IEC/EN 60079-14: Explosion Protection for Technical Plants

Part of the Basic Explosion Protection Compendium

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This brochure is intended for persons responsible for dealing with the explosion protection of potentially explosive electrical installations. Against the background of EU Directive 2014/34/EU, this brochure provides an overview of the identification of possible ignition sources, and how they should be handled in accordance with IEC EN 60079-14.

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Introduction

From a safety engineering point of view, the planning, erecting, testing, and operation of electrical installations require special care with regard to the prevention of dangerous contact voltages, and leakage currents. Series of standards such as VDE 0110, VDE 0105, etc. contain numerous requirements and information in this regard.

All these requirements also apply to electrical installations in hazardous areas, for which another potential hazard must be considered: Ignition sources can occur that are capable of igniting surrounding potentially explosive atmospheres.

To minimize the relevant risks to an acceptable level and to mitigate such hazards to the extent required, guidelines such as the IEC/EN 60079-14 (VDE 0165-1) standard contain additional requirements.

This publication does not claim to reproduce all details of the standard in full. Rather, it serves to provide an overview of the fundamentals and, above all, to focus on common misconceptions and errors that have been identified in numerous training sessions and consultations.

Furthermore, the special features of intrinsically safe circuits are not covered in this publication. Detailed information on this topic can be found in the publication "Intrinsic Safety and Fieldbus Technology".

For comprehensive information on the relationship between combustible substances, the occurrence of potentially explosive atmospheres and ignition sources, and the most important properties of combustible substances, refer to the publication "Explosion Protection—Physical and Technical Fundamentals".

Principles of Explosion Protection

Legal Basis

The basis for explosion protection is Directive 1999/92/EC on the minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres. In Germany, this Directive is partially implemented in the Hazardous Substances Ordinance (GefStoffV). These regulations specify a ranking of explosion protection measures, which are divided into primary, secondary, and design-driven explosion protection:

- Primary Explosion Protection:
  Prevention or temporal or spatial limitation of potentially explosive atmospheres (e. g., through substitution of combustible substances, ventilation, suction, or even inertization)
- Secondary Explosion Protection:
  Prevention of the ignition of a potentially explosive atmosphere (e.g., through the use of suitable devices listed for hazardous areas, smoking bans, measures against dangerous electrostatic charge, lightning protection, etc.)
- Design-driven Explosion Protection:
  Limitation of the effects of explosions to a non-hazardous level (e. g., through explosion suppression systems, bursting disks, quick closing slide valves, etc.)

Parallels to IEC/EN 60079-14 (VDE 0165-1)

A similar ranking is found in the standard for electrical installations in hazardous areas:

- Replacement:
  Replacement of a combustible substance with a non-combustible substance or a substance that is difficult to ignite
- Control:
  Limitation of the amount of combustible substances, prevention of the formation of potentially explosive atmospheres, prevention of ignition sources
- Mitigation:
  Limitation of possible explosion effects

The fact that the classification according to Directive 1999/92/EC differs at least slightly from that of IEC/EN 60079-14 (VDE 0165-1) is not relevant for this publication, since the following explanations refer only to the prevention of effective ignition sources.

Personnel Qualifications

General

A crucial aspect of the (explosion-related) safety of electrical installations in hazardous areas is that all persons involved in one or more life cycles of these plants are sufficiently qualified. It is not without reason that IEC/EN 60079-14 (VDE 0165-1), since the 2009 edition, has included corresponding requirements (at that time in Annex F) for the qualification of responsible persons, operatives/ technicians, and designers.

These requirements became more stringent in the 2014 edition (Annex A), where the main text of the standard stipulates that planning (design), device selection, and installation must be carried out only by persons who have the necessary knowledge of the functional principle of the individual types of protection, the respective installation techniques that are required, and the relevant rules and regulations.

Implementation in Practice

With regard to the exact wording of the standard, reference should be made here to the original text; however, experience shows that the admittedly very broad wording of the different qualification requirements regularly leads to numerous questions and extensive discussions.

From a legal standpoint, the employer responsible is obliged to define the required qualifications for employees in detail. In an earlier edition of the standard, e. g., a distinction was made between "knowledge" (with regard to operatives and technicians) and "detailed knowledge" (designers). Within the meaning of this standard, operatives and technicians are considered to be persons who work on or in plants in hazardous areas and install, replace and, if necessary, test devices or equipment there—usually in accordance with employer specifications. In contrast, designers are responsible for the proper design of the plant with regard to the expected explosion hazards (zones, groups, temperature classes, ambient conditions, etc.).

Example Regarding the Type of Protection Ex i

Within the framework of the quality management system of the respective employer, these terms must be made tangible by implementing them in practice; to illustrate this, here is an example for the type of protection Ex i, i.e., intrinsic safety:

As per IEC/EN 60079-25 (VDE 0170-10-1), the designer of intrinsically safe systems is responsible for the verification of intrinsic safety. In the majority of cases, this is limited to a simple comparison of safety-related characteristic values that takes certain cable parameters into account. However, there are also cases in which more than one item of associated apparatus is connected in the circuit, which at the very least makes the process of verification more time-consuming, and in some cases considerably more complicated. In such cases, the designer of such intrinsically safe systems must be familiar with all the rules and possible exceptions for the verification of intrinsic safety. In addition, the designer must be aware of the historical development of these requirements so as to be able to explain apparent contradictions between the information in type-examination certificates and those in the current installation standard ("detailed knowledge").

Operatives and technicians who subsequently erect these circuits based on appropriate specifications and plans do not necessarily need to be familiar with all these detailed differentiations ("knowledge").

Example for Inverter Operation of Motors

In some cases, the operation of motors listed for hazardous areas on the frequency inverter is not without its pitfalls, since this usually means taking a considerable intervention to adjust the heating behavior of the respective motor.

IEC/EN 60079-14 (VDE 0165-1) contains requirements on this subject, e. g., the requirement that motors of type of protection Ex e (increased safety) must be certified for inverter operation together with a specific electrical drive inverter and suitable protective equipment. On the other hand, there have been certified "e" motors for several years now with certificates that do not refer to a specific inverter type, but instead contain minimum requirements for aspects such as permissible speed ranges, minimum clock frequencies, maximum current limits, and overload times, etc. "Detailed knowledge" of explosion protection is required to explain this apparent contradiction. Operatives and technicians who subsequently erect these motors and electrical drive inverters based on appropriate specifications and plans do not necessarily need to be familiar with all these detailed differentiations ("knowledge").

On the basis of this distinction, the employer can now decide what kind of training and further training is required for the respective group of persons.

