3. TECHNICAL PRINCIPLES

3.5 PROTECTION TYPES

Explosion-protected equipment is predominantly used in locations with a threat of explosion. Explosion-protected electrical equipment for hazardous areas may be designed as per standard series IEC 60079 building provisions in various protection types. Protection types for non-electrical equipment are specified in the ISO 80079 standard series and formerly in EN 13463 in Europe.

The protection type used by a manufacturer for equipment mainly depends on its nature and function. Some protection types are available in different protection levels. They correspond to the equipment categories in Directive 2014/34/EU or the equipment protection level (EPL) in IEC 60079-0. In terms of intrinsic safety, an Ex ia version is available, although it is classified as Category 1 or EPL Ga. It may be installed in Zone 0. The Ex ib version corresponds to Category 2 or EPL Gb. It is suitable for Zone 1. Ex ic can be used as Category 2 or EPL Gc in Zone 2. In safety terms, all standardised protection types in a category or equipment protection level may be deemed equivalent. Tables 11 and 12 provide an overview of the standardised protection types and describe the basic principle and customary use cases. The protection type symbols are simplified (Table 13) by integrating the protection types for dust explosion hazardous areas into the standard series 60079.

Table 11: Protection types for electrical equipment in explosive gas atmospheres, Part 1

Protection type according to IEC, EN, ISA and UL	Representation (Diagram)	Basic principle	Main application
General requirements IEC 60079-0 EN 60079-0 UL 60079-0		This standard specifies the general requirements for explosion-protected electrical equipment and also details equipment marking.	
Increased safety "e" IEC 60079-7 EN 60079-7 UL 60079-7		Additional measures are adopted in this case to afford a higher degree of safety for preventing impermissible high temperatures and the occurrence of sparks and flashovers inside or on outer parts of electrical equipment that do not occur in normal operation.	Terminal and connection boxes, control boxes for installing ex components (with a different protection type), squirrel cage motors, lights eb = use in Zone 1, 2 ec = use in Zone 2
Flameproof enclosure "d" IEC 60079-1 EN 60079-1 UL 60079-1		Parts which can ignite an explosive atmosphere are housed in an enclosure which withstands the pressure of an explosive mixture exploding inside the enclosure and prevents transmission of the explosion to the atmosphere around the enclosure.	Switchgear and control gear, control and display units, control systems, motors, transformers, heaters, lights da = use in Zone 0, 1, 2 db = use in Zone 1, 2 dc = use in Zone 2
Pressurised enclosure "p" IEC 60079-2 EN 60079-2 UL 60079-2		The formation of an explosive atmosphere inside an enclosure is prevented by maintaining a positive internal pressure of inert gas in relation to the surrounding atmosphere and, where necessary, by supplying the inside of the enclosure with a constant flow of inert gas to dilute combustible mixtures.	Switchgear and control cabinets, analysers, large motors pxb = use in Zone 1, 2 and Zone 21, 22 pyb = use in Zone 1, 2 and Zone 21, 22 pyb = use in Zone 2 and Zone 22
Intrinsic safety "i" IEC 60079-11 EN 60079-1 UL 60079-11		Equipment that is used in a hazardous area only contains intrinsically safe electric circuits. An electric circuit is intrinsically safe if no sparks or thermal effects are produced under specified test conditions (which include normal operation and specific fault conditions) which might result in the ignition of a specific explosive atmosphere.	Measurement and control technology, fieldbus technology, sensors, actuators ia = use in Zone 0, 1, 2 and Zone 20, 21, 22 ib = use in Zone 1, 2 and Zone 21, 22 ic = use in Zone 2 and Zone 22 [Ex ib] = associated electrical equipment – installation in safe area
IEC 60079-25 EN 60079-25 EN 60079-25		Intrinsic safety evaluation for defined systems (equipment and cables).	Intrinsically safe systems
EN 60079-27 EN 60079-27	FISCO Ex ia IIC T4	Definition of the physical and electrical limit values of the intrinsically safe bus string.	Intrinsically safe fieldbus systems (FISCO) for Zone 0, 1 or 2

