration of the potentially explosive atmosphere is greatly reduced. Should ignition occur in the remaining space, the thermal capacity of the filling material extinguishes the emergent flame.

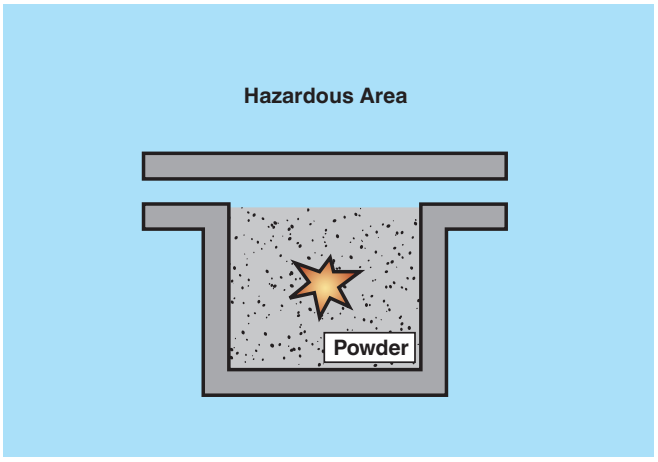

Figure 14. Illustration of powder filling

The user is responsible for following the manufacturer's instruction manual to install, bring into service, and operate the apparatus.

Level of Protection and Equipment Protection Level

An equipment protection level is assigned to every level of protection. This EPL is based on the likelihood of the device becoming an ignition source in a potentially explosive atmosphere.

In accordance with IEC/EN 60079-5:2015, equipment protected by Ex q is assigned level of protection “q” (EPL “Gb”).

Main Applications

- Operating devices and display devices
- Transformers
- Electronic ballasts

Product Marking

Example of Marking for ATEX

II 2 G Ex q IIB T4 Gb

Non-Incendive (Ex n)

Protection concept “n” encompasses a set of mostly constructive measures to ensure that electrical equipment cannot ignite a surrounding potentially explosive atmosphere during intended operation and under determined improper conditions.

Fundamentals

The type of protection “non-incendive” or “non-sparking” features different possibilities to safely construct apparatus. This prevents the apparatus from igniting a surrounding potentially explosive gas atmosphere during normal operation.

- **Non-Sparking Installation “ec” (Previously “nA”)**: Since 2016, the type of protection non-sparking installation “nA” has been named “ec” in accordance with IEC/EN 60079–7:2015. A device with this type of protection is constructed to minimize the risk of occurrence of arcs or sparks that present an ignition hazard during normal operation.

- **Restricted-Breathing Enclosure “nR”**: An enclosure that limits penetration by gas, vapor, or mist by limiting the amount that the enclosure is permitted to “breathe,” or exchange inside air volume with external air. The result is the isolation of the thermal or arcing/sparking ignition sources inside the enclosure from the potentially flammable or explosive atmosphere outside.

- **Enclosed-Break Device “dc” (Previously “nC”)**: Since 2016, the type of protection enclosed-break device “nC,” in accordance with IEC/EN 60079-1:2014, has been named “dc.” A device with this type of protection contains electrical contacts that are made and broken and without damage withstands an internal explosion of any ingressing flammable gas or vapor without transferring the internal explosion to a surrounding potentially explosive atmosphere. In accordance with IEC/EN 60079-5:2015, the equipment of the type of protection “q” is protected by the level of protection “qb” (EPL “Gb” or “Db”).

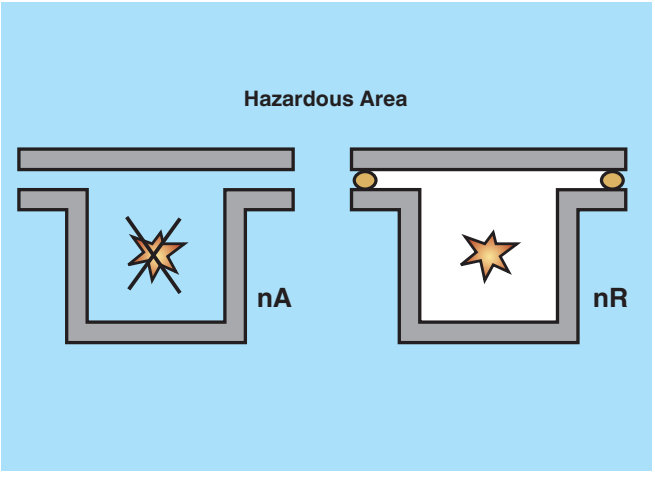

Figure 15. Illustration of type of protection Ex “n”