"Regular" Training

An excerpt from IEC/EN 60079-14 (VDE 0165-1) states:

"Personnel must undergo appropriate further education or training on a regular basis."

Within this context, the term "regular" is often misunderstood.

If you ask technicians or engineers about the meaning of this term, it is usually understood in the sense of "periodically": i. e., every year, every three years, or a similar time interval.

In the legal sense, however, "regular" means "according to a rule", meaning that further education or training must always be carried out when it is necessary. Here is an example to illustrate this:

An employer has decided that personnel need to attend training every two years. Suppose the first training session took place in April 2015, the next in April 2017, and the most recent session in April 2019. Continuing this, admittedly hypothetical, scenario, suppose that the International Electrotechnical Commission (IEC) now published a completely new version of the IEC 60079-14 standard in September 2019, which turns everything that has been understood about electrical installations in hazardous areas up to now on its head. In this case, the employer responsible must ensure that employees are informed of these requirements in a timely manner, e. g., via a follow-up training session in November 2019.

The next training session now takes place in May 2021, and in June of the same year, the German Federal Government again significantly changes the requirements for explosion protection within the framework of the Ordinances on Hazardous Substances and Industrial Safety and Health. Here, the employer must also decide the time by which personnel should have received the appropriate training.

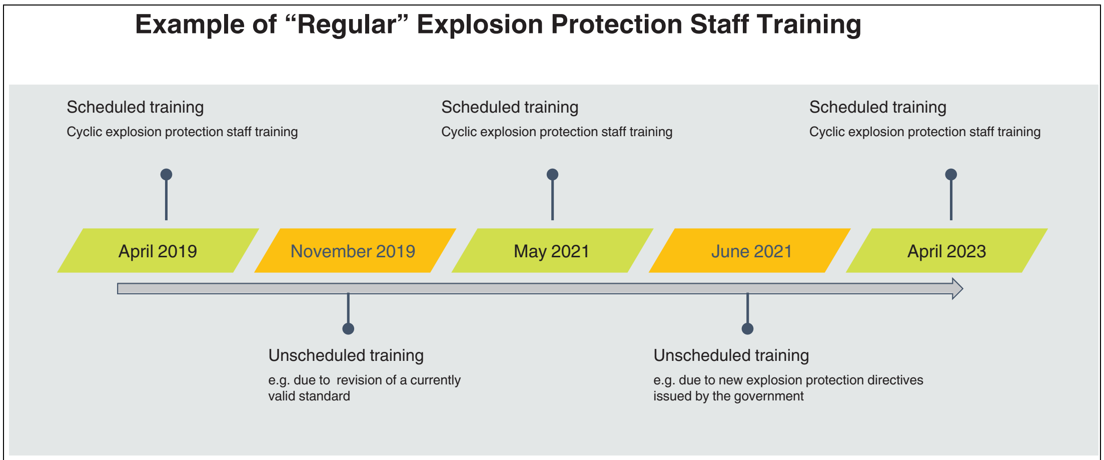

Figure 3.1 Example of regular staff training

Fundamental Requirements for Plants in Hazardous Areas

The fundamental requirements specified in the standard are not covered in detail here. Not only are these requirements extremely obvious, but they are also hardly ever discussed in practice:

- Wherever possible, required devices must be installed in non-explosion hazardous areas or in areas of lower risk, which can also be a sensible choice with regard to the potential cost savings.
- Devices must be operated in accordance with the vendor documentation (e. g., with regard to voltage, and temperature range, etc.).
- Cables and necessary glands must be selected in accordance with the respective type of protection.

Deviations from the Standard under the Supervision of a Competent Body

One piece of information that is likely of interest (and surprising to many) is that deviations from the requirements of IEC/EN 60079-14 (VDE 0165-1) are actually possible at any time—especially in the case of research or pilot plants—provided that these are supervised by a competent body.

Note

What is a Competent Body?

According to the definition given by the IEC/EN 60079-14 standard (3.1.1), a "competent body" is:

An "individual or organization which can demonstrate appropriate technical knowledge and relevant skills to make the necessary assessments of the safety aspect under consideration."

The "competent body" is **not** the same as the person qualified for testing e. g. under the German Ordinance on Industrial Safety and Health (BetrSichV)!

An individual in the sense of the "competent body" can be an in-house employee or even an employee of an external company. Similarly, the organization may be a subsidiary of the company in question or any other service provider.

Plant Documentation

The documentation required for electrical plants in hazardous areas essentially comprises three aspects:

- Plant
- Equipment
- Installation

It is has long been undisputed that the documentation of the plant must include the following information:

- Existing zones
- Required equipment groups
- Temperature classes of gases and vapors and ignition temperatures of combustible dusts
- External influences such as ambient temperature, increased mechanical hazard (e. g., due to strong mechanical vibration, etc.)

In addition, the following information is indisputably required for the individual devices:

- Instruction manuals
- Certificates where applicable
- Information on specific conditions of use ("X marking") where applicable
- Verification of intrinsic safety—tripping characteristics of motor protective switches

Relatively new, however, is the requirement that the documentation of the installation also be accompanied by an explanation as to the level of qualification of the persons involved in planning (design), device selection, and installation.

Selecting Electrical Equipment

The selection of equipment for use in or in connection with hazardous areas depends mainly on the following aspects:

- Existing zone or required equipment protection level (EPL)[1]
- Ignition characteristics of the combustible substances that are present (ignition temperatures and ignition energies, etc.)
- Expected ambient conditions (e. g., risk of corrosion, increased process temperatures, etc.)
- Where applicable, internal regulations, or customer specifications

With regard to the last point, it should be noted that it is not unusual for operators of complex processing plants with many different equipment to use equipment in Zone 1 and in Zone 2 that corresponds to the equipment protection level Gb or the equipment category 2G. This occurs even though the EPL Gc or the equipment category 3G would be sufficient for Zone 2. This may be due, for example, to the fact that the required stock of replacement equipment can be reduced considerably, or future modifications and extensions to the plant can be implemented more easily by doing so.

However, a deviation of this kind can also occur in the opposite direction. For example, it is possible to use equipment with EPL Gc (equipment category 3G) in Zone 1. See chapter "Fundamental Requirements for Plants in Hazardous Areas", section "Deviations from the Standard" and the corresponding requirements of Directive 1999/92/EC or the German Hazardous Substances Ordinance (GefStoffV). However, an appropriate hazard assessment always forms the basis for this.

Selecting According to Zone

The equipment in a potentially explosive plant/installation are selected by zone in Europe and by the two division model in the USA.

