

SIEMENS

SIMATIC

Principles of Explosion Protection

System Manual

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Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury will result if proper precautions are not taken.
⚠ WARNING
indicates that death or severe personal injury may result if proper precautions are not taken.
⚠ CAUTION
with a safety alert symbol, indicates that minor personal injury can result if proper precautions are not taken.
CAUTION
without a safety alert symbol, indicates that property damage can result if proper precautions are not taken.
NOTICE
indicates that an unintended result or situation can occur if the corresponding information is not taken into account.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation for the specific task, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be adhered to. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

1.1 Preface

Purpose of the manual

This manual describes the basic principles of explosion protection. It contains fundamental information that you must bear in mind for the planning, installation and operation of electrical systems in explosion-endangered areas.

Required basic knowledge

General knowledge of automation engineering is required to understand the manual.

Scope of validity of the manual

The manual applies to the

- Manual: S7-300 Automation Systems, ET 200 Ex I/O Modules
- Operating Instructions: ET 200iSP Distributed I/O Station
- Operating Instructions: DP/PA Coupler, Active Field Distributor, DP/PA Link and Y Link

Changes compared to the previous version

This manual contains the following changes/additions compared to the previous version:

- Updates of directives and standards
- Examples with the active field distributor AFDiS

Position in the information landscape

More information on explosion protection can be found in the corresponding directives and standards.

Guide

You can quickly access specific information in the manual by using the following aids:

- A comprehensive table of contents and a list of tables and figures included in the document are available at the beginning of the manual.
- Important terms are explained in the glossary.
- Navigate to the most important topics in our documents using the index.
- Cross-references are shown as hyperlinks in the running text. By clicking a hyperlink, you can open the associated section in this manual, or access the download page on the Internet that contains this information.

Further support

If you have questions regarding use of the products described in this manual, and do not find the answers in this document, contact your local Siemens representative.

You will find information on who to contact on the Web

(<http://www.automation.siemens.com/partner/>).

A guide to the technical documentation for the various SIMATIC products and systems is available on the Web (<http://www.siemens.com/simatic-tech-doku-portal>).

The online catalog and ordering systems are available on the Internet

(<http://www.siemens.com/automation/mall>).

Training center

Siemens offers a variety of courses to help you get started with the ET 200pro and the SIMATIC S7 automation system. Contact your regional Training Center or the central Training Center in D -90327 Nuremberg, Germany.

You will find more information on the Web (<http://www.siemens.com/sitrain>).

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You can contact Technical Support for all A&D products using the Support Request Web form on the Internet (<http://www.siemens.com/automation/support-request>).

Additional information about Siemens Technical Support is available on the Internet (<http://www.siemens.com/automation/service>).

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In addition to our documentation, we offer a comprehensive knowledge base on the Internet (<http://www.siemens.com/automation/service&support>).

There you can find:

- Our Newsletter, which constantly provides you with the latest information about your products.
- Any documents you may require via our search in Service & Support.
- The bulletin board, a worldwide knowledge exchange for users and experts.
- Your local contact person for Automation & Drives through our contact database.
- Information on local service, repairs, spare parts. And lots more on the "Services" pages.

Product overview

2.1 Introduction

Danger due to flammable materials and dusts

In many industries, flammable materials, gases, vapors or mists are created or escape during the manufacture, processing, transport and storage of flammable substances. In other industries, such as coal mining, flammable dusts are created.

In conjunction with oxygen, these flammable substances and dusts form an explosive atmosphere. In the event of detonation, this can lead to an explosion and severe damage to equipment or injury to persons.

Avoiding explosion hazards

To avoid explosion hazards, protection regulations in the form of laws, standards and ordinances have been developed in most countries. These regulations ensure a high level of safety and apply to manufacturers, installers and operators of equipment for the explosion-endangered area.

Overview of explosion protection

This manual provides you with an overview of explosion protection.

- Current standards and directives for explosion protection
- Explanation of protective measures and identification of equipment
- Notes on installation, operation and maintenance of EX equipment

2.2 Explosive atmosphere

2.2.1 Definition

Introduction

An explosive atmosphere is a mixture consisting of air and flammable gases, vapors, mists or dusts. This mixture is explosive if there is a corresponding concentration under atmospheric conditions. Combustion would continue autonomously after ignition by the ignition source.

Conditions

For an atmosphere to be explosive and for its ignition, the following aspects must be examined:

- Concentration of flammable substances
- Presence of a hazardous amount
- Efficiency of the ignition source.

2.2.2 Explosion-related characteristics

2.2.2.1 Gases

Liquids, gases / vapors

Evaporation transforms parts of a liquid substance into a gaseous state of aggregation. This is why a mixture of vapors and air forms above a free liquid surface, which is not yet flammable.

If the temperature is sufficiently high, evaporation means that the liquid develops such large quantities of vapor that it can form a flammable mixture with the air above the liquid. More information on flammability and other characteristic properties is defined in the safety parameters. Examples of flammable liquids and gases are the *flash point* and the *upper and lower explosive limits*.

Ignition temperature

The ignition temperature of flammable gases and liquids is the lowest temperature of a heated surface at which ignition of the gas/air or vapor/air mixture occurs: The highest surface temperature of any equipment must always be lower than the ignition temperature of the gas mixture to prevent explosion.

Flash point and burning point

The temperature at which the flammable gas or air mixture above the liquid ignites is referred to as the flash point; this is determined in a closed crucible under specified conditions.

However, continued combustion of the flammable mixture is not yet possible, as not enough vapor is developed at this liquid temperature. If the temperature is sufficient for the changed vapor/air mixture above the liquid to continue to burn, the temperature is referred to as the burning point.

The values of the flash point and burning point are not physical constants, they are substance-specific properties of that specific gas-air mixture. These are laid down as safety specifications, as other factors such as convection and diffusion also play a role in determining the above-mentioned temperatures.

2.2.2.2 Dusts

Dusts

Solid materials in a ground-up form, e.g. as dust, are frequently used in industry, such as chemical or cement plants. EN 61241-14 defines dust as "small solid particles in the atmosphere that settle because of their own weight but still remain in the atmosphere as a dust/air mixture for some time". Dust deposits are comparable to a porous body and have a voidage of up to 90%. If the temperature of dust deposits is increased, this can lead to spontaneous ignition of the flammable dust substance.

If dust deposits with a small particle size are stirred up, there will be a danger of explosion. The danger is increased as the size of the particles is reduced, because the void surface becomes larger.

Dust explosions are frequently the consequence of stirred-up, smoldering dust layers that contain the initial ignition potential.

Gas or vapor-air explosions can also stir up dust, with the result that the gas explosion is then frequently transformed into a dust explosion.

The danger of an explosion is reduced by using explosion-protected devices in accordance with their protective properties. The identification of the device category shows the effectiveness of the explosion protection and its use in the appropriate explosion-endangered areas.

The hazard potential of explosive dust atmospheres and the selection of appropriate protection measures is judged on the basis of the safety parameters. Dusts are therefore classified by two of their substance-specific properties:

- conductivity
- Dusts that have a specific electrical resistance of up to 10^3 ohmmeters are classified as conductive.
- flammability
- Flammable dusts can burn or smolder in the air.

Examples of safety parameters for stirred-up dusts are the *minimum ignition energy* and the *ignition temperature*, while for dust deposits the *smoldering temperature* is a characteristic property.

Smoldering temperature

The smoldering temperature is an important safety specification for dusts. This temperature is calculated for a dust layer of 5 mm and depends on the conductivity of the dusts.

With greater layer thicknesses than this, smoldering can begin below this smoldering temperature.

There are also explosion limits and areas for dust/air mixtures that depend on the thickness of the layer and the conductivity as with gases and vapors.

Ignition temperature

If equipment is installed in an environment with stirred-up dust, the surface temperature of the equipment must not exceed a specific value. This depends on the temperature of the substances involved and is two-thirds of the spontaneous ignition temperature of the dust minus the value of 75 K (Kelvin).

Smoldering or glowing

In the case of dust deposits, smoldering or glowing can also occur. In contrast to dust/air mixtures this is triggered at lower temperatures. In particular if the dust particles are stirred up, smoldering can be the ignition source for a dust/air mixture.

2.2.2.3 Concentration of flammable substances

Lower explosion limit

Whether an explosive atmosphere occurs depends on the concentration of the mixture that forms above the liquid. If there is a mixture concentration in which the mixture is only just explosive, this is the lower explosion limit (also referred to as the lower ignition limit).

The associated temperature is called the lower explosion point.

Upper explosion limit

If the mixture concentration is increased above the explosive concentration range, a degree of concentration is finally reached in which the mixture has too little oxygen due to the higher proportion of gases and vapors and is therefore no longer explosive.

In this case the upper explosion limit or the upper ignition limit is reached. Above this limit the mixture is too dense, but can still burn in an oxidizing environment.

Explosion range

The concentration ratio between the explosion limits (ignition limits) is referred to as the explosion range (see the following figure).

In the case of a mixture with oxygen, the upper explosion limit is considerably higher than in the case of a mixture with air. If an inert gas is used instead of oxygen, an explosion is no longer possible.

The ignition temperature of a flammable gas or a flammable liquid is the lowest temperature determined in a testing device of a heated wall on which the flammable substance in the mixture with air can still ignite.

The ignition temperatures of the flammable gases are classified into different temperature classes.

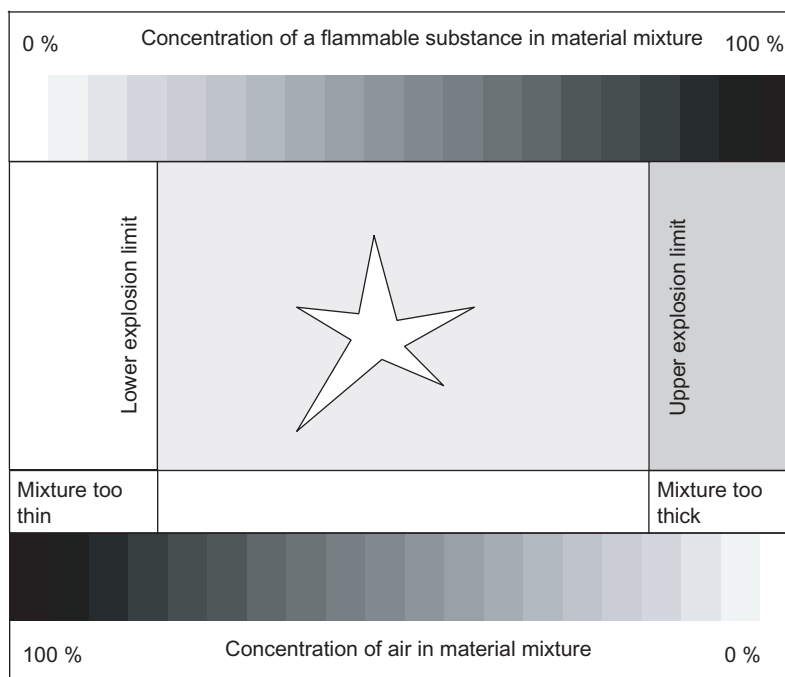


Figure 2-1 Concentration of a flammable substance in air (explosion limits dependent on substance)

See also

Safety Specifications (Page 119)

Temperature classes (Page 49)

2.2.3 Presence of a hazardous amount

Hazardous explosive atmosphere

An explosive atmosphere with a hazardous amount is a *hazardous* explosive atmosphere. In this case, there must be such an amount that leads directly or indirectly to personal injury or damage to property in the event of an explosion.

As a rule, 10 liters accumulated in an explosive atmosphere in a closed room (independent of the room size) is viewed as hazardous.

2.2.4 Efficiency of the ignition source

Definition

The efficiency of an ignition source and thus the capability of igniting an explosive atmosphere depends on

- the minimum ignition energy
- The **minimum ignition energy** is the smallest possible amount of energy that can ignite an explosive mixture. The minimum ignition energy is in the range of 10^{-5} joules for hydrogen to several joules for specific dusts.
- the properties of the explosive atmosphere.

Ignition sources

Possible ignition sources are:

- Hot surfaces
- Flames and hot gases (including hot particles)
- Mechanically created sparks
- Electrical systems
- Static electricity
- Exothermic reactions

Specific ignition sources are:

- Electrical equalizing currents, cathodic corrosion protection
- Lightning
- Electromagnetic waves
- Optical radiation
- Ionizing radiation
- Ultrasound
- Adiabatic compression, shockwaves from flowing gases

Devices and systems

In practice, electrical devices and systems represent a large number of possible ignition sources. In this context, sparks caused by switching and components heated by impermissibly high currents (e.g. in the event of faults in a short circuit) can act as ignition sources.

2.3 Protective measures

Avoiding explosions

Work safety regulations (Germany - ATEX 137) prescribe measures for the prevention of an explosive atmosphere.

Two principle types of explosions must be avoided:

1. **Preventing the formation** of a hazardous explosive atmosphere
= *primary explosion protection*.
2. **Preventing the ignition** of a hazardous explosive atmosphere
= *secondary explosion protection*.

Primary explosion protection

Primary explosion protection involves all measures that prevent or restrict the creation of a dangerous, explosive atmosphere.

This can involve the following:

- Avoiding flammable liquids
- Inerting
- Replacement of flammable substances by non-flammable substances
- Keeping the concentration below the lower explosion limit or above the upper explosion limit
- Suitable system design
- Natural and technical ventilation measures.

Note

Primary explosion protection is not explained in detail in this manual.

Secondary explosion protection

However, there are a large number of applications where primary protective measures cannot be applied. In such cases secondary protective measures are required. Secondary explosion protection measures prevent ignition, ensuring the safety of people and material in explosion-endangered areas.

There are different, standardized ignition protection types for this. Secondary explosion protection includes measures for enforcing the building regulations for electrical equipment that can be installed in explosion-endangered areas.

The constructive and/or circuitry measures within the building regulations are intended to prevent that

- an explosion is triggered, or
- in the case of an explosion inside equipment the surrounding outside atmosphere is not ignited.

See also

Principles (Page 36)

Planning

3.1 Directives and standards

3.1.1 Overview of world regulations

World directives and standards

Explosion protection is legally regulated worldwide by guidelines, directives and standards:

- EU directives, national laws, ordinances and explosion protection guidelines from bodies involved in occupational safety
- EU standards, national standards and NAMUR recommendations
- International standards and country-specific regulations

3.1.2 Legal principles of explosion protection

3.1.2.1 Worldwide harmonization

Worldwide regulations

Explosion protection is legally regulated worldwide by the governments of individual countries. Country-specific differences in technical requirements and the required approvals for explosion-protected devices are above all a significant trade barrier for globally operating manufacturers, requiring high overhead for development and approval procedures.