- **Sealed Device “nC”**: A device (e.g., relay) with this type of protection is either sealed or hermetically sealed. The internal part of the device has arcing or sparking contacts, but the seal prevents the atmosphere from being exposed to the ignition source.

Main Applications

- Motors
- Light fittings
- Switching devices
- All other types of electrical apparatus for Zone 2

Product Marking

Example of Marking for ATEX

 II 3 G Ex nR IIB T4 Gc

Dust Protection by Enclosure (Ex t)

The type of protection “t,” previously “tD,” in accordance with IEC/EN 61241-1, is a special type of protection for dust-hazardous areas. For Division-related classification, it is known as “dust igitionproof.” To fulfill this type of protection, the electrical apparatus is installed in an enclosure with protection against dust entry and precautions for limiting the surface temperature.

Fundamentals

Devices with this type of protection have a special enclosure that prevents the entry of dust. The enclosure must also be engineered in a way that a maximum surface temperature can never be exceeded. Devices with this type of protection can be used as apparatus for the device categories 1D (Zone 20), 2D (Zone 21), and 3D (Zone 22).

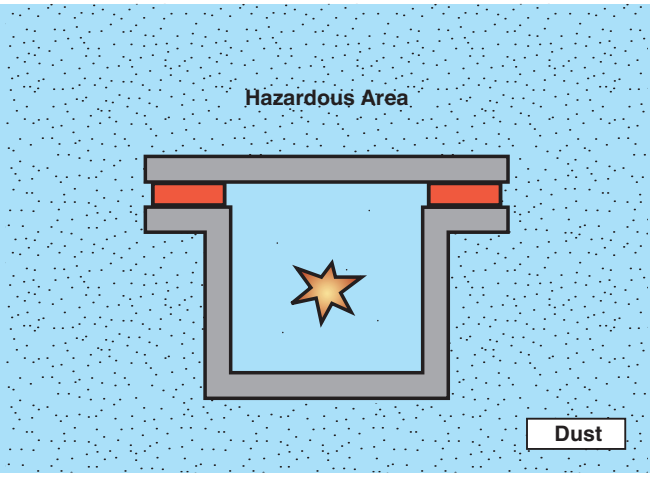

Figure 16. Illustration of dust protection by enclosure

Level of Protection and Equipment Protection Level

In accordance with IEC/EN 60079-31:2016, Ex t is subdivided into three levels of protection: “ta,” “tb,” and “tc.”

An equipment protection level is assigned to every level of protection. This EPL is based on the likelihood of the equipment becoming an ignition source in a potentially explosive atmosphere. Equipment of the type of protection “t” is protected by the level of protection “ta” (EPL “Da”) or “tb” (EPL “Db”) or “tc” (EPL “Dc”).

For equipment of the type of protection “ta,” the maximum permitted short circuit current of the current source must be cited in the identification. For the level of protection “ta,” the enclosure must undergo a thermal examination where an at least 200 mm thick dust layer is deposited all over the surface.

The devices must be protected against dust entry and meet the following requirements.

Level of protection	IIIC	IIIB	IIIA
ta	IP6X	IP6X	IP6X
tb	IP6X	IP6X	IP5X
tc	IP6X	IP5X	IP5X

Table 11. Type of protection Ex t: level of protection according to equipment group

Main Applications

- For all electrical apparatus in dust hazardous areas
- Light fittings
- Sensors
- Actuators

Product Marking

Example of Marking for ATEX
Ⓔx II 2D Ex tb IIIC T80 °C Gb

Optical Radiation (Ex op)

In accordance with IEC/EN 60079-28:2015, this protection method entails protection of equipment and transmission systems that operate with optical radiation.