Classification of Hazardous Areas

Areas that can exhibit a potentially explosive atmosphere are especially at risk. Such areas are distinguished according to the frequency and duration of occurrence of the atmosphere and categorized into corresponding zones.

Classification into Hazardous Areas According to the Three Zone Model

Areas that can exhibit a potentially explosive atmosphere are especially at risk. Such areas are distinguished according to the frequency and duration of occurrence of the atmosphere and categorized into corresponding zones.

The following zone definitions are derived from the 2015 German Hazardous Substances Ordinance, Annex I, 1.7 and are based on the Directive 1999/92/EG (ATEX 137).

1. For information on the relationship between equipment protection level (EPL) and the equipment category as per Directive 2014/34/EU, refer to the publication on "Types of protection for electrical apparatus—Types of protection for gas hazardous areas, functional principle, identification, specifics for use" in this series of compendia.

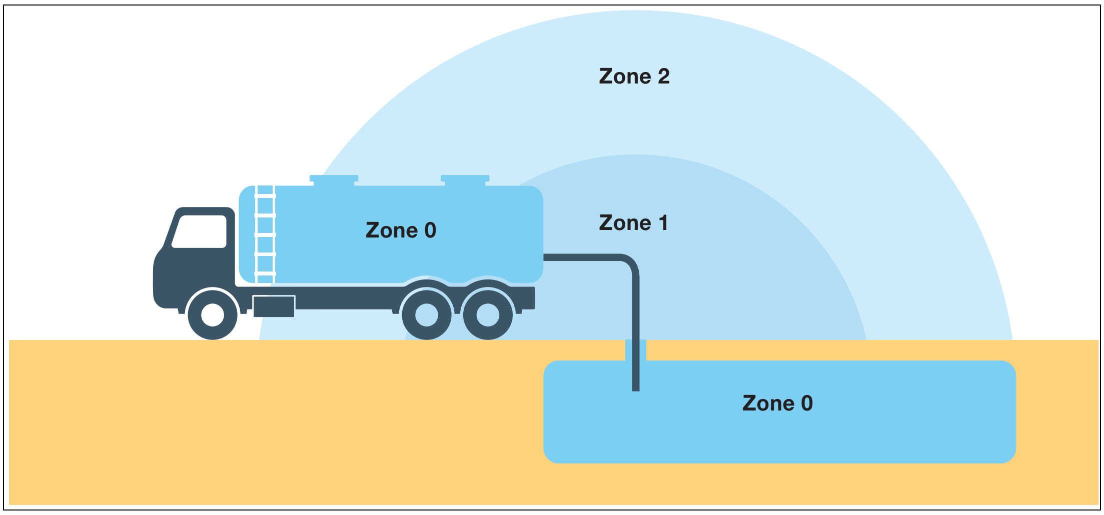

Figure 5.1 Schematic zone classification for a subterranean gasoline tank filling

Zone 0	Area in which a dangerous potentially explosive atmosphere as a mixture of air and combustible gases, vapors, or mists is constantly, persistently, or frequently present.
Zone 1	Area in which a dangerous potentially explosive atmosphere as a mixture of air and combustible gases, vapors, or mists can occasionally form 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 during normal operation and, if so, only rarely and for a short period of time.

Table 5.1 For definitions for 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 in the form of combustible dust contained in the air can occasionally form during normal operation.
Zone 22	Area in which a dangerous potentially explosive atmosphere in the form of combustible dust contained in the air does not normally arise during normal operation and, if so, only rarely and for a short period of time.

Table 5.2 For definitions for Zones 20 ... 22, see also IEC/EN 60079-10-2.

Assignment of Hazardous Zone, Equipment Category, and Equipment Protection Level (EPL)

Equipment categories for explosion hazardous areas (ATEX)			
Zone	Group	Category	Additional
0 / 20	II	1	G / D
1 / 21	II	1, 2	G / D
2 / 22	II	1, 2, 3	G / D

Typical EPL (IEC or EN 60079-...)	
Zone	EPL
0 / 20	Ga / Da
1 / 21	Ga, Gb / Da, Db
2 / 22	Ga, Gb, Gc / Da, Db, Dc

Figure 5.2 Overview of Zone, category, and the suitable EPL according to ATEX/IECEx

If only the aforementioned zones are specified in the classification of the hazardous areas, the respective equipment protection levels (or equipment categories) can be taken from the table above. If the EPLs or equipment categories are specified in the documentation, these requirements must be met for the equipment selected.

Equipment protection levels or equipment categories are based on the long-established direct relationship between the present zone and the respective suitable types of protection.

Equipment Protection Levels (EPLs) and Types of Protection in Gas Hazardous Areas

EPL	Type of protection	Abbrevia-tion	In accordance with...
Ga	Intrinsic safety	ia	IEC 60079-11
	Equipment protection by encapsulation "m"	ma	IEC 60079-18
	Two independent types of protection, each of which complies with EPL Gb N4)	--	IEC 60079-26
	Protection of equipment and transmission systems that use optical radiation	op is	IEC 60079-28
	Special protection	sa	IEC 60079-33

EPL	Type of protection	Abbrevia-tion	In accordance with...
Gb	Intrinsic safety	ib	IEC 60079-11
	Flameproof enclosure	db	IEC 60079-1
	Increased safety	eb	IEC 60079-7
	Equipment protection by encapsulation "m"	mb	IEC 60079-18
	Equipment protection by liquid immersion	ob	IEC 60079-6
	Purge and pressurization	p px py pxb pyb	IEC 60079-2
	Powder filling "q"	qb	IEC 60079-5
	Intrinsic safety concept for the fieldbus (FISCO)		IEC 60079-27
	Protection of equipment and transmission systems that use optical radiation	op is op sh op pr	IEC 60079-28
	Special protection	sb	IEC 60079-33

EPL	Type of protection	Abbrevia-tion	In accordance with...
Gc	Intrinsic safety	ic	IEC 60079-11
	Equipment protection by encapsulation "m"	mc	IEC 60079-18
	Non-sparking	nA	IEC 60079-15
	Restricted breathing	nR	IEC 60079-15
	Energy limitation	nL	IEC 60079-15
	Spark-generating equipment	nC	IEC 60079-15
	Purge and pressurization	pz pzc	IEC 60079-2
	Protection of equipment and transmission systems that use optical radiation	op is op sh op pr	IEC 60079-28
	Special protection	sb	IEC 60079-33

Equipment Protection Levels (EPLs) and Types of Protection in Dust Hazardous Areas