Harmonization of technical standards

For some time now, above all among the leading industrial nations, there has been an effort to remove these trade barriers by harmonizing the pertinent technical standards and, in parallel, to implement uniform safety standards. In the meantime, the harmonization process in the area of explosion protection has been largely completed within the European Union. On an international level, by introducing the 'IECEX Scheme', the IEC is attempting to approach the aim of 'one test and one certificate worldwide'.

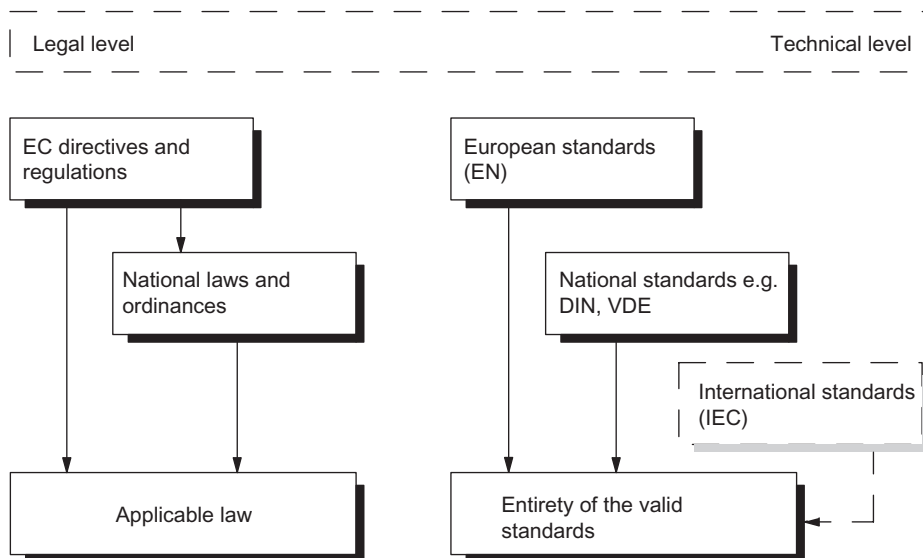


Figure 3-1 Legal framework of explosion protection in Europe

3.1.2.2 EU Directives

Explosion protection in the European Union

Explosion protection is regulated in the European Union by directives and laws. The basis of these EU activities is the so-called 'New Concept', which aims to achieve the following: "The free transfer of goods is a cornerstone of the internal market. To achieve this a goal mechanisms have been set up for mutual acceptance and technical harmonization".

EU Directives

This means that the aim of the EU is, on the one hand, to create equal opportunities for all providers within the EU internal market and, on the other hand, to create uniform safety standards for all operators of technical systems and equipment. This is why electrical devices for use in explosion-endangered areas must have an EC-type examination certificate (zones 0/20 and 1/21). The corresponding systems and facilities are classified as systems that require monitoring and may only be equipped with devices approved for this. Alongside this, commissioning, changes and regular safety inspections must be carried out and/or inspected/approved by approved institutions or companies. The legal framework is formed by the EU directives, which are binding for all EU Member States.

Important EU directives for the area of process devices

Short name	Complete title	Directive no.	Valid since
Low voltage directive	Directive 2006/95/EC of the European Parliament and Council of December 12, 2006, on the harmonization of the laws of the Member States relating to electrical equipment designed for use within certain voltage limits	2006/95/EC	16.01.2007
EMC directive	Directive 2004/108/EC of the European Parliament and Council of December 15, 2004, on the approximation of the laws of the Member States relating to electromagnetic compatibility and repealing the Directive 89/336/EEC	2004/108/EC	20.01.2005
Machines directive	Directive 2006/42/EC of the European Parliament and Council of May 17, 2006, on machinery, and amending Directive 95/16/EC (recast)	2006/42/EC	29.06.2006
ATEX directive	Directive 94/9/EC of the European Parliament and Council of March 23, 1994, on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in hazardous areas	94/9/EC	09.05.1994
Pressure equipment directive	Directive 97/23/EC of the European Parliament and the Council of May 29, 1997, to standardize legal regulations of the Member States regarding pressure equipment	97/23/EC	29.07.1997
ATEX 137 (old: ATEX 118a)	Minimum regulations for improvement of health and safety protection for employees that can be endangered by explosive atmospheres	99/92/EC	16.12.1999 ¹

¹⁾ The transitional regulations are defined in the relevant national legislation. In Germany, this is the working reliability regulation (BetrSichV)

2006/95/EC Low Voltage Directive

The low voltage directive (LVC) 2006/95/EC contains regulations relating to all risks to health and safety which can result from electrical equipments designed for use within certain voltage limits

Explosion protection directive 94/9/EC

Directive 94/9/EC (or ATEX 95) regulates the manufacture and distribution of devices and protection systems for use in explosion-endangered areas. The safety engineering basis is defined in Annex II "Essential Health and Safety Requirements Relating to the Design and Construction of Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres". The guideline prescribes an EC type examination and a corresponding test certificate (Ex-certificate) for electrical equipment in categories 1 and 2. Devices of category 3 require a manufacturer's declaration (EC declaration of conformity) regarding compliance with the directive, if necessary using specific standards.

Directive 1999/92/EC (ATEX 137)

Directive 1999/92/EC, also known as ATEX 137, formulates minimum requirements for the safety and health protection of employees at workplaces that can be endangered by explosive atmospheres. This directive is mainly addressed to the operators of explosion-endangered systems and equipment. The content of this directive is reflected in German law covering work safety regulations and ordinances.

See also

Identification by zones (Page 51)

3.1.2.3 National laws and ordinances

Explosion protection ordinance ExVO

In general, EU directives are European law that has to be adopted unchanged 'one-to-one' in the individual Member States by means of national ratification. The content of Directive 94/9/EC has been adopted in full into the (German) explosion protection ordinance. The fundamental legislation (in Germany) for technical equipment is the Device Safety Act (GSG), of which the ExVO is a part as a separate ordinance (11.GSGV).

Work safety regulations

On the other hand, ATEX 137 (Directive - 1999/92/EC) only contains "Minimum requirements for improving the health and safety protection of workers at risk from explosive atmospheres", which means that each EU state can pass its own regulations that go beyond the minimum requirements. In Germany, the content of the directive has been adopted in the work safety regulations. In order to simplify the legislation, the content of several former ordinances has been summarized in these work safety regulations. From the area of explosion protection, this includes:

- Ordinance regarding electrical systems in explosion-endangered areas (ElexV)
- Acetylene ordinance
- Ordinance regarding flammable liquids

This ordinance was replaced when the work safety regulations (BetrSichVO) came into force on January 1, 2003.

3.1.2.4 Explosion protection directives (EX directives) of the occupational safety association

Explosion protection directives (EX-RL)

The "Directives for prevention of dangers through explosive atmospheres with collection of examples" from the (German) occupational safety association in the chemicals sector contain concrete information on the dangers in explosion-endangered areas and indicate measures for prevention or reduction. In particular, the collection of examples serves to provide detailed information on measures in the context of individual explosion-endangered process systems in a wide variety of industrial sectors. Valuable suggestions and risk assessments are thus available to planners and operators of such process systems or comparable process systems. Although the EX guidelines have no legal status, they are still to be regarded as important recommendations which can be used particularly to settle legal questions in the event of cases of injury or damage.

Laws, ordinances and sets of regulations regarding explosion protection

Laws, ordinances and sets of regulations regarding explosion protection in Germany

Short description	Complete title	Valid as of
Device Safety Act (Germany)	Law governing technical equipment	Continuously supplemented
Explosion protection	Ordinance regarding bringing to market of devices and protection systems for explosion-endangered areas –Explosion protection ordinance (ExVO, 11.GSGV)	12.12.96
Work safety regulations	Ordinance to legally regulate the area of safety and health protection in the provision of equipment and its use during work, safety for the operation of systems requiring monitoring and the organization of occupational safety.	03.10.02
Explosion protection directives EX directive	Occupational safety association regulations and rules for safety and health at work 104: Explosion protection rules, EX guideline	(Status December 2002)

3.1.3 Standards

3.1.3.1 Overview

Preface

There are a large number of technical standards worldwide for the area of explosion protection. The standards landscape is subject to continuous changes. This is due to adaptations to technical progress and also to higher requirements for safety in society. The international efforts for harmonization with the final goal of unified worldwide safety standards also contribute to the number of changes.

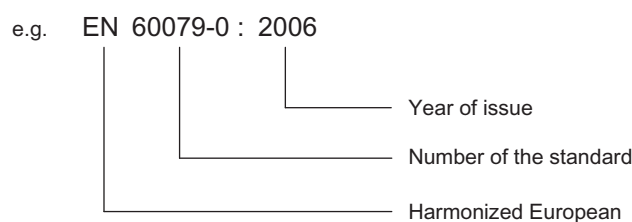
3.1.3.2 EU standards

CENELEC

The standards for explosion protection that apply in the European Union are created on the basis of the EU directives, led by CENELEC (European Committee for Electrotechnical Standardization). Members of CENELEC are the national committees of the Member States. As in the meantime the degree of standardization on an international level has gained in significance due to the high dynamism in the IEC, CENELEC has decided to develop standards with the IEC using only the parallel procedure. Practically, this means that European standards in the area of electrical engineering will be almost exclusively created as harmonized EN standards on the basis of IEC standards. For the area of explosion protection, this primarily affects the standards of the EN 60079 and EN 61241 series.

Scheme of the harmonized European standards

The numbers of harmonized European standards are based on the following scheme:



Changes that are issued to complement the basic standard are indicated by the letter "A" with a consecutive number, e.g. A1.

3.1.3.3 National standards

DIN standards and VDE regulations

In most EU Member States, there are also separate national standards, and these can be applied in parallel to the valid EN standards in this country. In Germany, these are the DIN standards (German Industrial Standard) and VDE regulations (Association of German Engineers). In the area of explosion protection, however, harmonization has taken place for the most part and most standards in the meantime also have a "DIN EN" version, and these have also been adopted into the VDE regulations. DIN EN standards are identical to the corresponding EN standards, and special national features, e.g. validity ranges etc., are formulated in a national preamble.

3.1.3.4 International standards

IEC

On an international level, the IEC, the International Electrotechnical Commission, issues standards for explosion protection. The Technical Committee TC31 is responsible. The IECEx certification is based on the IEC standards. Standards for explosion protection are included in the IEC 60079-x series and IEC 61241-x. The x stands for the numbers of the individual technical standards, e.g. IEC 60079-11 for intrinsic safety.

USA

The leading regulatory authority in the USA is OSHA (Occupational Safety and Health Administration), which enacts regulations regarding occupational safety. This is then the basis on which different organizations issue standards. Explosion protection is regulated within the National Electrical Code (NEC), a construction regulation issued by the National Fire Protection Association (NFPA) in consultation with the American National Standard Institute (ANSI). Building on this, various testing organizations such as UL (Underwriters Laboratories) and FM Approvals issue their own sets of standards.

Important for the classification of explosion protection are Article 500 to 505 of the NEC, whereby the former lays down regulations of the conventional Ex classification (Class-Division model) and the latter lays down the regulations for the new zone model based on Europe and the IEC. Devices can be certified in parallel on the basis of both models.

Canada

In Canada, the structure is similar to that in the USA. Building on the CEC, the Canadian Electrical Code, the Canadian Standards Association (CSA) issues standards that are the basis for corresponding device approvals. Explosion protection in Canada also uses a conventional Class-Division model and the new international zone system, on the basis of which parallel approvals are also possible.

cULus/ cFMus are combined approvals which are valid for the USA as well as Canada.

Comparison of international and European standards:

Subject	International	Europe	USA			Canada		
			FM	UL	ANSI/ISA	Ex zone model	Ex Class-Div. model	Others
Ex: General specifications	IEC 60079-0	EN 60079-0	FM 3600	UL 60079-0	ANSI/ ISA 60079-0	C22.2 No. 60079-0		
Oil immersion "o"	IEC 60079-6	EN 60079-6		UL 60079-6	ANSI/ ISA 60079-6	E60079-6		
Pressurized apparatus "p"	IEC 60079-2	EN 60079-2	FM 3620	(NFPA49 6)		E60079-2	CSA TIL. E 13 A	
Powder filling "q"	IEC 60079-5	EN 60079-5		UL 60079-5	ANSI/ ISA 60079-5	E60079-5		
Flameproof enclosure "d"	IEC 60079-1	EN 60079-1	FM 3615	UL 60079-1	ANSI/ ISA 60079-1	C22.2 No. 60079-1	CSA C22.2 No. 30	
Increased safety "e"	IEC 60079-7	EN 60079-7		UL 60079-7	ANSI/ ISA 60079-7	CSA-E79-7		
Intrinsic safety "i"	IEC 60079-11	EN 60079-11	FM 3610	UL 60079-11	ANSI/ ISA 60079-11	E60079-11	CSA C22.2 No. 157	
Type of protection "n"	IEC 60079-15	EN 60079-15	FM 3611	UL 60079-15	ANSI/ ISA 60079-15	E60079-15	CSA C22.2 No. 213	
Encapsulation "m"	IEC 60079-18	EN 60079-18		UL 60079-18	ANSI/ ISA 60079-18	CSA-E79-18		
Optical radiation "op"	IEC 60079-28	EN 60079-28						

3.1.3.5 NAMUR

NAMUR recommendations

In the field of process engineering, the NAMUR recommendations have great significance in Germany - but also in other European countries. The NAMUR - standards committee for measuring and control technology - is an association of users of process control engineering that aims to influence both standardization committees and the manufacturers of process equipment to define security standards, solutions and systems with a practical orientation for applications in the chemicals and pharmaceuticals sectors. In this context, NAMUR issues recommendations on practically all the technical topics in which this circle of users is interested, and they are published as NAMUR recommendations under a serial number NE

3.2 Certificates, Certification Processes and Product Conformity

3.2.1 Certificates

Country-specific certificates

The manufacturer must enclose various country-specific certificates with products, certifying that the corresponding directives and standards have been complied with.

Before a product is placed on the market, it must be tested for certain areas of application by a so-called notified body.

3.2.2 European Union

3.2.2.1 EU declaration of conformity and CE symbol

EU declaration of conformity by manufacturer

Products that are placed on the market for the first time within the European Union are subject to the stated EU directives. The manufacturer (who brings the product onto the market) is under obligation to adhere to all the EU directives applicable to each product. This is confirmed in the EU declaration of conformity, a paper that has to be enclosed with each delivered device. All the applied EU directives and EN standards complied with should appear on the declaration of conformity. Issuer of the declaration of conformity is the manufacturer who places the device on the market.