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Table 12: Protection types for electrical equipment in explosive areas, Part 2

Protection type according to IEC, EN, ISA and UL	Representation (Diagram)	Basic principle	Main application
Oil immersion “o” IEC 60079-6 EN 60079-6 UL 60079-6		Electrical equipment or parts thereof are immersed in a protective fluid (such as oil), so that an explosive atmosphere cannot be ignited above or inside.	Transformers, starting resistors 0 = use in Zone 1, 2
Powder filling “q” IEC 60079-5 EN 60079-5 UL 60079-5		Filling the enclosure of electrical equipment with a fine granular packing material stops flashovers inside during intended operation igniting the explosive atmosphere around the enclosure. Ignition cannot result either from flames or due to increased temperatures on the enclosure surface.	Sensors, electronic ballast, transmitters q = use in Zone 1, 2
Encapsulation “m“ IEC 60079-18 EN 60079-18 UL 60079-18		Parts that may ignite an explosive atmosphere are embedded in sealing compound to stop ignition of the explosive atmosphere.	ma = use in Zone 0, 1, 2 and Zone 20, 21, 22 mb = use in Zone 1, 2 and Zone 21, 22 mc = use in Zone 2 and Zone 22
Protection type “n” IEC 60079-15 EN 60079-15 UL 60079-15		Electrical equipment cannot ignite a surrounding explosive atmosphere (during normal operation and under defined abnormal operating conditions).	All electrical equipment for Zone 2 nA = non-sparking equipment nC = fittings and components nR = restricted breathing enclosure
Optical radiation “op” IEC 60079-28 EN 60079-28 EN 60079, 28		Appropriate measures prevent ignition of an explosive atmosphere by optical radiation.	Fibre optics / use in gas explosion hazardous areas There are three different methods: Ex op is = inherently safe optical radiation Ex op pr = protected optical radiation Ex op sh = optical radiation with interlock
Protection via enclosure “t” IEC 60079-31 EN 60079-31		Thanks to its tightness, dust cannot penetrate the enclosure or reduces it to a negligible degree. Ignitable apparatus can now be mounted in the enclosure. The enclosure temperature must not be sufficient to ignite the surrounding atmosphere.	Switchgear and control gear, control, connection, and terminal boxes, motors, lights ta = use in Zone 20, 21, 22 tb = use in Zone 21, 22 tc = use in Zone 22

Table 13: Marking pursuant to standard series IEC 61241 and IEC 60079

Standard series 61241		Standard series 60079		Application range
Standard	Symbol	Standard	Symbol	Zone
Protection via enclosure				
IEC 61241-1	tDA20, tDB20 tDA21, tDB21 tDA22, tDB22	IEC 60079-31	ta	20
			tb	21
			tc	22
Pressurised enclosure				
IEC 61241-4	pD21 pD22	IEC 60079-2	pxb	21
			pzb	21
			pzc	22
Intrinsic safety				
IEC 61241-11	iaD20 ibD21	IEC60079-11	ia	20
			ib	21
			ic	22
Encapsulation				
IEC 61241-18	maD20 maD21	IEC 60079-18	ma	20
			mb	21
			mc	22

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Table 14: Protection types for non-electrical equipment in explosive areas