EPL	Type of protection	Abbrevia-tion	In accordance with...
Da	Intrinsic safety	ia or iaD	IEC 60079-11 or IEC 61241-11
	Equipment protection by encapsulation "m"	ma	IEC 60079-18
	Protection by enclosure	ta	IEC 60079-31
	Special protection	sa	IEC 60079-33

EPL	Type of protection	Abbrevia-tion	In accordance with…
Db	Intrinsic safety	ib or ibD	IEC 60079-11 or IEC 61241-11
	Equipment protection by encapsula-tion "m"	mb	IEC 60079-18
	Protection by enclosure	tb or tD	IEC 60079-31 or IEC 61241-11
	Purge and pressurization	pD	IEC 61241-4
	Special protection	sb	IEC 60079-33

EPL	Type of protection	Abbrevia-tion	In accordance with…
Dc	Intrinsic safety	ic	IEC 60079-11
	Equipment protection by encapsula-tion "m"	mc	IEC 60079-18
	Protection by enclosure	tc or tD	IEC 60079-31 or IEC 61241-11
	Purge and pressurization	pD	IEC 61241-4
	Special protection	sc	IEC 60079-33

New marking codes for protection with EPLs may be introduced in the future.

Typical Equipment Marking

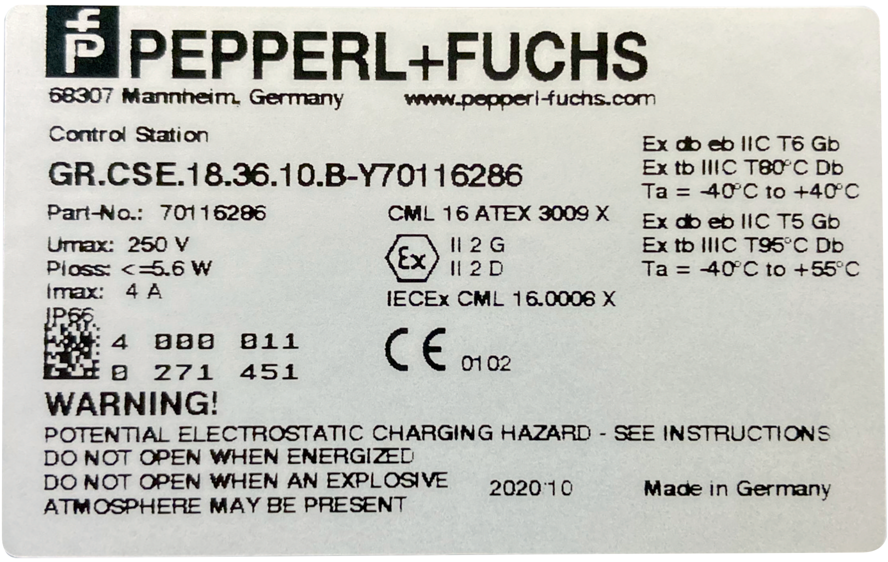

Figure 5.3 Example of a nameplate with the equipment marking for a control cabinet with Ex-d-e approval by Pepperl+Fuchs

Selecting According to Equipment Groups

In addition to the existing zone requirements, equipment must always be selected so that the equipment group meets the requirements of the respective gas group, or dust group. Equipment markings of the types of protection "i" and "d" have been assigned a subdivision for some time now, e.g.:

Ex ia IIC T6 Ga

Ex db IIB T4 Gb

For other types of protection, this was not the case; for these types, the marking contained only group "II":

EEx m II T5

EEx e II T4

Now, however, equipment of all types of (gas) protection feature the subdivisions a, b, or c:

Ex ma IIB T5 Gb

Ex eb IIC T4 Gb

This system may appear incomprehensible at first glance, yet it becomes clearer when looking into the background of this "new" marking. Traditionally, electrostatic ignition hazards that could arise from the insulating plastic enclosures of equipment listed for hazardous areas, for example, were covered by the marking "X" and a corresponding note in the equipment documentation ("Do not charge the enclosure electrostatically!"). However, there are now specifications for the maximum permissible electrostatically chargeable surfaces depending on the respective gas group (for details, see section "Electrostatic Protective Measures").

Assignment of Gas/Vapor or Dust Groups to Permissible Equipment Groups

Gas/vapor or dust group depending on the operating location	Permissible equipment group
IIA	II, IIA, IIB or IIC
IIB	II, IIB or IIC
IIC	II or IIC

Assignment of Electrostatic Groups to Permissible Equipment Groups

Electrostatic group depending on the operating location	Permissible equipment group
IIIA	IIIA, IIIB, or IIIC
IIIB	IIIB or IIIC
IIIC	IIIC

Selecting According to Ignition Temperature or Temperature Class

It is obvious that the temperature of hot surfaces in hazardous areas must not exceed the ignition temperature of the substances that are present. This also applies to the temperature generated by the equipment that is used. Since flammable dusts, in contrast to gases and vapors, are not categorized into temperature classes, they require a slightly different approach when selecting equipment.

It should always be noted that the equipment marking with a temperature class or a maximum expected surface temperature is always linked to the ambient temperature range specified by the manufacturer. If no indication of the ambient temperature range is given in the marking, the equipment is suitable for use in a temperature range of - 20 °C ... + 40 °C.

Gas or Vapor

Permissible Temperature Classes of a equipment According to Zones or Ignition Temperatures

Temperature class required by zone classification	Ignition temperature of gas or vapor in °C	Permissible temperature classes of the equipment
T1	> + 450	T1, T2, T3, T4, T5, T6
T2	> + 300	T2, T3, T4, T5, T6
T3	> + 200	T3, T4, T5, T6
T4	> + 135	T4, T5, T6
T5	> + 100	T5, T6
T6	> + 85	T6

Dust

In contrast to gas-ignition proof equipment, for which the respective manufacturer is already required to take into account a specified safety margin between the limit of the marked temperature class and the actual expected surface temperature, this is not the case for dust-ignition proof equipment. The responsibility for complying with the required safety margin of this equipment lies with the plant designer or owner.

Because many types of dust have ignition temperatures well above + 100 °C, many manufacturers of dust-ignition proof equipment do not measure the actual hot-spots on the outer surface of the equipment. Instead, they specify a maximum surface temperature that is derived from the temperature classes for gas, even though the true maximum surface temperatures are actually significantly lower.