CE symbol

The corresponding device is to be indicated on the type plate with the CE symbol. The CE symbol indicates that a device bearing it corresponds to all (!) applicable European regulations and not, as sometimes incorrectly assumed, only adherence to the EMC directive!

3.2.2.2 EC-type examination certificate

EC-type examination certificate by a "notified body"

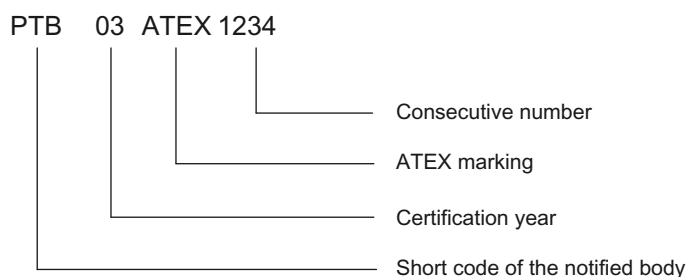
The ATEX directive 94/9/EC prescribes a design test for explosion-protected electrical devices of categories 1 and 2. To this end, the manufacturer submits all of the technical documents necessary for the inspection and, if applicable, sample devices to a so-called 'notified body'. After successful conclusion of the test, an EC-type examination certificate is issued, certifying all of the binding information and parameters for use in explosion-endangered areas.

The EC-type examination certificate contains all the required information regarding explosion protection and is the basis for operation and interconnection of multiple electrical devices in Ex Zones 0 and 1 and in Dust Ex Zones 20 and 21.

Certificate number

Each certificate is given its own certificate number, structured as follows:

Example



An "X" following the number identifies "Special notes on operation" in the EC-type examination certificate. A "U" following the number identifies a partial certificate for products that are not used as 'stand-alone' devices, rather only as parts relevant to safety for Ex devices.

Devices of category 3

For devices of category 3, as prescribed for use in Zone 2 and Zone 22, no EC-type examination certificate is required by the ATEX directive and the issuance of a certificate is not permitted. Instead the manufacturer can declare the conformity itself.

See also

EU Directives (Page 21)

Division (Page 32)

3.2.2.3 Inspection bodies in the EU

Notified bodies

In practically all EU countries, there is one or more approved inspection bodies, referred to in EU jargon as a notified body. These are commissioned by the Member States after evaluating their technical skills and determining their independence and impartiality, then published by the Commission in the European Union gazette.

European inspection bodies

The table contains a selection of the most important European inspection bodies. The complete and current list can be viewed on the sites of the EU on the Internet (<http://www.ec.europa.eu/>).

Notified Body	Country
TÜV-Österreich A-1015 Wien	AT
DEKRA-EXAM Prüf- und Zertifizier GmbH D-44809 Bochum	D
DMT GmbH D-45307 Essen	D
IBEXU - Institut für Sicherheitstechnik GmbH D-09599 Freiberg	D
Physikalisch-Technische Bundesanstalt (PTB) D-38116 Braunschweig	D
TÜV Nord AG D-30519 Hannover	D
TÜV Nord e.V. D-22525 Hamburg	D
UL International DEMK DK-02730 Herlev	DK
Laboratoire Central d. Industries Electriques (LCIE) F-92260 Fontenay-aux-Roses	F
CESI Centro Electrotecnico Sperimentale Italiano I-20134 Milano	I
NEMKO AS N-0314 Oslo	N
KEMA Quality B.V. NL-6802 ED Arnheim	NL
SIRA Certification Servicesira Test & Cert. Ltd. BR7 5EH Chislehurst - Kent	UK

3.2.3 North America

USA

Tested, explosion-protected electrical equipment is also necessary in the USA for operation of equipment in explosion-endangered areas. Approved testing organizations (NRTLs - National Recognized Test Laboratories) such as FM, UL, CSA among others test devices for compliance with the corresponding regulations and standards and issue an "Approval Report" for operation in "Hazardous Locations".

In the USA compliance with general safety standards for electrical devices can also be tested for non-explosion-protected devices and a "Safety Approval" can be issued.

The testing organizations award a test symbol that is to be attached to the device. In general, the recognized testing organizations have equal rights.

Canada

In Canada, the situation is comparable to that in the USA. The CEC (Canadian Electrical Code) applies, and tests are run based on CSA standards. Recognized inspection bodies are the CSA, UL, FM and a few others. As in the USA, devices also require an Approval for Hazardous Locations for the operation in explosion-endangered areas in Canada. Alongside this, there is also the usual Safety Approval ("CSA Approval"), certifying compliance with the electrical safety standards.

3.2.4 Russian Federation

Import certificate and GOST-R certificate

The Russian Federation also has its own certification system for electrical devices. In general, each device requires an import certificate and the so-called GOST-R certificate, certifying electrical safety. Explosion-protected devices also receive a special explosion protection certificate. As a supplement, some Russian users also require metrological certificates. All of these certificates can be acquired through the Russian approval body GOSSTANDARD.

3.2.5 Switzerland

Some separate certificates

Switzerland also has a special position. Although not an EU member, the EC-type examination certificate in the area of explosion protection is recognized by law.

3.2.6 IECEx Scheme

IEC certificate

The work of the IECEx Scheme has advanced to the stage that certifications for explosion-protected devices on the basis of the IEC standards and with issue of a corresponding IECEx certificate are now possible. The aim is worldwide recognition of the IEC certificate so that in future manufacturers no longer require additional approvals for the entire world market.

3.3 Secondary Explosion Protection

3.3.1 Principles

Definition

Secondary explosion protection involves technical measures to prevent an (effective) ignition source triggering an explosion.

The scope of secondary explosion protection measures depends on the probability of the occurrence of a dangerous explosive atmosphere.

3.3.2 Division

Definition

Explosion-endangered areas are divided into zones. The zone classification depends on the temporal and local probability of the presence of a dangerous, explosive atmosphere.

Equipment in continuously explosion-endangered areas (Zone 0) is subject to higher requirements, equipment in less endangered areas (Zone 1, Zone 2) is subject to lower requirements.

As a rule, 95% of systems are set up in Zone 1 and only 5% in Zone 0.

In North America (USA/Canada), the following special features apply:

- Explosion-endangered areas are separated according to divisions (NEC 500, conventional system) or zones (NEC 505).

Zones/equipment protection levels (EPL) according to IEC/CENELEC

Zone classification

In Europe, explosion-endangered areas are divided into zones (IEC). The equipment is divided into categories (directive 94/9/EC). The category indicates in which zone the relevant equipment can be used.

Materials	Zones according to IEC/CENELEC for gases/vapors and dusts	Categories of equipment
Gases Vapors	Zone 0 Areas in which hazardous concentrations of flammable gases/vapors are present continuously or over long periods .	1G
	Zone 1 Areas in which hazardous concentrations of flammable gases/vapors are present occasionally .	2G, 1G
	Zone 2 Areas in which hazardous concentrations of flammable gases/vapors are present rarely and then only briefly .	3G, 2G, 1G
Dusts	Zone 20 Areas in which hazardous concentrations of flammable dusts are present continuously or over long periods .	1D
	Zone 21 Areas in which hazardous concentrations of flammable dusts are present occasionally .	2D, 1D
	Zone 22 Areas in which hazardous concentrations of flammable dusts are present rarely and then only briefly .	3D, 2D, 1D

Equipment protection level (EPL)

An alternative method for classifying the Ex equipment for the potentially explosive areas is the system of (EPL Equipment Protection Level) according to IEC 60079-26.

Materials	Equipment protection levels (EPL) according to IEC/CENELEC for gases/vapors and dusts	Comparable with
Gases Vapors	Ga Equipment for explosive gas atmospheres with a "very high" protection level which does not present an ignition source during proper operation, anticipated errors and very rarely occurring errors.	Category 1G (Zone 0)
	Gb Equipment for explosive gas atmospheres with a "high" protection level which does not present an ignition source during proper operation, and anticipated errors, even those which are not necessarily normal.	Category 2G (Zone 1)
	Gc Equipment for explosive gas atmospheres with an "increased" protection level which does not present an ignition source during proper operation and which can have a certain additional protection to ensure that it remains inactive as an ignition source in the event of regularly anticipated events.	Category 3G (Zone 2)
Dusts	Da Equipment for flammable dust atmospheres with a "very high" protection level which does not present an ignition source during proper operation and very rarely occurring errors.	Category 1D (Zone 20)
	Db Equipment for flammable dust atmospheres with a "high" protection level which does not present an ignition source during proper operation, and anticipated errors, even those which are not necessarily normal.	Category 2D (Zone 21)
	Dc Equipment for flammable dust atmospheres with an "increased" protection level which does not present an ignition source during proper operation and which can have a certain additional protection to ensure that it remains inactive as an ignition source in the event of regularly anticipated events.	Category 3D (Zone 22)

Zones according to NEC 505

National Electrical Code NEC 505 is used in North America. NEC 505 takes into account the new IEC requirements, i.e., the explosion-endangered areas are classified according to zones. NEC 505 defines only one material allocation, i.e., Class I for gases/vapors.

Materials	Zones according to NEC 505 for gases/vapors
Class I Gases Vapors	Zone 0 Areas in which hazardous concentrations of flammable gases/vapors are present continuously or over long periods under normal operating conditions.
	Zone 1 Areas in which hazardous concentrations of flammable gases/vapors are present occasionally under normal operating conditions.
	Zone 2 Areas in which hazardous concentrations of flammable gases/vapors are not expected under normal operating conditions.

Divisions according to NEC 500

The conventional system in North America, NEC 500, classifies explosion-endangered areas into divisions. The material allocation is classified according to Class I, II, and III.

Materials	Zones according to NEC 500 for gases/vapors, dusts, and fibers/flyings
Class I Gases Vapors	Division 1 Areas in which hazardous concentrations of flammable gases/vapors are present continuously or over long periods under normal operating conditions.
	Division 2 Areas in which hazardous concentrations of flammable gases/vapors are not expected under normal operating conditions.
Class II Dusts	Division 1 Areas in which hazardous concentrations of flammable dusts are present continuously or occasionally under normal operating conditions.
	Division 2 Areas in which hazardous concentrations of flammable dusts are not expected under normal operating conditions.
Class III Fibers Flyings	Division 1 Areas in which hazardous concentrations of flammable fibers and flyings are present continuously or occasionally under normal operating conditions.
	Division 2 Areas in which hazardous concentrations of flammable fibers/flyings are not expected under normal operating conditions.

3.3.3 Ignition protection types

3.3.3.1 Principles

Operating principle

The following ignition protection types comprise constructive and circuitry measures. These measures prevent the ignition of a surrounding explosive atmosphere due to spark formation or unacceptable heating of electrical equipment. The measures prevent the simultaneous occurrence of an ignition source and a hazardous amount of explosive mixture at the ignition source.

Division

The ignition protection types are divided into

- Increased safety "e"
- Flameproof enclosure "d"
- Pressurized apparatus "p"
- Intrinsic safety "i"
- Oil immersion "o"
- Powder filling "q"
- Encapsulation "m"
- Type of protection "n"
- Optical radiation op
- Dust explosion protection

3.3.3.2 Increased safety "e"

Operating principle

This ignition protection type is intended to completely prevent the formation of ignition sources. Here, it is particularly important to adhere to the maximum permitted surface temperature in accordance with the target temperature classes T1 to T6, including on all surfaces within the housing. This means that this ignition protection type can be used for electrical equipment and associated components,

- that under normal conditions sparks, light arcs or dangerous temperatures do not occur
- that have a nominal voltage not exceeding the value of 11 kV.

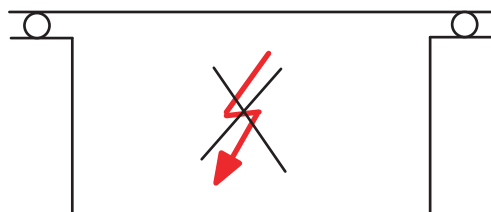


Figure 3-2 Increased safety "e"

Applications

- Terminals and terminal boxes
- Control boxes for installation of Ex components (protected by another ignition protection type)
- Squirrel cage motors
- Lights

Applicable standards and directives

- EN 60079-7
- IEC 60079-7
- ANSI/ ISA/ UL 60079-7

Field of application

- Zone 1 and Zone 2
- Equipment protection level Gb and Gc

3.3.3.3 Flameproof enclosure "d"

Operating principle

With this ignition protection type, the parts that could ignite an explosive atmosphere are enclosed in a housing. This housing is designed in such a way that in the event of ignition of an explosive mixture inside the housing it withstands the corresponding pressure. A transfer of the explosion to the explosive atmosphere surrounding the housing is prevented.

This is ensured by the strength of the housing and the 'non-penetrable gap'. These prevent flames penetrating to the outside.

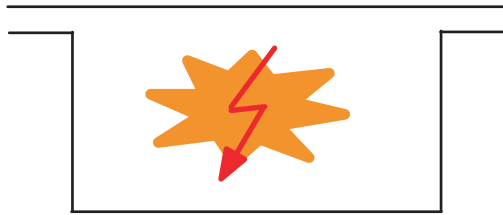


Figure 3-3 Flameproof enclosure "d"

Applications

- Switchgear and switchboards
- Command and display devices, control systems
- Motors, transformers, heaters, lights

Applicable standards and directives

- EN 60079-1
- IEC 60079-1
- ANSI/ ISA/ UL 60079-1
- FM 3615

Field of application

- Zone 1 and Zone 2
- Equipment protection level Gb and Gc

3.3.3.4 Pressurized apparatus "p"

Operating principle

With this ignition protection type, penetration of an explosive atmosphere into the housing of electrical equipment is prevented by an ignition protection gas (inert gas, air or similar) located in the housing. This is held pressurized at ≥ 0.5 mbar compared to the surrounding atmosphere. The pressure can also be maintained by means of continuous flushing with ignition protection gas.

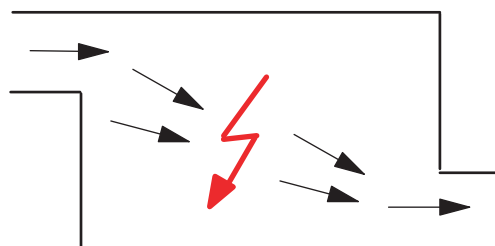


Figure 3-4 Pressurized apparatus "p"

Applications

- Switch and control cabinets
- Analyzers
- Large motors

Applicable standards and directives

- EN 60079-2
- IEC 60079-2
- FM 3620
- NFPA 496

Field of application

- Zone 1 and Zone 2
- Equipment protection level Gb and Gc

3.3.3.5 Intrinsic safety "i"

Operating principle

The intrinsic safety "i" of an electrical circuit is achieved by limiting the current, voltage, power and temperature. The measures take account of normal operation and, depending on the safety level, the occurrence of 1 or 2 so-called countable errors in components with safety functions.