Protective type pursuant to ISO or EN	Representation (Diagram)	Basic principle	Main application
General requirements ISO 80079-36 (formerly EN 13463-1)		This standard specifies the general requirements for explosion-protected electrical equipment and also details equipment marking.	
Constructional safety “c” ISO 80079-37 (formerly EN 13463-5)		Proven technical principles are applied to equipment types which do not have any ignition source in normal operation, so that the risk of mechanical faults causing incendive temperatures and sparks is reduced to a negligible degree.	Couplings, pumps, gear drives, chain drives, conveyor belts
Flameproof enclosure “d” IEC 60079-1 (formerly EN 13463-3)		Parts that can ignite an explosive atmosphere are housed in an enclosure which withstands the pressure of an explosive mixture exploding inside the enclosure and prevents transmission of the explosion to the atmosphere around the enclosure.	Brakes, couplings
Pressurised enclosure “p” IEC 60079-2 (formerly EN 60079-2)		The formation of an explosive atmosphere inside an enclosure is prevented by maintaining a positive internal pressure of inert gas in relation to the surrounding atmosphere and, where necessary, by supplying the inside of the enclosure with a constant flow of inert gas to dilute combustible mixtures.	Pumps
Control of ignition source “b” ISO 80079-37 (formerly EN 13463-6)		Sensors are integrated into the equipment to detect imminent hazardous conditions and adopt countermeasures at an early stage before potential ignition sources become effective. The measures can be initiated automatically by means of a direct connection between the sensors and the ignition protection system or manually by issuing a warning to the operator of the equipment.	Pumps, conveyor belts
Liquid immersion “k” ISO 80079-37 (formerly EN 13463-8)		Ignition sources are rendered ineffective by immersion in a protective liquid or by constant moistening with a liquid film.	Submerged pumps, gears, liquid immersion
Protection via enclosure “t” IEC 60079-31		Thanks to its tightness, dust cannot penetrate the enclosure or reduces it to a negligible degree. Ignitable apparatus can now be mounted in the enclosure. The enclosure temperature must not be sufficient to ignite the surrounding atmosphere.	Equipment exclusively for dust explosion hazardous areas

Table 15: Difference between intrinsically safe and associated electrical equipment

Intrinsically safe equipment	Associated electrical equipment	
Ex ib IIC T6 Gb	[Ex ib Gb] IIC	Ex de [ib] IIC T6 Gb
All necessary details such as category, explosion group and temperature class are available.	The square brackets indicate that the respective electrical equipment contains an intrinsically safe electric circuit which is listed in Zone 1, explosion groups IIA, IIB and IIC.	
The equipment may be used in Zone 1.	The equipment must be installed outside the hazardous area.	Due to installation in a flameproof enclosure ("d") the equipment may be used in Zone 1.

3.5.1 APPLICATION OF PROTECTION TYPE INTRINSIC SAFETY "i"

The **intrinsic safety** protection type is based on the principle of current and voltage limiting in an electric circuit. The electric circuit energy (which may be capable of causing an explosive atmosphere) is limited to the extent that neither sparks nor impermissible surface heating of electrical components can take place in the surrounding explosive atmosphere. This protection type is particularly common in measurement and control technology in which no high currents, voltage and capacities are required.

Intrinsically safe electrical circuit

An electric circuit in which neither a spark nor the effect of heat can cause a certain explosive atmosphere to ignite.

Intrinsically safe electrical equipment

Electrical equipment in which all circuits are intrinsically safe.

Associated electrical equipment

Electrical equipment that contains both intrinsically safe and non-intrinsically safe electric circuits. It is designed such that the non-intrinsically safe electric circuits cannot compromise the intrinsically safe ones (Table 15).

An essential aspect of the protection type "intrinsic safety" is the matter of reliability in respect of observance of voltage and current limit values, even in the event of specific faults. Intrinsically safe electrical equipment and parts of associated equipment are classified according to this reliability into the different protection levels ia, ib and ic. These protection levels are matched to the various zones. Intrinsic safety ia is thus suitable for use in Zone 0, ib for use in Zone 1 and ic for Zone 2.

A distinction is also drawn between **singe fault safety** and **double fault safety**:

- **Single fault safety:** Upon the failure of one safety-relevant component a second component must assume its task (protection level ib: one redundant component).
- **Double fault safety:** Upon the failure of two safety-relevant components a third component must assume their tasks (protection level ia: two redundant components).

An important safety measure for intrinsically safe circuits is the **safe isolation of all intrinsically safe from all non-intrinsically safe electric circuits**. Excepting safety barriers, safe electric isolation is always required. Galvanic separation is generally recommended for Zone 0. Zener diodes for limiting voltage and other semiconductor components are regarded as fallible and must be safeguarded by redundant components. Sheet or wire-wound resistors for current limiting are regarded as infallible (displaying high resistivity in the event of a fault). A single-component version is sufficient in this case.