Examples:

Gas: T6 => Dust: + 80 °C

Gas: T5 => Dust: + 95 °C

Temperature Limits due to Dust Clouds

The maximum surface temperature of the equipment must not exceed two thirds of the minimum ignition temperature in degrees Celsius for the dust/air mixture concerned:

$T_{max} \leq 2/3\, T_{CL}$

Where T_{CL} is the minimum ignition temperature of the dust cloud.

Temperature Limits due to Dust Deposits

If no dust layer thickness is specified in the equipment marking, a safety factor must be applied to take the dust thickness into account.

In the dust-free test, the maximum surface temperature of the equipment must not exceed a value of + 75 °C below the minimum ignition temperature for a layer thickness of 5 mm of the dust concerned.

$T_{max} \leq T_{5\,mm} - 75\ °C$

Where $T_{5\,mm}$ is the minimum ignition temperature of the dust deposit of 5 mm.

If the ignition temperature of a layer of 5 mm is below + 250 °C, a laboratory verification must be performed for the equipment used.

Note

Safety Margins vs. Dust Prevention

For dust deposits between 5 mm ... 50 mm, increased safety margins are specified in IEC/EN 60079-14 (VDE 0165-1). However, if it is technically possible to prevent dust deposits with a thickness of more than 5 mm from occurring, it is preferable to do so altogether.

Selecting According to External Influences

External influences that can adversely affect the explosion protection of the equipment used should ideally be taken into account as early on as the planning phase of the plant. If they cannot be completely eliminated through the selection of suitable equipment, the required test plans of the plant or installation must be adapted accordingly. This can be achieved, e. g., by shortening the inspection periods of the proof test or by a conducting a detailed inspection instead of a visual inspection or close inspection.

Damaging external influences can include:

- Extremely low or high temperatures

  Example: At low temperatures, the resistance of the equipment enclosure to impact can be reduced
- Solar radiation

  Example: Solar radiation can result in increased heating of the equipment and damage plastic materials
- Pressure conditions

  Example: A pressure increase in non-atmospheric conditions must be considered
- Corrosive atmosphere

  Example: Salt water—especially in combination with increased ultraviolet radiation—can damage equipment
- Mechanical vibration, mechanical shocks, friction, or abrasion
- Paint coatings

  Example: Paint coatings can impair electrostatic properties and heat dissipation
- Corrosion from chemicals
- Water and humidity
- Dust

  Example: Dust deposits that are present can impair heat dissipation
- Plants, animals, and insects

  Example: In certain regions, termite infestation may occur in some plastic materials; rodents may gnaw on cable sheaths.

Example of corrosion caused by chemicals
Source: thuba AG

Example of water ingress in the equipment
Source: thuba AG

Example of mouse bite marks in the cable sheath
Source: Pepperl+Fuchs

Suitable measures must be taken in particular when condensation is expected to form in enclosures. Appropriate options include, e. g., the use of drainage plugs for draining or breather drains for pressure compensation.

Note

Professional Measures to Prevent Condensation

It is never recommendable to mechanically damage the enclosure—e. g., by drilling a hole to allow condensed water to drain, as has unfortunately been observed on occasion.

Instead, use breather drains for pressure compensation and to minimize condensation in the enclosure.

Figure 5.4 Example of an enclosure breather drain

Mobile Devices

In principle, two types of mobile devices are available to the plant operator for use:

- Equipment listed for hazardous areas that are suitable for the respective application.
- Equipment not listed for hazardous areas that can be used only within the framework of a corresponding work permit system; information on the basic requirements for such work permit systems is found in Annex B of IEC/EN 60079-14 (VDE 0165-1).

Example

Procedure for Plant Overhaul Involving Welding Work

Overhauls in a plant must be carried out in an Zone 1 hazardous area. This requires the use of welding equipment. Because the welding equipment has no approval for the hazardous area, it can be used only within the framework of a work permit system.

Tip

Mobile Devices for Service and Maintenance in Hazardous Areas

Special cell phones, smartphones, or tablets are available for use in hazardous areas; such devices are often suitable for use in Zone 1 or Zone 21. These mobile devices cannot be used in Zone 0 (e. g., inside a storage tank) or in Zone 20 (e. g., silo). However, the use of mobile devices is normally not sought or required in these locations.

Figure 5.5 Mobile devices for use in hazardous areas

Batteries

Spare batteries must neither be placed in the hazardous area nor batteries replaced without taking appropriate precautions.

Note

Important when Replacing Batteries

When replacing the batteries of devices listed for hazardous areas, ensure that the battery manufacturer and battery type is approved for the respective device. The approved manufacturers and types are listed in the instruction manual.

Rotating Electrical Machines

When selecting electrical machines, the following aspects in particular must be considered:

- Load cycle
- Supply voltage and frequency range
- Heat transfer from the driven device (e.g., a pump with heat-transfer oil)
- Service life of bearings and lubricants
- Class of insulation

Strong mechanical vibration is one example of an aspect that can be considered an especially critical environmental influence. This increases the risk of terminals loosening and the strain on the cable and the gland increasing.

Operating Modes of Electrical Drives

Motors can be operated in different operating modes. These are listed below.

The motor manufacturer provides information about which operating modes the motor is suitable for and values for the useful working period, the load time, or the relative duty cycle, if this information is required.

The operator must assign the motor to an operating mode. More information on this is found in IEC/EN 60034-1 (VDE 0530-1).

Possible operating modes include:

- S1: Continuous operation
- S2: Short-term operation
- S3: Intermittent operation without influence of the start-up process
- S4: Intermittent operation with influence of the start-up process
- S5: Intermittent operation with influence of the start-up process and the electrical braking
- S6: Continuous duty with intermittent loading
- S7: Uninterrupted operation with start-up and electrical braking
- S8: Uninterrupted operation with periodic load speed change
- S9: Uninterrupted operation with non-periodic load change and speed change

Motors with current-dependent time-delayed overload protection devices are permitted in continuous operation if only light and rare start-up processes occur for these and therefore no significant additional heating is caused. In the case of frequent or heavy start-up processes, suitable protective equipment must ensure that the limit temperature is not exceeded. [1]

1. Heavy start-up processes occur when the motor is switched off by the current-dependent time-delayed protective equipment adapted to the rated current before the motor has reached its rated speed.

Protection Against Overload and Against Impermissible Heating

If a motor cannot carry the start-up current that it requires or a generator cannot carry the short circuit current on a permanent basis without heating up to an impermissible level, this machine must also be protected against overload.

The standard permits different versions in this regard:

- A current-dependent, time-delayed device (motor protective switch, to be set to the rated current at maximum) or
- Direct temperature monitoring (winding temperature sensor) or
- Another equivalent device

However, no other such equivalent devices have been available up to now. This is, in effect, an opening clause that accommodates future approved monitoring devices. Such devices include, e. g., approved protective equipment in which the rotational speed of the motor is monitored to prevent impermissible heating.