The intrinsic safety "i" ignition protection type can only be used for electrical circuits with relatively low power.

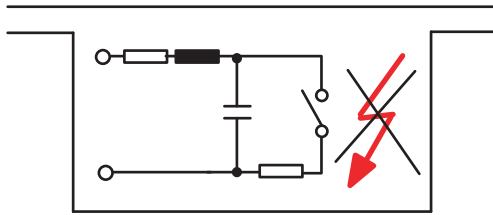


Figure 3-5 Intrinsic safety i

Applications

- Measuring and automatic control engineering
- Communications technology
- Sensors, actuators

Applicable standards and directives

- EN 60079-11
- IEC 60079-11
- ANSI/ ISA/ UL 60079-11
- FM 3610

Field of application

- Zone 0, Zone 1 and Zone 2
- Equipment protection level Ga, Gb and Gc

See also

Equipment in the intrinsically safe electrical circuit (Page 68)

3.3.3.6 Oil immersion "o"

Operating principle

With this ignition protection type, electrical equipment or parts of electrical equipment are immersed in oil. This means that an explosive atmosphere above the oil surface or outside the housing cannot ignite.

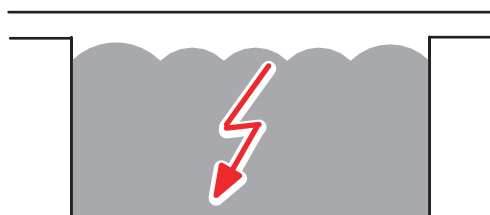


Figure 3-6 Oil immersion "o"

Applications

- Transformers
- Starting resistors
- Power engineering equipment

Applicable standards and directives

- EN 60079-6
- IEC 60079-6
- ANSI/ ISA/ UL 60079-6

Field of application

- Zone 1 and Zone 2
- Equipment protection level Gb and Gc

3.3.3.7 Powder filling "q"

Operating principle

With this ignition protection type, the housing of electrical equipment is filled with a fine-grain material. This means that a light arc created inside the housing does not ignite the surrounding explosive atmosphere.

Ignition must not occur by means of flames nor increased temperatures on the housing surface.

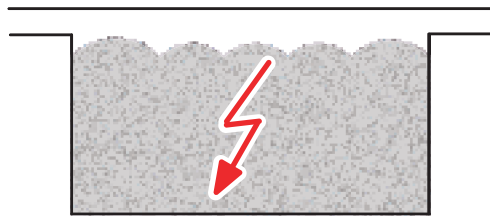


Figure 3-7 Powder filling "q"

Applications

- Transformers
- Capacitors
- Heat conductor connection boxes
- Control circuits with hot or sparking parts

Applicable standards and directives

- EN 60079-5
- IEC 60079-5
- ANSI/ ISA/ UL 60079-5

Field of application

- Zone 1 and Zone 2
- Equipment protection level Gb and Gc

3.3.3.8 Encapsulation "m"

Operating principle

With this ignition protection type, the parts that can ignite an explosive atmosphere are embedded in a casting compound. This means that the explosive atmosphere surrounding the equipment can be ignited neither by sparks nor by unacceptable heating.

The casting compound is adequately resistant to environmental influences. There are two subdivisions for ignition protection:

- Ex ma: Zones 0, 1, 2
- Ex mb: Zones 1, 2



Figure 3-8 Encapsulation "m"

Applications

- Switchgear for low power levels
- Command and indication devices
- Electronic assemblies in process measuring and control and analysis technology
- Small transformers/mains supply circuits

Applicable standards and directives

- EN 60079-18
- IEC 60079-18
- ANSI/ ISA/ UL 60079-18

Field of application

- Zone 0, Zone 1 and Zone 2
- Equipment protection level Ga, Gb and Gc

3.3.3.9 Optical radiation op

Operating principle

With this ignition protection type, the optical energy in a system is limited by suitable measures so that no ignition of a potentially explosive atmosphere is possible.

The optical energy is limited using 3 methods:

- Ex op is: Intrinsically safe optical radiation
- Ex op pr: Protected optical radiation
- Ex op sh: Blocking of optical radiation

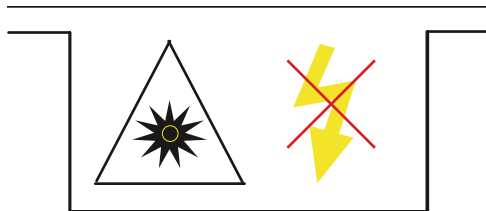


Figure 3-9 Optical radiation op

Applications

- Process technology with optical technology
- Industrial Ethernet
- Fiber-optic cable

Valid standards and directives

- EN 60079-28
- IEC 60079-28

Field of application

- Zone 0, Zone 1 and Zone 2
- Equipment protection level Ga and Gb

3.3.3.10 Ignition protection type "n"

Operating principle

This ignition protection type involves slightly simplified applications of ignition protection types for Zone 2. 'n' means non-igniting.

A fundamental distinction is made between non-sparking equipment and equipment that generates light arcs, sparks or hot surfaces during normal operation.

Explanations

Equipment	Designation	Description
Non-sparking equipment	nA	For non-sparking equipment, additional requirements must be met depending on the device design to prevent potential ignition sources arising during operation.
Equipment that involves light arcs, sparks or hot surfaces	nC	The equipment is installed in hermetically sealed or encapsulated facilities. These enclosed facilities are based on the ignition protection type 'flameproof enclosure'.
	nR	The equipment is fitted in gas-proof housings. The housing is designed in such a way that explosive atmospheres can only penetrate to a limited extent.
	pz	Simplified pressurizing based on the ignition protection type 'pressurizing'.
	mc	Simplified encapsulation based on the ignition protection type pressurizing.
	ic/ nL	This involves energy-restricted equipment based on the ignition protection type intrinsic safety "i", however with lowered safety factors.

Applications

- PLCs
- Automation devices
- Analyzers

Applicable standards and directives

- EN 60079-15 (nA, nC, nR, nL), EN 60079-2 (pz), EN 60079-18 (mc), EN 60079-11 (ic)
- IEC 60079-15 (nA, nC, nR, nL), IEC 60079-2 (pz), IEC 60079-18 (mc), IEC 60079-11 (ic)
- ANSI/ ISA/ UL 60079-15
- FM 3611

Field of application

- Zone 2
- Equipment protection level Gc

3.3.3.11 Ignition protection types for dust explosion protection

Operating principle

The ignition protection types for dust explosion protection are based in part on the ignition protection types for gases and vapors.

Explanations

Designation	Description
pD	The penetration of a surrounding atmosphere in the housing of electrical equipment is prevented in that an ignition protection gas (air, inert or other suitable gas) is pressurized inside the housing in relation to the surrounding atmosphere.
mD	Parts that could ignite an explosive atmosphere by sparking or heat are embedded in a casting compound that prevents ignition of an explosive atmosphere. This takes place by surrounding the components on all sides with a casting compound that is resistant to physical (in particular electrical, thermal and mechanical) as well as chemical influences.
tD	The housing is so dense that no flammable dust can enter the inside. The surface temperature of the outer housing is limited.
iaD, ibD	Current and voltage are limited in such a way that intrinsic safety is ensured. No spark or thermal effect can ignite a dust-air mixture. iaD: Use in Zones 20, 21, 22 ibD: Use in Zones 21 and 22

Applications

- Equipment where light arcs, sparks or hot parts occur.
- Large machines, slip ring motors or collector motors, switch and control cabinets
- Measuring and monitoring systems
- Sensors and actuators

Applicable standards and directives

- EN 61241-4 (pD), EN 61241-18 (mD), EN 61241-1 (tD), EN 61241-11 (iaD, ibD)
- IEC 61241-4 (pD), IEC 61241-18 (mD), IEC 61241-1 (tD), IEC 61241-11 (iaD, ibD)

Field of application

- Zone 20, Zone 21 and Zone 22
- Equipment protection level Da, Db and Dc

3.3.4 Device groups, explosion groups

3.3.4.1 Device groups

Equipment grouping for explosive atmospheres:

Group	Description
Device group I	Devices for use <ul style="list-style-type: none"> • in underground operations • in mines • as well as their above-ground systems
Device group II	Devices for use in the remaining areas

3.3.4.2 Device group I

Grouping of equipment of device group I

Device group I is equipment used in underground operations of mines as well as the above-ground systems. Device group I is also referred to as firedamp protection.

- Division into device categories:
 - Device category **M1**: This category is intended for equipment which is installed in an area which is comparable with Zone 0 for pit gas and/or flammable dust. If two independent faults occur, this equipment must ensure adequate safety. This equipment must have a very high degree of safety.
 - Device category **M2**: This category is intended for equipment which is installed in an area which is comparable with Zone 1 for pit gas and/or flammable dust. This equipment must be switched off if an Ex atmosphere occurs. This equipment must have a very high degree of safety.
- Division into equipment protection levels (EPL):
 - Equipment protection level **Ma**: Device for installation in a mine with a "very high" protection level for which there is adequate security that it will not become an ignition source, even if it remains in operation during a gas eruption.
 - Equipment protection level **Mb**: Device for installation in a mine with a "high" protection level for which there is adequate security that it will not become an ignition source in the time between the eruption of a gas and the switching off of the device.

3.3.4.3 Device group II (explosion groups)

Grouping of electrical equipment of device group II

For electrical equipment of device group II, another subdivision into explosion groups is made. This subdivision depends on the maximum experimental safe gap and the minimum ignition current ratio:

Explosion group	Maximum experimental safe gap	Minimum ignition current ratio	Hazard	Requirements for the equipment
II A	> 0.9 mm	> 0.8	low	low
II B	0.5 mm to 0.9 mm	0.45 to 0.8	medium	medium
II C	< 0.5 mm	< 0.45	high	high

Note

Electrical equipment with approval for explosion group II C may also be used in the explosion groups II A and II B.

Maximum experimental safe gap and minimum ignition current

The maximum experimental safe gap (MESG) and minimum ignition current (MIC) are determined for different gases and vapors under precisely defined testing conditions.

Maximum experimental safe gap: The maximum experimental safe gap is the gap in which flames no longer penetrate the mixture in a test vessel with 25 mm gap widths.

Minimum ignition current: In order for an explosive atmosphere to be ignited, the ignition must have a minimum energy content. The required minimum energy content is a specific property of the ignitable gases and vapors. One measure for this is the minimum ignition current ratio: This represents the ratio of the minimum ignition current of the respective gas to the minimum ignition current of the laboratory value for methane.

3.3.5 Temperature classes

Definition

The ignition temperature of a flammable gas/liquid is the lowest temperature of a heated surface at which detonation of the gas/air or vapor/air mixture occurs: the highest surface temperature of an item of equipment must therefore always be lower than the ignition temperature of the surrounding atmosphere.

For electrical equipment of explosion group II, temperature classes T1 to T6 have been introduced. The equipment is assigned a temperature class on the basis of its maximum surface temperature. Equipment that corresponds to a higher temperature class can also be used for applications with a lower temperature class.

Temperature classes

Flammable gases and vapors are assigned to the relevant temperature class on the basis of the ignition temperature:

Temperature classes according to IEC/ CENELEC/ NEC 505	Temperature classes according to NEC 500	Maximum permissible surface temperature of equipment in °C	Ignition temperatures of flammable materials in °C
T1	T1	450	> 450
T2	T2	300	> 300 ≤ 450
	T2A	280	> 280 ≤ 300
	T2B	260	> 260 ≤ 280
	T2C	230	> 230 ≤ 260
	T2D	215	> 215 ≤ 230
T3	T3	200	> 200 ≤ 300
	T3A	180	> 180 ≤ 200
	T3B	165	> 165 ≤ 180
	T3C	160	> 160 ≤ 165
T4	T4	135	> 135 ≤ 200
	T4A	120	> 120 ≤ 135
T5	T5	100	> 100 ≤ 135
T6	T6	85	> 85 ≤ 100

3.3.6 Explosion protection of non-electric equipment

ATEX directive 94/9/EC and EN 13463-x standards series

The ATEX directive 94/9/EC refers very generally to "Equipment and protective systems intended for use in potentially explosive atmospheres". This includes electrical and also non-electrical devices.

The EN 13463-1 "Non-electrical equipment for potentially explosive atmospheres" standards series is available for non-electrical devices. They "specify the basic method and requirements for design, construction, testing and marking of non-electrical equipment intended for use in air in potentially explosive atmospheres of gas, vapor, mist and dusts". Additional standards that describe ignition protection types:

- EN 13463-2 Protection by flow-restricting enclosure "fr"
- EN 13463-3 Protection by flameproof enclosure "d"
- EN 13463-4 Protection by inherent safety "g"
- EN 13463-5 Protection by constructional safety "c"
- EN 13463-6 Protection by control of ignition source "b"
- EN 13463-7 Protection by pressurization "p"
- EN 13463-8 Protection by liquid immersion "k"

Typical non-electrical devices

Typical non-electrical devices from which a potential hazard can emanate are, for example, engines/motors, gears, pumps, parts made of light alloys, devices with heat sources or that can get hot, among other things.

Risk analysis under standard 13463-1

The procedure agreed between the notified bodies and manufacturers currently stipulates that the manufacturer runs a detailed risk analysis according to standard EN 13463-1 for all non-electrical devices intended for use in Zone 1 or 2. The corresponding documents are stored there in consultation with a notified body. If the results of the risk analysis indicate that the products are adequately safe, they may be put into circulation with a declaration of conformity. In the case of products intended for use in Zone 0, however, a design test similar to that for electrical devices is compulsory. The relevant inspection body (notified body) then also issues an EC-type examination certificate.

See also

National standards (Page 26)

3.4 Identification of Explosion-Protected Equipment

3.4.1 Identification of the equipment

Identification

All equipment for the explosion-endangered area must be given a corresponding identification. The identification shows

- in which category / zone / division the equipment may be used
- which ignition protection types ensure explosion protection for the equipment
- which explosion groups and temperature classes apply to the equipment.

3.4.2 Identification by zones

Overview

A division into zones is used in Europe (CENELEC), in North America (NEC 505) and in the IEC.