Fundamentals

This type of protection is applied to an optical device to prevent optical radiation from igniting a potentially explosive surrounding atmosphere. This is achieved through the following protection concepts:

- **Inherently Safe Optical Radiation “op is”**: Visible or infrared radiation that cannot, under normal circumstances or under determined fault conditions, produce sufficient energy to ignite a potentially explosive atmosphere. The concept is akin to that of intrinsic safety, providing energy limitation in the system to safe values, and enables the exchange of components during operation. If the limited values do not suffice for the application, other options must be implemented. In accordance with IEC/EN 60079-28:2015, table 1, this protection concept is suitable for EPL Gc and Dc. When considering and avoiding errors, Gb, Db, Ga, and Da are also possible.

- **Protected Optical Radiation “op pr”**: Visible or infrared radiation constructed and encapsulated normally or with mechanical protection in an optical fiber or another transmitting medium. No radiation should leak from this encapsulation. To prevent radiation leaking from its encapsulation, fiber optic cables must be set out in an appropriately robust fashion or a manner that makes them safe from destruction. In this construction, no simple exchange is possible during operation. If optical components must be exchanged frequently, alternative options must be considered. In accordance with IEC/EN 60079-28:2015, table 1, this protection concept is suitable for EPL Gc and Dc. With additional mechanical protection, Gb and Db are also possible.

- **Optical Systems with Locking “op sh”**: System for encapsulating visible or infrared radiation that is encapsulated in fiber optic cables or other transmitting mediums. If the protection guaranteed by the ecapsulation fails and the radiation is released, this is locked and the radiation is shut down. This way, the unprotected ray strength is reduced to safe values in a defined time and the radiation can even be shut down entirely. In accordance with IEC/EN 60079-28:2015, table 1, this protection concept is suitable for EPL Gc and Dc. When operating a protected fiber optic cable “op pr,” Gb, Db is also possible. EPL Ga or Da is possible when using a protected fiber optic cable “op pr” that fulfills the EPL Gb or Db.

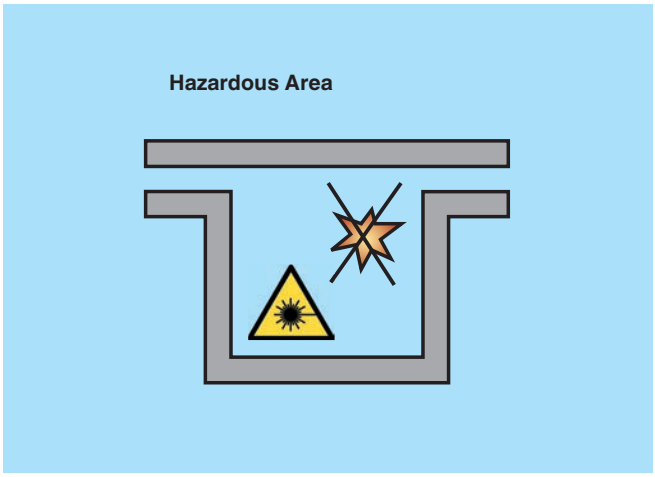

Figure 17. Illustration of protection of equipment using optical radiation

Main Applications

This type of protection is typically used with the following components for connecting sensors and sensing elements that also serve to transfer data in general:

- Light fittings
- Laser
- LEDs
- Fiber optic cable

Product Marking

Examples of Markings for ATEX
II 1G Ex op is IIB T4 Ga
II 2G Ex op pr IIC T4 Gb
II 3D Ex op sh IIC T90 ˚C Dc

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Relevant Standards and Protection Methods

Zone-Related Standards

Flame Proof “d” (gases only)
IEC 60079-1 , EN 60079-1, UL 60079-1, CSA 22.2 No. 60079-1

Intrinsic Safety “i” (gases and dusts)
IEC 60079-11, EN 60079-11, UL 60079-11, CSA 22.2 No. 60079-11