Checking the winding temperature is important because the insulating layer of the coil is damaged at higher temperatures and can cause a short circuit. If this occurs, the coil is heated further. This can result in spark generation and the overrange of the maximum permissible surface temperature.

Classes of Insulation

To be able to take suitable protective measures, a class of insulation is assigned to the winding material. The class of insulation indicates the limit temperature up to which the respective material has a functioning insulating layer. The winding temperature must therefore not be higher than the limit temperature of the winding material used.

The classes of insulation are listed in the following table.

Possible Classes of Insulation

Thermal class in °C	Letter designation
90	Y
105	A
120	E
130	B
155	F
180	H
200	N
220	R
250	-

Table 6.1 List of insulation classes

Motors in Inverter Operation

In addition to being supplied from the power grid, motors can also be supplied with power via an electrical drive inverter or a soft start device. However, special care should be taken if such equipment is used, since these can generally have a strong (negative) influence on the temperature behavior of the motor. Caution: When operating motors with voltages greater than 1 kV, careful consideration must be given to the possible hazards caused by the high voltages. For more information, see IEC/EN 60079-14 Clause 5.11.5. For this, the motor must meet either of the following requirements:

- The motor has been type-tested for the relevant operating mode as a unit, in conjunction with the electrical drive inverter and the protective equipment.
- The motor is euqipped with an appropriate device that controls its temperature with probes in the winding and that switches the motor off in the event of excessive heating.

Other effective measures can be taken in this regard to limit the surface temperature of the motor housing. Current-dependent time-delayed protective equipment is not a suitable measure for this and should not be used.

Type of protection	Combined certificate[1]	Temperature monitoring[2]
Flameproof enclosure "d"	permitted	permitted
Increased safety "e"	permitted	**not permitted**
Pressurized enclosure "p" and "pD"	permitted	permitted
Equipment dust protection by enclosure "t"	permitted	permitted
Non-sparking "nA"	permitted	permitted

Table 6.2 [1] The motor has been type-tested for the respective operating mode as a unit in conjunction with the electrical drive inverter and the protective equipment provided.
[2] The motor temperature must be directly controlled by a device using a temperature probe embedded in the winding. In the event of excessive heating, protective equipment switches off the motor.
This also applies for soft start controls.

Cables

With regard to selecting cables in hazardous areas, the standard leaves a considerable scope of discretion for the designer or user in making their selection for both permanently installed and portable devices. The following is a brief description of the fundamental requirements.

- Maintenance of the essential features of the respective type of protection:

  Especially in the case of devices of the type of protection "d", special attention must be given to ensure that there is no transfer of flames or hot gases from the inside of the device to the surrounding potentially explosive atmosphere.

- Protection against damage, e. g., causes like:
  - Mechanical hazards
  - UV irradiation
  - Chemically aggressive substances
  - Rodent gnawing or damage from insects
  - etc.

  This can be achieved by selecting cables with suitable sheathing and/or installing them in a protective rigid conduit or flexible conduit.

- Limitation of surface temperature through dimensioning depending on current and laying method.
- Prevention of flame propagation, e. g., by testing in accordance with IEC 60332-1-2 or -2-2, firewall, or similar.
- Compliance with the minimum tensile strength. Cables with a tensile strength of the inner or outer sheath that is < 8.5 MPa must not be used.

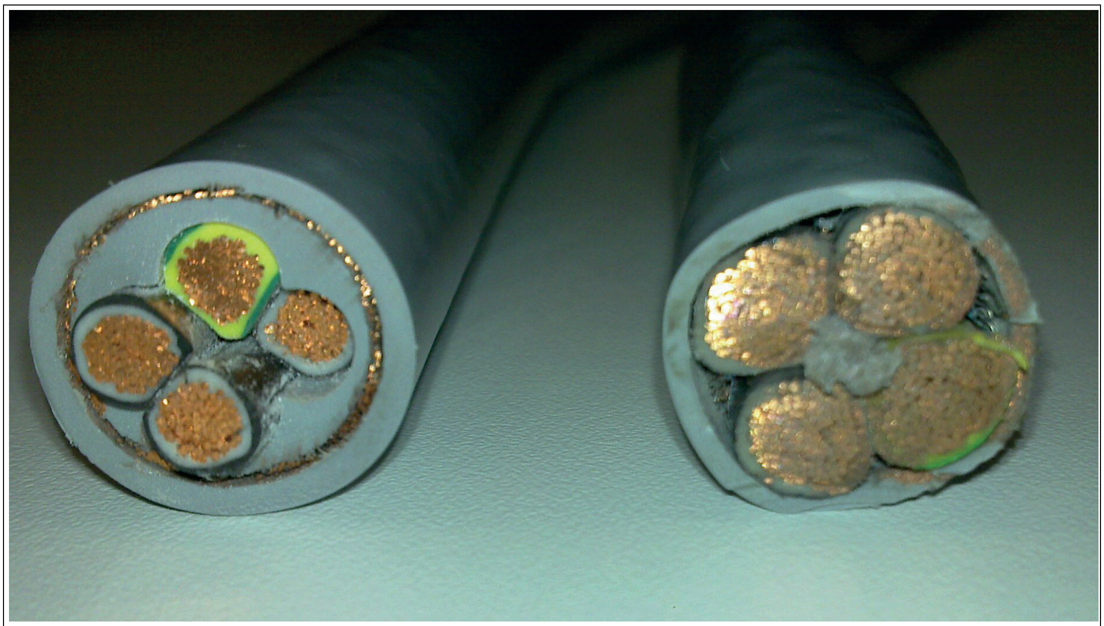

Figure 7.1 Left: The cable sheath meets the Ex-d requirements.
Right: Without taking additional measures, the cable sheath does not meet the Ex-d requirements and bears the risk of flame penetration or similar
Source: Pepperl+Fuchs

Aluminum Conductors

Aluminum may be used as a conductor material only in systems without limited energy or in intrinsically safe systems if it is provided with a suitable connection device and has a conductor cross-sectional area of $\geq 16\ mm^2$. Precautions against electrolytic corrosion should also be taken.

Cables for Permanent Installation

Cables with the following properties are suitable for permanent installation:

- Thermoplastic, thermoset, or elastomer sheathing, circular, and compact without hygroscopic filling material or
- Mineral insulation with metal sheathing or
- Custom cables

Note

What Are Custom Cables?