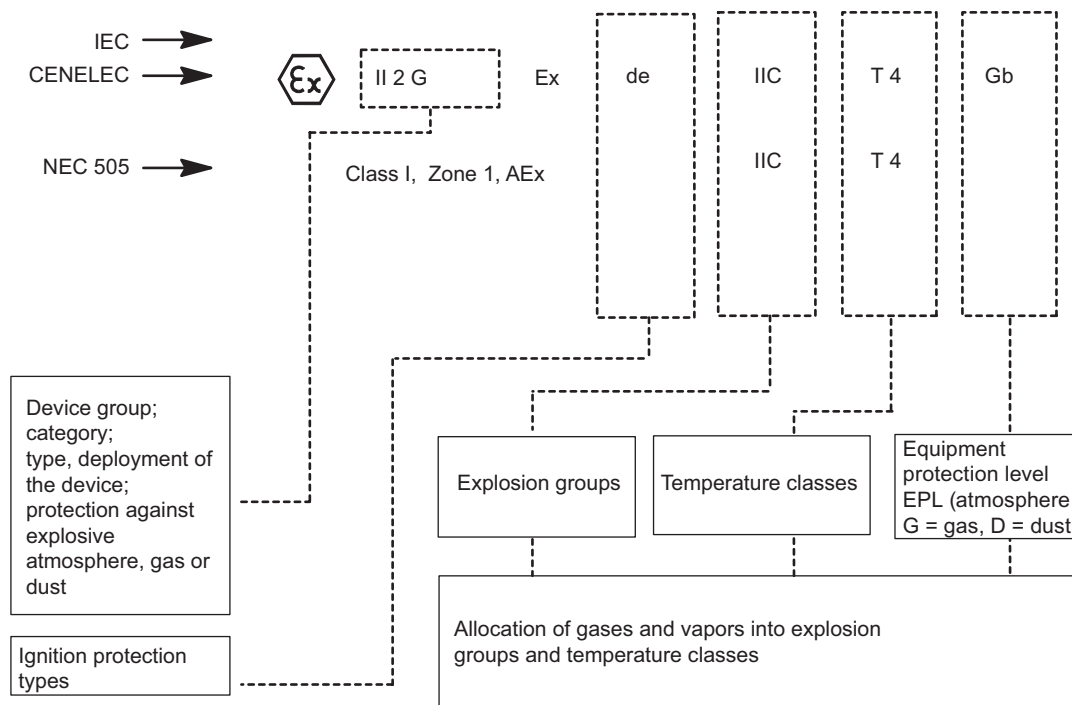


Figure 3-10 Identification according to IEC/ CENELEC/ NEC 505

Device group I

- Identification of the categories

Device group I (For devices in underground operations of mines, as well as the above-ground systems that could be endangered by pit gas and/or flammable dusts)		
Category	M1	M2
Requirement	Very high degree of safety	High degree of safety
Adequate safety	independent faults are under control 2 independent apparatus-based protective measures required	if an Ex atmosphere occurs, the devices must be switched off

- Identification of the equipment protection levels (EPL)

Device group I (For devices in underground operations of mines, as well as the above-ground systems that could be endangered by pit gas and/or flammable dusts)		
Equipment protection level (EPL)	Ma	Mb
Requirement	Very high protection level	High protection level
Adequate safety	During a gas eruption (if the device remains in operation).	In the time between the gas eruption and the switching off of the device.

Device group II

- Identification of the categories

Device group II (For devices in the other hazardous areas)						
Category (atmosphere G= gas, D= dust)	1G	1D	2G	2D	3G	3D
Requirement	Very high degree of safety		High degree of safety		Normal level of safety	
Adequate safety	if two independent faults occur during normal operation and with rare device malfunctions two independent apparatus-based protective measures are required		during normal operation and frequently occurring device malfunctions, as well as with fault states that can be regarded as usual		during (fault-free) normal operation	
Use in	Zone 0	Zone 20	Zone 1	Zone 21	Zone 2	Zone 22

- Identification of the equipment protection levels (EPL)

Device group II (For devices in the other hazardous areas)						
Equipment protection level EPL (atmosphere G= gas, D= dust)	Ga	Da	Gb	Db	Gc	Dc
Requirement	Very high protection level		High protection level		Increased protection level	
Adequate safety	In proper operation In the event of anticipated faults and rarely occurring faults.		In proper operation In the event of anticipated faults and those which are not necessarily normal.		In proper operation Which remains inactive as an ignition source in the event of regularly anticipated events.	
Use in	Zone 0	Zone 20	Zone 1	Zone 21	Zone 2	Zone 22

Zone classification

Material Assignment	Zone classification	IEC/ CENELEC	NEC 505
Gases Vapors	Zone 0	G	Class I
	Zone 1 ¹		
	Zone 2		
Dusts	Zone 20	D	---
	Zone 21		
	Zone 22		

¹ A device approved for Class I, Zone 1 can automatically also be used in Class I, Division 2.

Ignition protection types

Ignition protection types	Identification
Increased safety	e
Flameproof enclosure	"d"
Pressurized apparatus	p
Intrinsic safety	i ¹
Oil immersion	o
Sand filling	q
Encapsulation	m
Optical radiation	op
Ignition protection type	n
¹ ia = Use in Zones 0, 1, 2; ib = Use in Zones 1,2; ic = Use in Zone 2 [Ex ia] = associated electrical equipment, installation in safe area; the wires of the intrinsically safe connections can lead to Zones 0, 1 or 2.	

Explosion groups

Explosion group	Typical gas
I	Methane
II A	Propane
II B	Ethylene
II C	Hydrogen

Temperature classes

Highest permitted surface temperature	CENELEC/IEC USA (NEC 505)
450°C	T 1
300°C	T 2
200°C	T 3
135°C	T 4
100°C	T 5
85 °C	T 6

Classification of gases and vapors into explosion groups and temperature classes

	T 1	T 2	T 3	T 4	T 5*	T 6
I	Methane					
II A	Acetone Ethane Ethyl acetate Ammonia Benzene (pure) Acetic acid Carbon oxide Methane Methanol Propane Toluene	Ethyl alcohol i-amyl acetate n-butane n-butyl alcohol	Gasoline Diesel fuel Aircraft fuel Heating oils n-hexane	Acetyl aldehyde Ethyl ether		
II B	Town gas (lighting gas)	Ethylene				
II C	Hydrogen	Acetylene				Carbon bisulfide

* No gas is known today that corresponds to temperature class T5.

3.4.3 Identification by divisions

Overview

Identification by divisions is used in the USA and Canada.

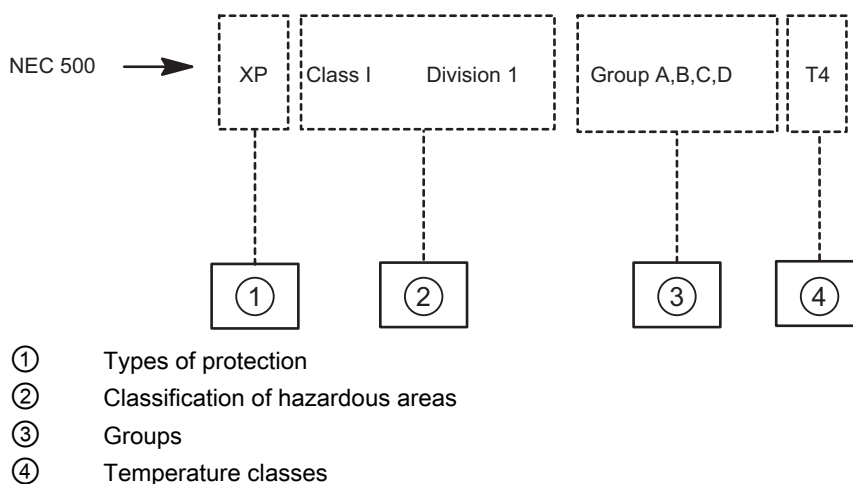


Figure 3-11 NEC 500 overview

3.4 Identification of Explosion-Protected Equipment

Types of protection

Types of protection	Meaning
XP	Explosion-proof: Comparable with flameproof enclosure. Prescribed for Group A-D in Division 1 or 2.
IS	Intrinsically safe: Comparable with intrinsic safety. Prescribed for Group A-D in Division 1 or 2.
X, Y or Z	Pressurized: Comparable with pressurized apparatus <ul style="list-style-type: none"> • X, Y is applied for Division 1 • Z is applied for Division 2
DIP	Dust-ignition-proof Type of protection refers to the dust explosion protection. Prescribed for Group E-G in Division 1 or 2
NI	Nonincendive: Comparable with type of protection "n". This is applied in Division 2.

NEC 500 classification of hazardous areas

Classification of hazardous areas			
Division		Division 1	Division 2
Material allocation	Gases/ vapors	Class I	Class I
	Dusts	Class II	Class II
	Fibers/ flyings	Class III	Class III

Temperature classes

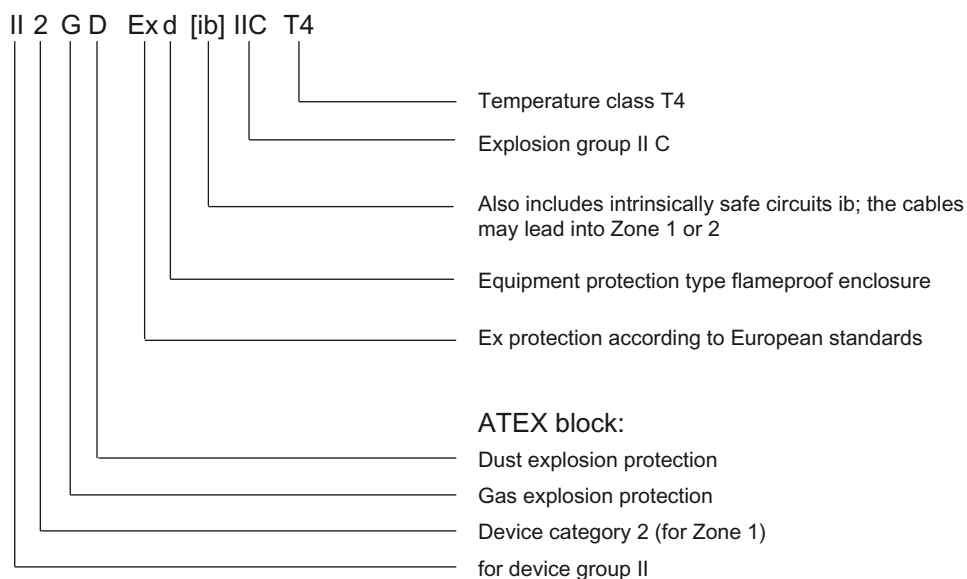
Highest permitted surface temperature	NEC 500
450°C	T1
300°C	T2
280°C	T2A
260°C	T2B
230°C	T2C
215°C	T2D
200°C	T3
180°C	T3A
165°C	T3B
160°C	T3C
135°C	T4
120°C	T4A
100°C	T5
85°C	T6

Classes and groups in accordance with NEC 500

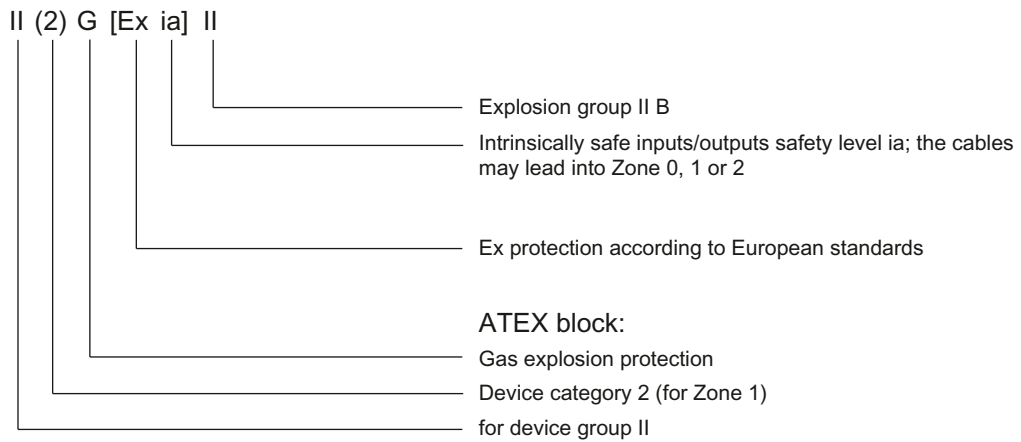
Typical gases / dusts / fibers / flyings	Group	
Acetylene	Class I	Group A
Hydrogen	Class I	Group B
Ethylene	Class I	Group C
Propane	Class I	Group D
Methane	Mining	
Metallic dust	Class II	Group E
Coal dust	Class II	Group F
...all other dusts (grain dust)	Class II	Group G
Fibers / flyings	Class III	

3.4.4 Examples of identification of explosion-protected equipment

Example: explosion-protected equipment

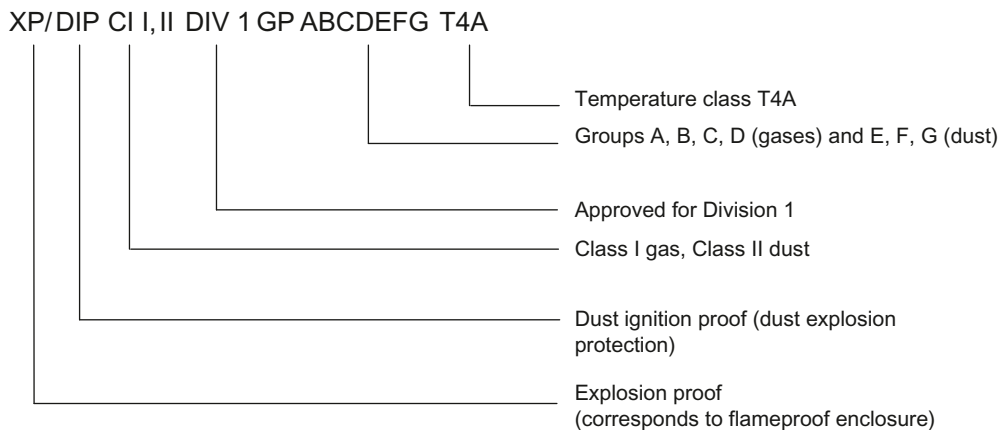


Example: Associated Equipment

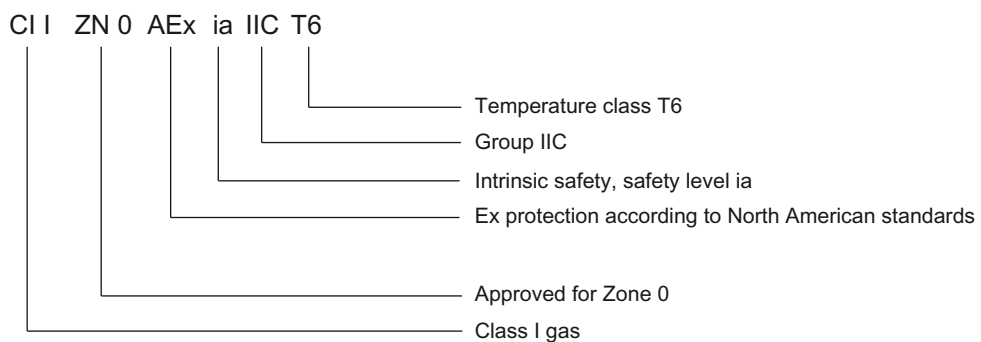


The intrinsically safe inputs and outputs of the associated equipment may be led into the explosion-endangered area; the equipment itself may only be installed outside the Ex area.