Pressurization “p” (gases and dusts)
IEC 60079-2, EN 60079-2, UL 60079-2, CSA 22.2 No. 60079-2,

Encapsulation “m” (gases and dusts)
IEC 60079-18, EN 60079-18, UL 60079-18, CSA 22.2 No. 60079-18

Oil Filled “o” (gases only)
IEC 60079-6, EN 60079-6, UL 60079-6, CSA 22.2 No. 60079-6

Powder Filled “q” (gases only)
IEC 60079-5, EN 60079-5, UL 60079-5, CSA 22.2 No. 60079-5

Increased safety “e” (gases only)
IEC 60079-7, EN 60079-7, UL 60079-7, CSA 22.2 No. 60079-7

Type “n” (gases only)
IEC 60079-15, EN 60079-15, UL 60079-15, CSA 22.2 No. 60079-15

Enclosure “t” (dusts only)
IEC 60079-31, EN 60079-31, UL 60079-31, CSA 22.2 No. 60079-31

Optical Radiation “op”
IEC 60079-28, EN 60079-28, UL60079-28, CSA 22.2 No. 60079-28

Division-Related Standards

Explosionproof (gases only)
UL 1203, CSA 22.2 No. 30, FM 3615, UL 2225 (fittings), CSA 22.2 No. 174 (fittings)

Intrinsic Safety (gases and dusts)
UL 60079-11, CSA 22.2 No. 60079-11, UL 913, CSA 22.2 No 157, FM 3610

Pressurization (gases and dusts)
NFPA 496, FM 3620

Non-incendive (gases only)
UL121201/CSA 22.2 No. 213 (Bi-national), FM 3611

Dust Ignition Proof (dusts only)
UL 1203, CSA 22.2 No 25, FM 3616, UL 2225 (fittings), CSA 22.2 No. 174 (fittings)

References and Sources

EN 1127-1:2011: Explosive atmospheres—Explosion prevention and protection—Part 1:
Basic concepts and methodology

Ordinance on Industrial Safety and Health:
Ordinance on safety and health protection when using work equipment. (Germany)

Gefahrstoffverordnung (GefStoffV):
Ordinance on Hazardous Substances. Germany, 2010

IEC 60079-0 Explosive atmospheres—Part 0:
Equipment- General requirements

IEC 60079-1 Explosive atmospheres—Part 1:
Equipment protection by flameproof enclosures “d”

IEC 60079-2 Explosive atmospheres—Part 2:
Equipment protection by purge and pressurization “p”

IEC 60079-5 Explosive atmospheres—Part 5:
Equipment protection by powder filling “q”

IEC 60079-6 Explosive atmospheres—Part 6:
Equipment protection by oil immersion “o”

IEC 60079-7 Explosive atmospheres—Part 7:
Equipment protection by increased safety “e”

DIN EN 60079-10-1 Explosive atmospheres—Part 10-1:
Classification of areas--Explosive gas atmospheres

DIN EN 60079-10-2 Explosive atmospheres—Part 10-2:
Classification of areas--Explosive dust atmospheres

IEC 60079-11 Explosive atmospheres—Part 11:
Equipment protection by intrinsic safety “i”

IEC/EN 60079-14 Explosive atmospheres—Part 14:
Electrical installations design, selection and erection

IEC 60079-15 Explosive atmospheres—Part 15:
Equipment protection by type of protection “n”

IEC 60079-18 Explosive atmospheres—Part 18:
Equipment protection by encapsulation “m”

IEC 60079-28 Explosive atmospheres—Part 28:
Protection of equipment and transmission systems using optical radiation “op”

IEC 60079-31 Explosive atmospheres—Part 31:
Equipment dust explosion protection by enclosure “t”

Directive 1999/92/EC
of the European Parliament and Council of December 16, 1999 regarding minimum provisions to improve health protection and safety of employees who may be endangered by potentially explosive atmospheres (Fifteenth Individual Directive for the Purpose of Article 16, Para. 1 of Directive 89/391/EEG)

NFPA 70®, National Electrical Code® (NEC®)

CSA C22.1, Canadian Electrical Code (CE Code)

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