The term "custom cable" often leads to misunderstandings. This is not necessarily a custom product (i. e. a custom-made cable), but rather a cable that has been selected based on a hazard assessment for the respective application area.

Flexible Cables for Mobile Devices

The following cables are suitable for mobile devices:

- Sheathed conductors made of heavy polychloroprene, heavy rubber hose line
- Cables with an equally robust design
- Cables with a minimum cross section of 1 mm^2; a required protective conductor must be included in the cable where necessary

Dealing with Unused Single Cores

The question of how to deal with unused single cores in a multicore cable is a frequently discussed topic. With regard to this matter, the standard essentially permits two options:

- Unused cores must be safely grounded at the end in the hazardous area or
- Unused cores must be isolated from earth using a suitable means (e. g., via a suitable terminal)

Generally, heat-shrinkable caps are also accepted by the inspection experts of the approved inspection bodies.

Terminals

When using insulated wires and terminals, the following must be complied with:

- Connect the cores in accordance with the vendor documentation for the terminals
- Where necessary, cores must be protected against splicing; soldering is not permissible
- Depending on the type of protection, clearances, and creepage distances must be complied with

Conveying and Accumulation of Combustible Materials

Previous editions of IEC/EN 60079-14 (VDE 0165-1) already included the requirement to select and install cables in such a way that flammable gases and vapors or potentially explosive atmospheres can neither be conveyed through the cables themselves nor through any existing protective rigid conduits or flexible conduits (keyword: "zone entrainment"). This can be achieved by selecting suitable cables that are sufficiently "gas-tight" or by sealing shafts, channels, or pipes with sand, or other suitable means. Adequate ventilation can also prevent the accumulation of combustible materials in trenches.

As far as the "gas-tightness" of cables themselves is concerned, Annex H of the standard describes a test method that users themselves can only carry out with a considerable amount of effort. With regard to this matter, it is recommended to ask the respective cable manufacturer, for example, since the manufacturer may be able to confirm the required leak-tightness of its cables by providing a corresponding declaration.

Accumulation of Dust

Cable glands should be arranged so that the minimum amount of dust accumulates and so that the cable glands are easily accessible for cleaning. When cables are routed through ducts, channels, pipes, or trenches, measures must be taken to prevent the passage and accumulation of dust in the interior.

Cables in dusty atmospheres should be dimensioned insofar as possible to prevent the cables from heating up, since dust deposits that are present can have an insulating effect and impair the heat dissipation.

Cable Gland Systems and Sealing Elements

Selecting Cable Glands

Cable glands must be selected to match the cable diameter. The cable must not be adapted to fit the cable gland through the use of other materials (e. g., sealing tape, heat-shrinkable tube). This ensures the required degree of protection (IP). Additionally, this maintains the properties of the respective type of protection of the connected device. For devices of the type of protection "d" in particular, precise attention must be given to ensuring that a flame penetration cannot occur at the cable gland in the event of an internal ignition.

With sufficient knowledge of the function principle of the various types of protection, it is obvious that for equipment of the type of protection "d" with a direct cable gland, a gland of the type of protection "e" would be unsuitable and impermissible.[1]

However, it is often asked what the reverse case would look like: Can a gland (or a sealing element) of the type of protection "d" be used with a device of the type of protection "e" (for example, a terminal box)?

In previous years, this question could only be answered with considerable effort on the part of the designer or operator, because the requirements for cable glands had to be taken from the respective device standards and compared. The issue has now become much easier to resolve, since the current edition of the installation standard contains the following table, which establishes the connection between the type of protection of the equipment and the respective glands.

1. For details, see the publication "Types of protection for electrical apparatus".

Permissible Combinations of Types of Protection for Equipment and for Connection Technology in According with IEC/EN 60079-14

Protective technology for the equipment	Protective technology for cable glands, adapters, and sealing elements			
	Ex "e"	Ex "d"	Ex "n"	Ex "t"
Ex "d"		X		
Ex "e"	X	X		
Ex "i" and "nL"—Group II[1]	X	X	X	
Ex "i"—Group III				X
Ex "m"	Ex "m" would not normally be used for wiring connections. The protective technology for connections must match the wiring system that is used.			
Ex "n"	X	X	X	
Ex "o"	Ex "o" would not normally be used for wiring connections. The protective technology for connections must match the wiring system that is used.			
Ex "p", all degrees of protection	X	X	X[2]	
Ex "pD"				X
Ex "q"	Ex "q" would not normally be used for wiring connections. The protective technology for connections must match the wiring system that is used.			
Ex "s"	Only those approved in the requirements of the certificate			
Ex "t"				X

Table 7.1 X indicates that use is permitted.
[1] If only one intrinsically safe circuit is used, there are no specified requirements for cable glands.
[2] Only permitted for GC equipment.

Special Features of Flameproof Cable Glands

These glands can be fundamentally distinguished to the effect that they are either

- Simple in design with a sealing element or
- Must be provided with a hardening sealing compound: Barrier glands

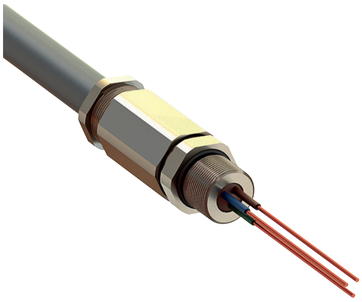

Figure 7.2 Example for a barrier gland

Barrier glands are Ex d metal fittings for armored or non-armored cables. They are filled with a 2-component casting compound, which encloses the individual inner cores so that an explosion discharge cannot occur in the cable.

In this regard, Clause 10.6.2 of the IEC/EN 60079-14 standard states that the use of standard Ex-d cable glands is permitted only if the following two requirements for the cables are met:

- The minimum length of the connected cable is 3 m
- The cable is covered by sheathing made from a thermoplastic, thermoset, or elastomer material. It must be circular and compact

Any embeddings or sheathing must be extruded. If filling material is present, this must not be hygroscopic. If these requirements are not met, barrier glands must be used. The most critical point in the evaluation of whether the use of barrier glands can be avoided lies in the structure and the quality of the cable. This raises the following questions:

- When is a cable no longer "circular," or what does "compact" mean in reality?
- How does the user know if an embedding or a coat was extruded or whether a filling material is not hygroscopic?