Example: US identification according to NEC 500



Example: US identification according to NEC 505











3.4.5 Housing/enclosure protection types

3.4.5.1 IP protection types according to EN 60529 (IEC 60529)

Classification scheme

The classification of housing/enclosure protection according to the IP system is used most frequently worldwide. It corresponds to the European and international IEC standard.

The IP system distinguishes between protection against foreign bodies (First digit) and protection against water (Second digit)

Foreign body protection		First digit	Second digit	Water protection	
IP					
No protection	-	0	0	No protection	-
Foreign bodies > 50 mm	-	1	1	Vertically falling, dripping water	
Foreign bodies > 12 mm	-	2	2	Angled falling, dripping water	
Foreign bodies > 2.5 mm	-	3	3	Spraying water	-
Foreign bodies > 1 mm	-	4	4	Splashing water	
Dust protected		5	5	Water jets	
Dust tight		6	6	Strong water jets	-
			7	Occasional immersion	
			8	Continuous submersion	 ...atü

3.4.5.2 Housing/enclosure protection types according to ANSI / NEMA 250 (USA)

Classification scheme

The American classification scheme for housing/enclosure protection according to NEMA is considerably different to that in Europe and also to the IP scheme used by the IEC. The standard makes a fundamental distinction between the three application classes:

- Housing/enclosure for indoor non-hazardous locations
- Housing/enclosure for outdoor non-hazardous locations
- Housing/enclosure for hazardous locations

Non-hazardous

The housing/enclosure protection types for explosive atmospheres (hazardous locations - types 7, 8, 9, 10) are based on those for non-hazardous locations in that special Ex requirements (e.g. pressure check for "explosion proof enclosures") are also checked. In the USA, however, it has in the meantime become standard practice only to use the non-hazardous types, as the explosion protection has to be tested and certified anyway by an authorized inspection body (e.g. FM, UL, CSA).

Common housing/enclosure types

The most common housing/enclosure types today, also for explosion-protected field devices, are outdoor enclosure types 4, 4X, 6 and 6P with corresponding application in conjunction with explosion protection certification.

Specific requirements for housings/enclosures

Specific requirements for housings/enclosures are described in the NEMA Standard Publication 250.

3.5 Ignition Protection Type Intrinsic Safety "i"

3.5.1 General

Increasing use of ignition protection type intrinsic safety "i"

The ignition protection type intrinsic safety has become increasingly important in the last few years for installing electrical systems in explosion-endangered areas. Not only the individual intrinsically safe equipment (in accordance with EN 60079-11) but also several items of equipment as a whole, including the wires in the intrinsically safe electrical system are of significance here.

Advantages of the ignition protection type intrinsic safety "i"

This ignition protection type has great advantages for users as it represents an ignition protection type that is particularly easy to handle, as intrinsically safe electrical circuits may be opened and closed during operation because of their property of being unable to generate explosive sparks. For the system operator, this permits the important possibility to replace components, perform repairs and expand the system without switching off. Handling during operation and maintenance is virtually identical to that for non-explosion-protected systems. The cables for intrinsically safe electrical circuits are also integrated in the explosion protection. On the other hand, the ignition protection type intrinsic safety provides considerably more economical problem solutions, as the electrical equipment used in the field does not require sophisticated special constructions such as flameproof enclosures or embedding in casting compounds.

Disadvantages of the ignition protection type intrinsic safety "i"

The disadvantages of this ignition protection type include that the intrinsic safety makes stronger demands on planning and installing a system than other ignition protection types. Not only the building regulations for the individual items of equipment must be adhered to; the interconnecting of all equipment in the intrinsically safe electrical circuits must be carefully and correctly planned.

See also

Interconnection of two intrinsically safe items of equipment or one intrinsically safe and one associated item of equipment (Page 73)

Interconnections with more than one item of associated or active equipment (Page 74)

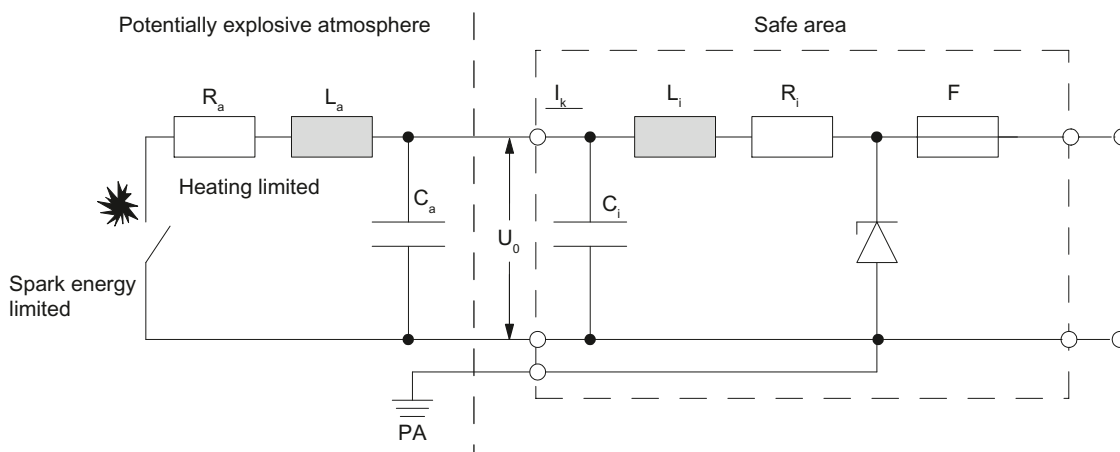
3.5.2 Principles of the ignition protection type intrinsic safety "i"

3.5.2.1 Operating principle

The basis for the intrinsic safety "i" ignition protection type is that for ignition of an explosive atmosphere a certain minimum ignition energy is necessary. In an intrinsically safe electrical circuit, this minimum ignition energy is not present in the explosion-endangered area during normal operation or in the event of a fault. The intrinsic safety of an electrical circuit is achieved by limiting the current, voltage and power. To avoid opening/closing sparks, the capacitance and inductance of an intrinsically safe electrical circuits are restricted depending on the maximum voltage and current values. This limits the ignition protection type intrinsic safety "i" to use in electrical circuits with relatively low power.

In an intrinsically safe electrical circuit, no sparks and no thermal effects (heating) occur during operation or in the event of a fault that can cause ignition of an explosive atmosphere. The following illustration shows the basic circuit of the ignition protection type intrinsic safety "i":

Components of an intrinsically safe electrical circuit



Character	Meaning
U_0	No-load voltage
I_k	Short-circuit current
R_i	Internal resistance
L_i	Internal inductivity
C_i	Internal capacitance
F	Fuse
D	Z - diode
PA	Equipotential bonding
R_a	External resistance
L_a	External inductivity
C_a	External capacitance

Figure 3-12 Basic circuit for voltage/current limitation with ignition protection type intrinsic safety "i"

No spark ignition

In the case of intrinsic safety "i", spark ignition is excluded: no sparks are explosive, occurring, for example, during normal operation with opening and closing of the electrical circuit or in the event of a short circuit or ground fault.

No heat ignition

No heat ignition occurs either during normal operation or in the event of a fault, as excessive heating of the equipment or cables in the intrinsically safe electrical circuit is excluded.

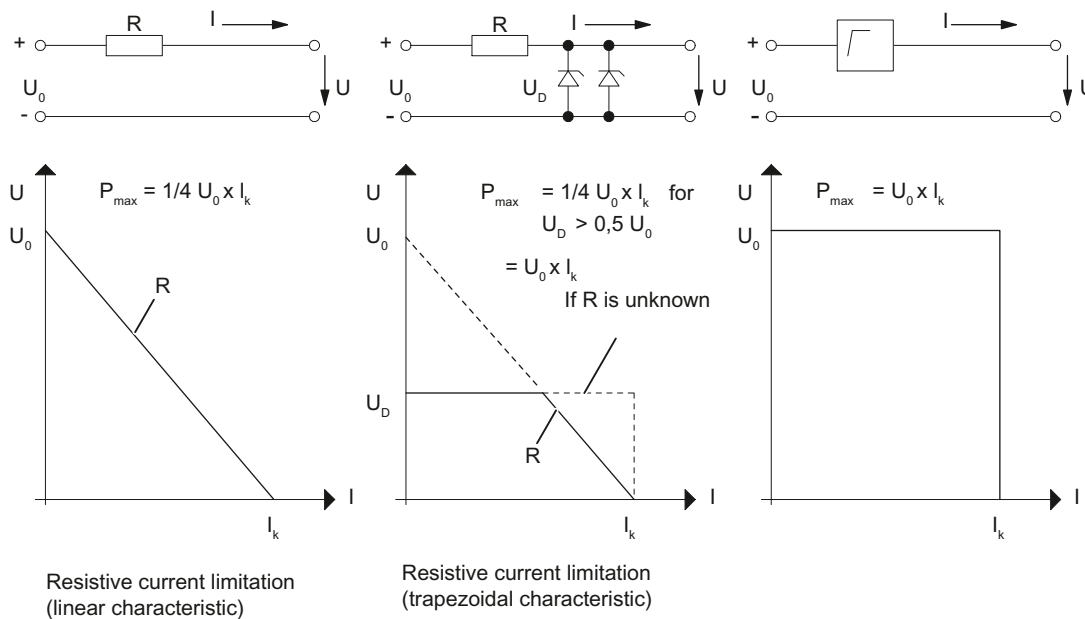
Intrinsic safety "i" means voltage limitation

Z diodes, for example, are used for voltage limitation in the event of a fault. These have the property that they only conduct electricity as of a certain voltage, i.e. above the so-called Z voltage the current through the Z diode rises strongly, resulting in a voltage limitation.

Intrinsic safety "i" means current limitation

Two cases should be examined in the case of current limitation:

- **resistive** current limitation with a linear or trapezoid output characteristic curve
- **electronic** current limitation with, e.g., a rectangular output characteristic curve.



Character	Meaning
R	Current limitation resistance
U ₀	No-load voltage
U _D	Zener voltage
I _k	Short-circuit current
P _{max}	Maximum performance

Figure 3-13 Output characteristic curves for resistive and electronic current limitation

3.5.2.2 Ignition limit curves

Definition

A standardized spark testing device is used to determine in experiments with which current and voltage values the sparks created in the intrinsically safe electrical circuit are not yet explosive. This is documented by so-called ignition limit curves.

As the probability of ignition of a mixture also depends on the number of times it is activated and deactivated, the test (according to EN 60079-11) must include at least 1000 activations and deactivations. Ignition must not occur in any case.

Note

The ignition limit curves displayed are not intended for practical application. Use the ignition limit curves illustrated in the standard EN 60079-11.

Ignition limit curves for resistive electrical circuits

For electrical circuits with negligibly small inductance and capacitance - also referred to as resistive electrical circuits - the ignition limit curves are displayed below. The maximum power of a short circuit spark for line adaptation results from 1/4 multiplied by the product of short-circuit current and no-load voltage.

The pairs of current-voltage values on the ignition limit curve indicate for which values there are no longer any explosive sparks during the test with the spark testing device.

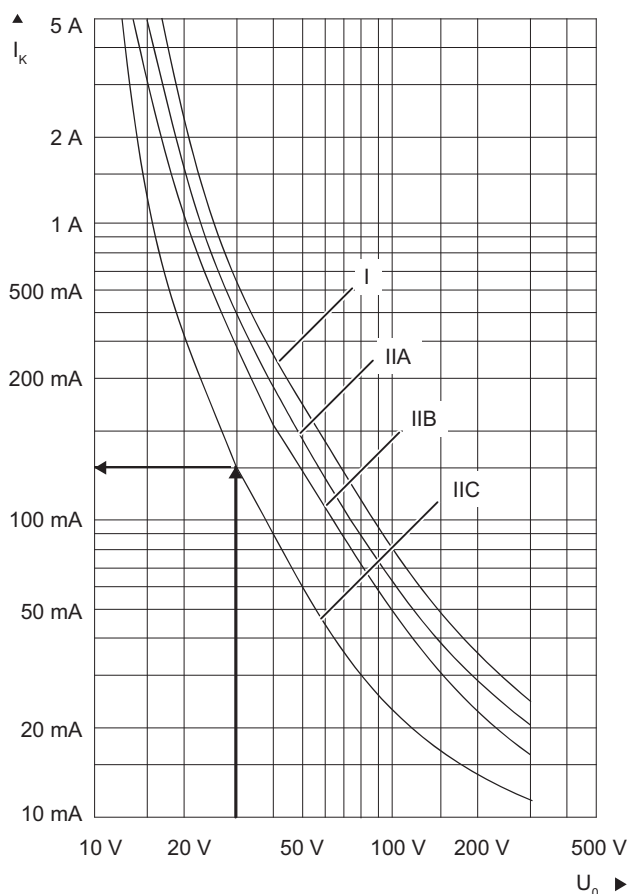
Ignition limit curve for resistive circuits of explosion groups I, IIA, IIB, IIC (according to EN 60079-11)

Example:

With a specified maximum voltage U_0 (i.e. no-load voltage), the ignition limit curve can now be used to determine the corresponding ignition limitation current. In order to obtain the maximum current I_k (i.e. short-circuit current) permitted for an intrinsically safe electrical circuit, a safety factor must be taken into account. The short-circuit current I_k is obtained by dividing the ignition limitation current taken from the ignition limit curve by a safety factor of 1.5.

$$U_0 = 30 \text{ V}$$

$$I_k = \frac{150}{1,5} \text{ mA} = 100 \text{ mA}$$



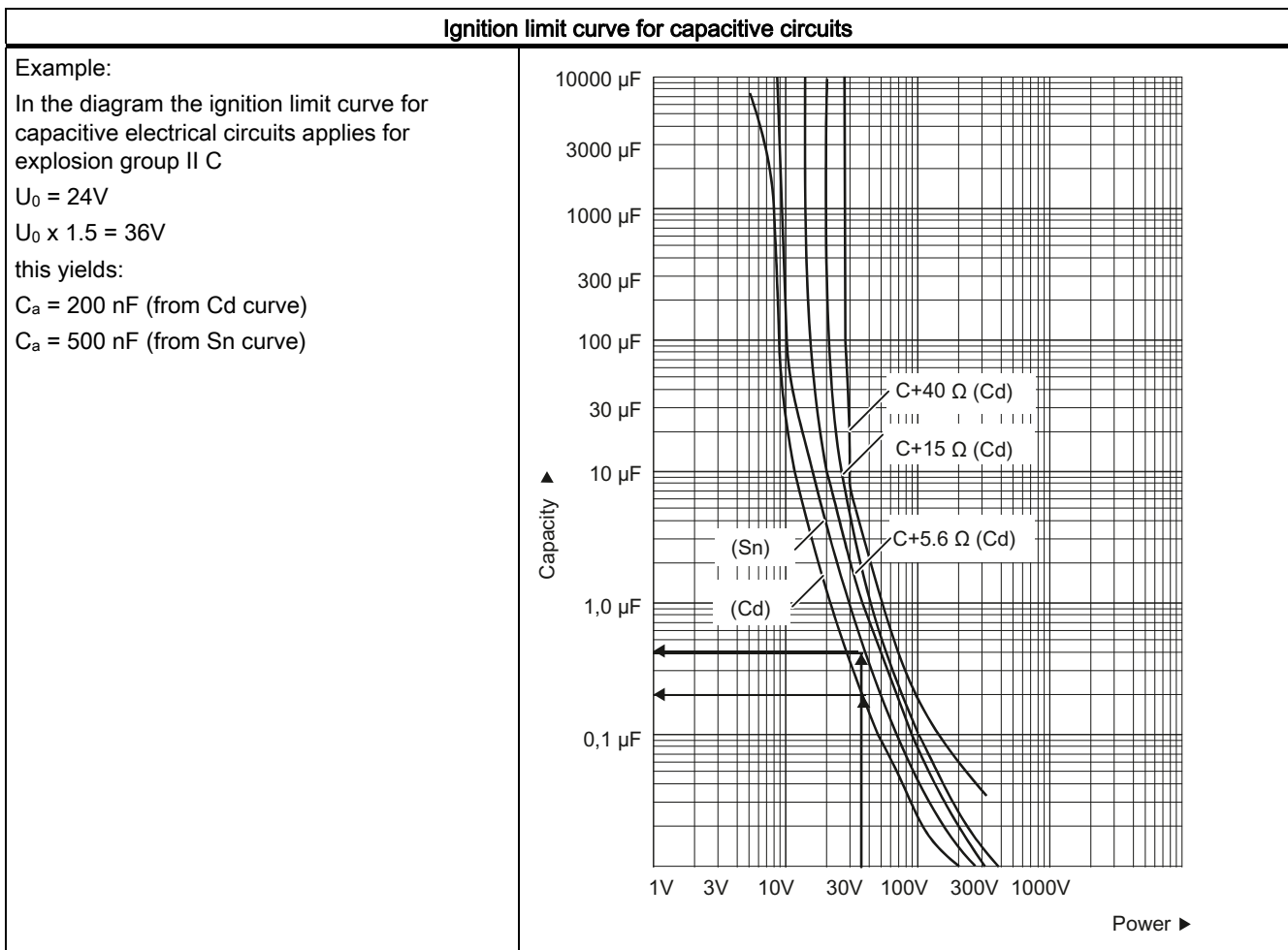
Ignition limit curve for capacitive electrical circuits

Capacitors very quickly provide the saved energy $W= 1/2 CU^2$ when electrical circuits are closed. At the start of contact of the contact faces, higher current flows immediately, melting or vaporizing the microscopic bumps on the material surface and thus contributing to the formation of so-called crackling sparks.

The highest voltage occurring in the electrical circuit, no-load voltage U_0 , is related to the size of the capacitance C_a permitted in an intrinsically safe electrical circuit. This relationship has been determined experimentally using a testing device and documented as an ignition limit curve for capacitive electrical circuits.

When ignition limit curves are used, a safety factor is to be taken into account in that the value for no-load voltage U_0 is initially multiplied by the safety factor of 1.5 and then the permitted capacitance C_a is established for this value from the ignition limit curve.

The following illustration shows the ignition limit curves for capacitive electrical circuits (explosion group IIC).

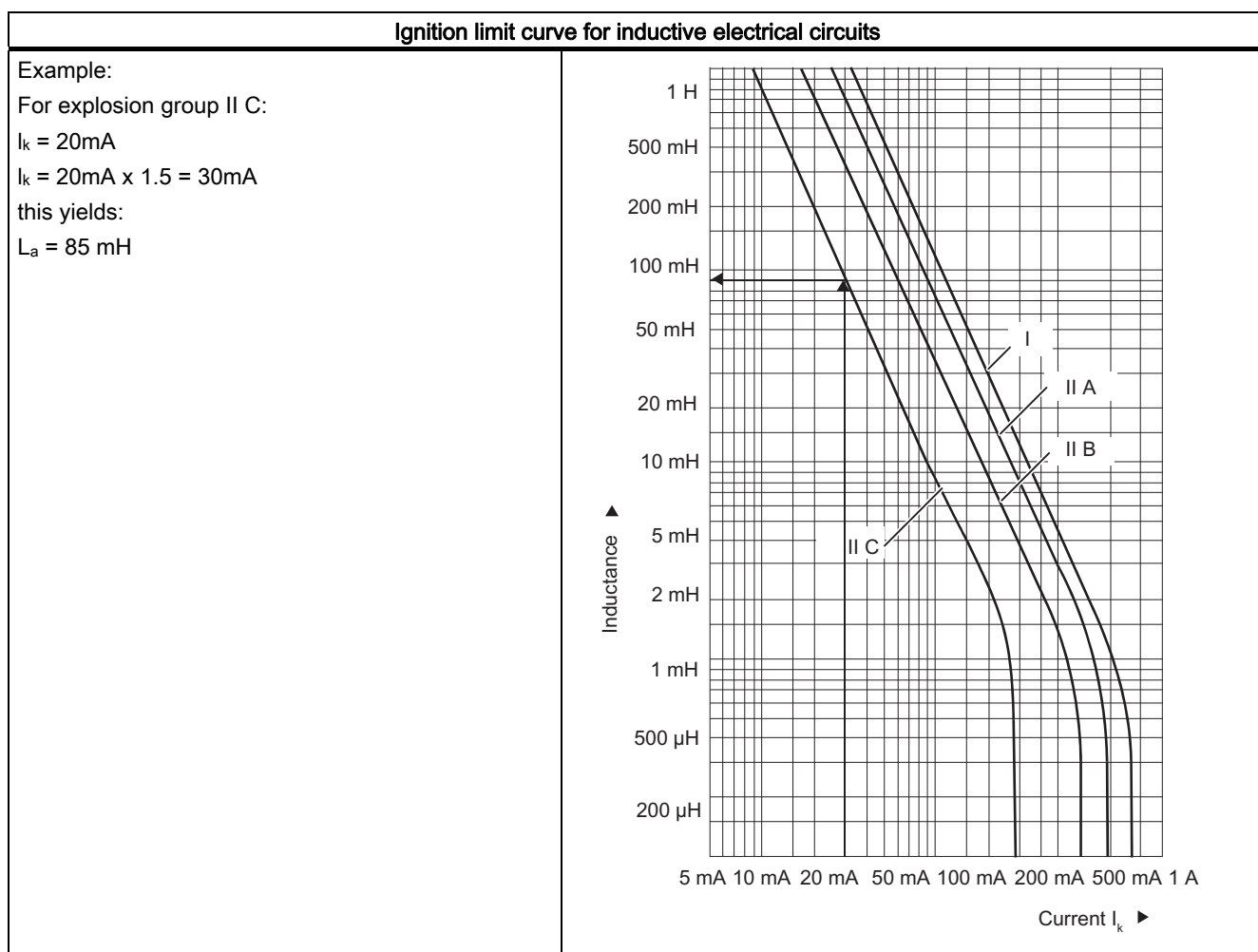


Ignition limit curve for inductive electrical circuits

Inductances cause spark formation when an electrical circuit is opened. The stored energy $W = 1/2 LI^2$ generates high voltage when contacts are opened, which means that a free air gap can be bridged by an electrical discharge in the form of a light arc. The relationship between technically safe maximum current in the event of a short circuit I_k and the permitted inductance L_a is shown again in ignition limit curves.

Here, too, a safety factor is to be taken into account if ignition limit curves are used in that firstly the short-circuit current I_k is multiplied by the safety factor 1.5. With the resulting current value, the corresponding inductance L_a can be read off the ignition limit curve (see example).

In general, it should be noted here for the application of ignition limit curves that they are important not only for testing individual items of electrical equipment but also for interconnections of several associated items of equipment in an intrinsically safe electrical circuit. The following illustration shows the ignition limit curve for inductive electrical circuits.



3.5.3 Equipment in the intrinsically safe electrical circuit

Complete intrinsically safe electrical circuit

A complete intrinsically safe electrical circuit (see illustration below) consists of:

- intrinsically safe electrical equipment.
- associated electrical equipment
- Cables
- or two intrinsically safe items of electrical equipment and their cables

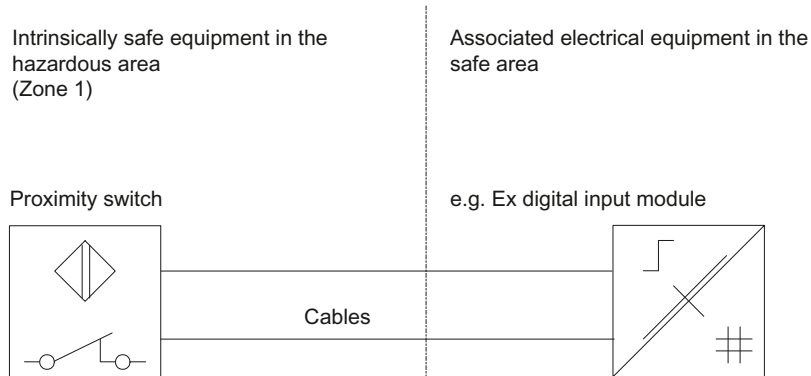


Figure 3-14 Intrinsically safe electrical circuit (example)

Intrinsically safe electrical equipment

In an item of intrinsically safe electrical equipment, all the electrical circuits are configured as intrinsically safe. Voltages and currents in this equipment are so small that in the event of a short circuit, interruption or ground fault, no ignition of an explosive atmosphere is triggered.

Intrinsically safe electrical equipment is suitable for operation directly in the explosion-endangered area.

All intrinsically safe electrical equipment must be tested and approved, unless the electrical values 1.5 V, 0.1 A, 25 mW (EN 60079-11) are not exceeded. This equipment that does not require certification includes, for example, thermal elements, photo elements and dynamic microphone capsules.

Categories of intrinsically safe electrical equipment

Intrinsically safe electrical equipment and intrinsically safe parts of the associated equipment are divided into categories (safety levels). The safety levels depend on the safety requirements in configuring the equipment.

Safety level	Description according to EN 60079-11	Installation
ia	Intrinsically safe electrical equipment must not cause ignition <ul style="list-style-type: none"> during normal operation and in the presence of those non-countable errors that produce the worst-case condition. during normal operation and in the presence of a countable error plus those non-countable errors that produce the worst-case condition. during normal operation and in the presence of two countable errors plus those non-countable errors that produce the worst-case condition. 	up to Zone 0 up to Zone 20
ib	Intrinsically safe electrical equipment must not cause ignition <ul style="list-style-type: none"> during normal operation and in the presence of those non-countable errors that produce the worst-case condition. during normal operation and in the presence of a countable error plus those non-countable errors that produce the worst-case condition. 	Zone 1 and Zone 21 Zone 2 and Zone 22

Associated electrical equipment

Associated electrical equipment is equipment in which not all electrical circuits are intrinsically safe but contains at least one intrinsically safe electrical circuit that leads into an explosion-endangered area. Here, in general, an intrinsically safe signal is converted into a non-intrinsically safe signal or vice versa, whereby the current can flow into or out of the explosion-endangered area. This means that associated electrical equipment has the task of signal separation (e.g. safety barriers), signal conversion (measurement converters, circuit breaker boosters) or supply (supply device).

Associated electrical equipment is not appropriately protected and thus may not be installed in the explosion-endangered area. It is identified by square brackets around the ignition protection type indicator and the lack of temperature class (e.g. [Ex ib] IIC).

Associated electrical equipment contains current circuits that may lead into the explosion-endangered area (e.g. sensor circuit of a temperature measurement converter).

Cables

For selection and routing cables, EN 60 079-14 must be taken into account. Here, particular attention must be paid to cable characteristics such as dielectric strength and minimum cross-section. In the case of long cables, the cable capacitance and inductance must also be included in the analysis. The connection points and cables of intrinsically safe electrical circuits must be marked and separated from the rest of the connection points and cables of non-intrinsically safe electrical circuits. For example, if cables are marked in *colors*, light-blue must be used to identify intrinsically safe electrical circuits.

To sum up, it can be said that electrical circuits of the ignition protection type inherent safety are configured in such a way that on opening, closing, in the event of short circuit and ground fault, even if there are a number of countable faults, they are unable to create explosive sparks.

3.5.4 Separator circuits

Safety barriers and separator circuits

The structure of an intrinsically safe system for measuring, controlling and regulating in the explosion-endangered area is shown below. The essential automation and display devices that do not require explosion protection are outside the explosion-endangered area, e.g. in a control room. All of the field current circuits leading into the explosion-endangered area must be intrinsically safe. Separator circuits between the intrinsically safe field current circuits and non-intrinsically safe passive current circuits, such as those of a control room, achieve the necessary voltage and current limitation for the intrinsically safe area.

The separator circuits to the actuators and sensors can be configured as separate equipment (e.g. isolating transformers) or integrated in SIMATIC Ex assemblies.