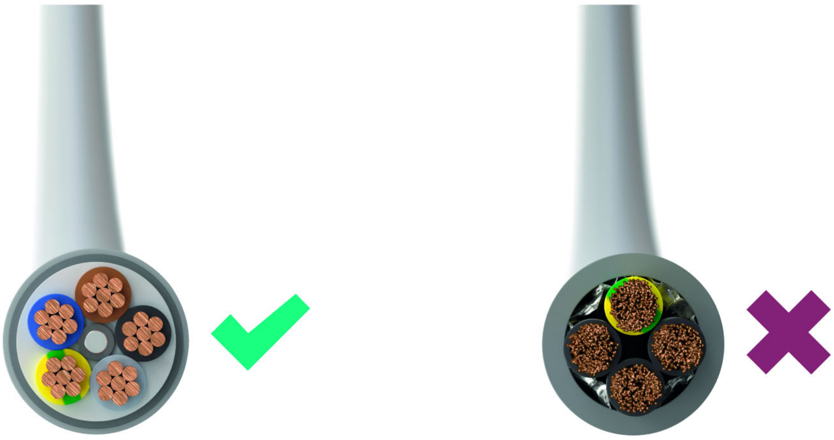

Figure 7.3 Left: A sufficiently filled cable
Right: An insufficiently filled cable

Barrier glands must be used if the internal cable structure and the external installed cable length do not reliably prevent explosion propagation. Cable manufacturers will rarely give official confirmation of compliance with one or even all of the above conditions. In addition, cable gland manufacturers cannot usually give any statements regarding cables that are tried and tested in conventional Ex-d glands, although some combinations have already been tested in real laboratory explosion experiments.

Experienced installers in hazardous areas generally know that the installation of barrier glands—and normal reinforced Ex-d glands—can be a source of potential installation errors. Even if the explosion protection functions without problems, this can depend on a rubber seal with a length of only 10 mm.

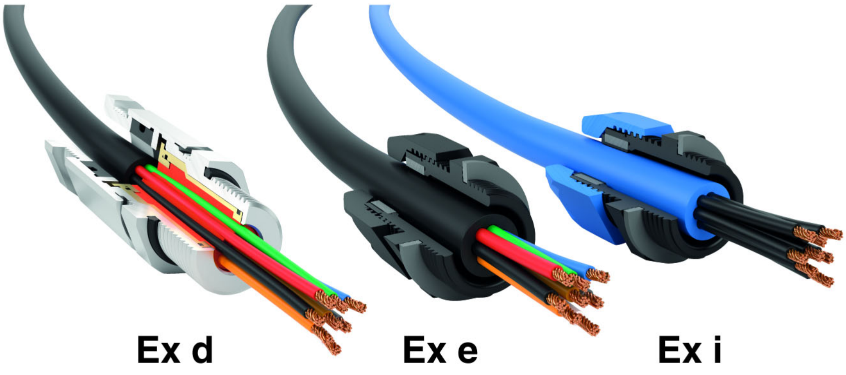

Figure 7.4 Cross sections of Ex-type barrier glands

Protection Against Sparks—Static Electricity

One point that has considerably gained in importance in recent years is the protection against the dangerous electrostatic charging of surfaces in hazardous areas. Even though manufacturers of equipment listed for hazardous areas must comply with a number of requirements in this regard, a large quantity of components still remain that need to be subjected to a critical check by the designer or the user themselves. These can include components such as the following:

- Plastic or plastic-coated cable racks
- Protective rigid conduits
- Flexible conduits
- Supporting cables
- Other components that are not subject to Directive 2014/34/EU and therefore do not have any marking obligation or certification obligation with regard to explosion protection

Fundamental Electrostatic Protective Measures

The following measures can be taken to prevent dangerous electrostatic charge:

- Select materials with a maximum permissible surface resistance
- Limit the use of chargeable surfaces
- Limit the thickness of insulating layers on conductive surfaces
- Provide a warning message

Selecting Materials

If materials are selected that do not exceed a surface resistance measured in accordance with IEC/EN 60079-0, the risk of ignition through electrostatic discharge is considered to be sufficiently low:

- 10^9 Ω, measured at (50 ±5) % relative humidity or
- 10^{11} Ω, measured at (30 ±5) % relative humidity

This relates to materials that are conductive yet known as "dissipative" (e.g., carbon-reinforced plastics), which would be electrically insulating without this measure. Both types of materials—conductive and dissipative—are referred to as antistatic.

Surface Limitation

If insulating materials with surface resistances greater than those mentioned above need to be used, it may be possible in some circumstances to limit their surface and, consequently, the amount of energy that is stored electrostatically. The standard specifies the following values:

	Surface area [mm²]		
EPL	**Group IIA**	**Group IIB**	**Group IIC**
Ga	5000	2500	400
Gb	10 000	10 000	2000
Gc	10 000	10 000	2000

Table 8.1 The table is applicable to enclosures, (plexiglass) viewing panels, information signs, etc.

In the case of long, thin objects such as rigid installation conduits or installation hoses, and supporting cables, etc., the entire surface in mm must not be limited, but rather the diameter of these objects, since the radius of curvature of a surface has a decisive influence on the expected spark energy.

	Width or diameter [mm]		
EPL	**Group IIA**	**Group IIB**	**Group IIC**
Ga	3	3	1
Gb	30	30	20
Gc	30	30	20

Table 8.2 The table is applicable to rigid installation conduits or installation hoses, etc.

Thickness Limitation

Paint coatings or corrosion protection coatings on grounded metal parts generally have an electrically insulating effect. For these, there is a risk that above certain layer thicknesses, the throughput resistance through the layer will become too high to discharge electrostatic charges toward the ground. In this case, these layer thicknesses must be limited:

	Layer thickness [mm]		
EPL	**Group IIA**	**Group IIB**	**Group IIC**
Ga	2	2	0.2
Gb	2	2	0.2
Gc	2	2	0.2

Table 8.3 The table is applicable to devices with paint coatings, etc.

Warning Message

If neither of the aforementioned measures are effective, the last option is to attach a warning message:
"Do not electrostatically charge", "Risk of electrostatic charge", or similar.

A proven means of meeting this requirement can be, for example, to wipe insulating and therefore electrostatically chargeable surfaces only with damp cotton cloths in the course of cleaning or testing. In this case, however, it is essential to inform personnel of the reason for this need through appropriate training.

Limitations of Applicability

All of the outlined measures are only sufficient as a sole protective measure if manual charging processes are expected. Such processes include, for example, wiping down these surfaces with a cloth or (unintentionally) brushing against these surfaces with items of clothing. However, if the processes in question generate a high amount of charge, additional measures must be taken to avoid dangerous electrostatic measures. These processes include the limitation of conveying speeds and flow rates; for more information, see TRGS 727.

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