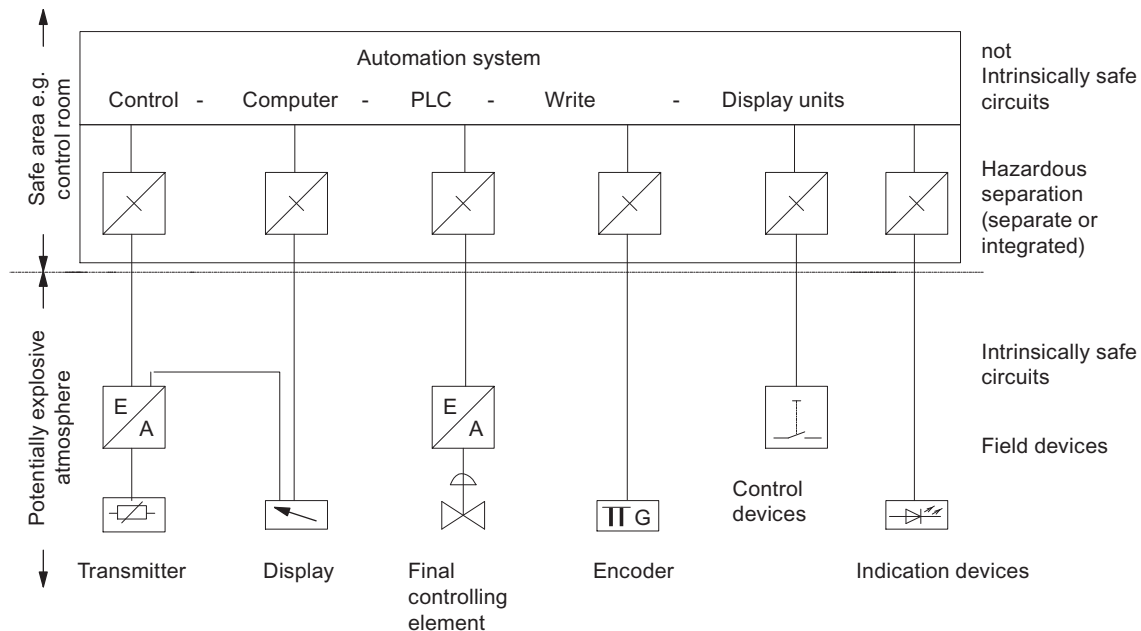


Figure 3-15 Typical structure of an intrinsically safe measuring and control system

Safety barriers

Safety barriers are equipment that protects electrical circuits so that they are intrinsically safe.

If a fault raises the voltage U on the non-intrinsically safe side of the safety barrier beyond a permitted value, the Zener diodes limit the voltage for the intrinsically safe electrical circuit to the value of the Z diode voltage.

To protect the Z diodes, there is an upstream fuse (F), which means that in the event of excessive current load the fuse blows first before the Z diodes are overloaded or destroyed. The fuse and Z diode are geared to one another accordingly on the basis of their current-time characteristic curves.

In the event of a short circuit on the intrinsically safe side, the resistance R limits the short-circuit current to a permitted value.

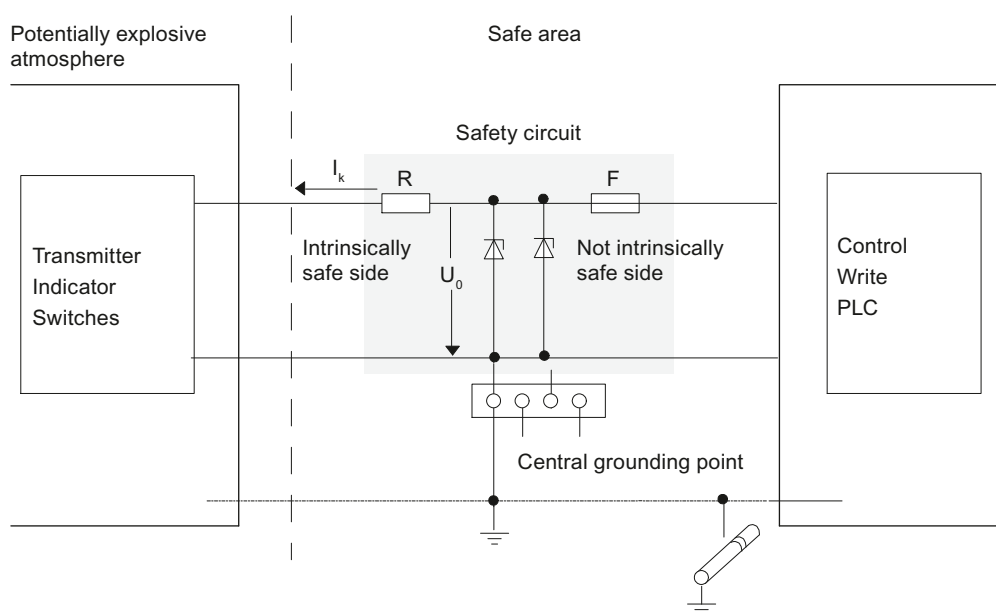
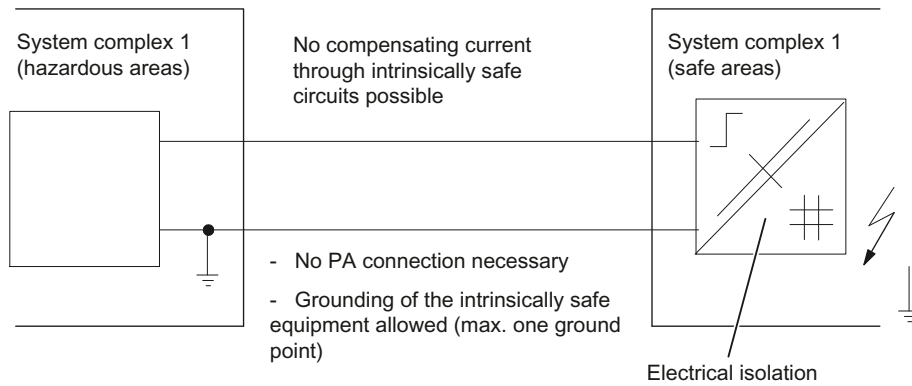


Figure 3-16 Circuit diagram of a safety barrier

Separator circuits with electrical insulation

The SIMATIC S7 Ex modules are electrically insulated from one another through the integrated isolating transformer. In the event of multiple SIMATIC S7 Ex modules, there is also an electrical insulation between the channels.



The SIMATIC S7 Ex modules have the following characteristics:

- The intrinsically safe equipment in the field can be grounded in service so that in the event of grounding at only one point no compensatory current can flow (use in applications with unfavorable grounding conditions for modules with electrical insulation between the channels.).
- From a metrological point of view, no faults due to ground potentials can occur.
- No additional potential compensation cable is necessary, reducing the installation overhead.
- Intrinsically safe electrical circuits and evaluation circuits can lie on different potentials.

The ET 200iSP has an electrical insulation from the station to the supply voltage and to the bus connector. The individual electronic modules are also electrically insulated from one another.

The ET 200iSP has the following characteristics:

- The ET 200iSP can be used in Zone 1 with a housing/enclosure with protection type Ex e.
- The sensors and actuators connected to the ET 200iSP can be used up to Zone 0 and Zone 20 (category "ia").
- The intrinsically safe equipment in the field can be grounded in service.
- From a metrological point of view, no faults due to ground potentials can occur.
- No additional equipotential bonding conductor is necessary, reducing the installation overhead.

3.5.5 Interconnection in the intrinsically safe electrical circuit

3.5.5.1 Introduction

Electrical circuits

With the interconnection of intrinsically safe or associated equipment, a new electrical circuit is created. The electrical properties of this circuit must be checked for compatibility with the rules of intrinsic safety. Three types of electrical circuits can be distinguished:

Interconnection of

- two intrinsically safe devices
- one intrinsically safe device with an item of associated equipment
- Interconnections with more than one item of associated or active equipment

The check of permissibility of the interconnection is relatively easy in the first and second case and it is done by comparing the safety parameters from the EC-type examination certificate or technical data of the manufacturer. Case three can be more or less complicated and should only be performed by persons with the necessary knowledge.

3.5.5.2 Interconnection of two intrinsically safe items of equipment or one intrinsically safe and one associated item of equipment

Conditions

The interconnection rules are derived from the installation regulations of the EN 60079-14 or IEC 60079-14 standard. This stipulates that to check whether the interconnection of two devices with intrinsically safe electrical circuits meet the requirements of intrinsic safety the safety-related maximum values of the input/output parameters have to be compared.

Here, the following conditions must be met:

Maximum values of the supplying output		Maximum value of the (passive) input
U_o	\leq	U_i
I_o	\leq	I_i
P_o	\leq	P_i
L_o	\geq	$L_i + L_{cable}$
C_o	\geq	$C_i + C_{cable}$
L_o / R_o	\geq	L_{Cable} / R_{Cable}

The interconnection is only permitted if all the necessary conditions have been met. On some devices not all of the above parameters are specified, e.g. a resistive output or input only two of the three parameters U, I, P are sufficient for the system to be uniquely determined. The L/R ratio is also not really necessary. However, if the L/R ratio is specified and simultaneously the inner inductance of the intrinsically safe equipment is $L_i = 0$, the condition for L_o does not have to be met.

3.5.5.3 Interconnections with more than one item of associated or active equipment

Conditions

These cases require a detailed safety analysis. The procedure also depends on the shape of the characteristic curves of the devices. In the case of linear current/voltage characteristic curves, Appendix A and B of the installation standard EN/IEC 60079-14 or VDE 0165 T.1 specifies a procedure for safety analysis.

For the more complicated case of non-linear characteristic curves, the German Federal Physical Technical Institute specifies a procedure in the report PTB-ThEx-10 that can be used to graphically prove the intrinsic safety of such interconnections. However, these analyses should be run in all cases by experts.

The planner must create a system description in which the individual items of electrical equipment and electrical specifications of the system, including the wires, are specified. The standard IEC 60079-25 for intrinsically safe systems describes both the calculation and analysis procedures as well as a procedure for documentation of an intrinsically safe system.

3.5.5.4 Example 1 of interconnecting two intrinsically safe items of equipment

Verification of intrinsic safety

Verification of the intrinsic safety of the interconnection of a SITRANS P DSIII pressure transmitter with an analog input module of the ET 200iS distributed I/O module.

Equipment	Characteristics
Module 4AI I 2WIRE HART analog input Order no. 6ES7134-7TD00-0AB0	EG-type examination certificate KEMA 04 ATEX 1244
	Type of protection: II 2 G (1) GD and I M2 Ex ib [ia] [iaD] IIC T4; Ex ib [ia] I
Intrinsically safe Pressure transmitter SITRANS P DSIII Model 7MF4*33-*****-B**	EG-type examination certificate PTB 99 ATEX 2122
	Type of protection: II 1/2 G Ex ia IIC/IIB T6

Interconnection

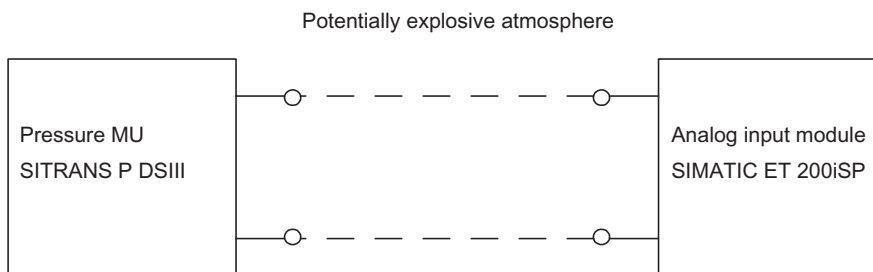


Figure 3-17 Interconnecting a pressure transmitter with an analog input module

As both items of equipment are explosion-protected, both can be installed in the explosion-endangered area of Zone 1.

The connected SITRANS P DSIII can also be located in Zone 0.

Comparison of the safety-related maximum values:

SIMTATIC analog input module 6ES7134-7TD00-0AB0			SITRANS P DSIII Model 7MF4*33- ****-B**		
Uo	27.6 V	≤	Ui	30 V	okay
Io	91 mA	≤	Ii	100 mA	okay
Po	630 mW	≤	Pi	750 mW	okay

Result of the comparison: the equipment can be interconnected.

Calculation of the maximum cable length

	Lo [mH]		Li [mH] (cell)		L [mH] (cable)	max. permitted cable length at L'=1 uH/m
Group II B	13	-	0,4	=	12,6	12600 m
Group II C	3	-	0,4	=	2,6	2600 m

	Co [nF]		Ci [nF] (cell)		C [nF] (cable)	max. permitted cable length at C'= 200 pF/m	max. permitted cable length at C'= 100 pF/m
Group II B	650	-	6	=	644	3220 m	6440 m
Group II C	83	-	6	=	77	385 m	770 m

The max. permitted cable length is 3220 m for gas group II B and 385 m for gas group II C (Notice - depending on the cable type used). It can be seen that in this example the cable length is limited by the capacitances of the electrical circuit. The inductances would each permit longer cables.

Note

Specific information for Germany according to DIN EN 60079-14 (national preamble):

This type of calculation is only recommended if the connected equipment contains only concentrated inductances or only concentrated capacitances. For mixed electrical circuits, this type of calculation is permitted when the specified values for Lo and Co for the supplying equipment represent pairs of values for mixed electrical circuits. This must be expressly indicated in this way in the examination certificate. This must be complied with particularly for Zone 0 applications.

3.5.5.5 Example 2 of interconnecting two intrinsically safe items of equipment

Verification of intrinsic safety

Verification of the intrinsic safety of the interconnection of a non-specified NAMUR sensor with the 8 DI NAMUR electronic module of the ET 200iSP distributed I/O module.

Equipment	Characteristics
Electronic module 8DI NAMUR Order no. 6ES7131-7RF00-0AB0	EG-type examination certificate KEMA 04 ATEX 1248
	Type of protection: II 2 G (1) GD Ex ib [ia] IIC T4
Intrinsically safe NAMUR sensor (manufacturer-specific)	Manufacturer-specific
	Type of protection: II 1/2 GD Ex ia IIC/IIB T6

interconnection

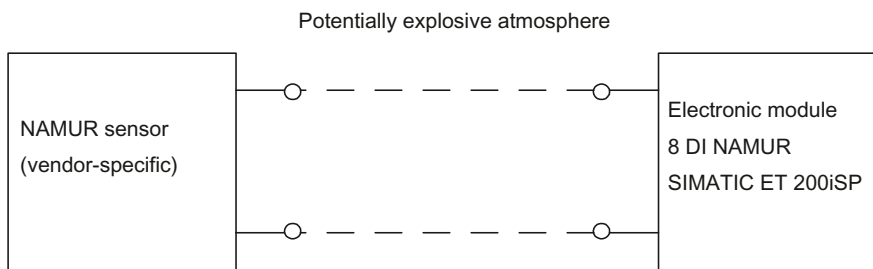


Figure 3-18 Interconnection of a NAMUR electronic module with a NAMUR sensor

As both items of equipment are explosion-protected, both can be installed in the explosion-endangered area of Zone 1.

The connected, intrinsically safe NAMUR sensor can also be located in Zone 0.

Comparison of the safety-related maximum values:

SIMATIC electronic module 6ES7131-7RF00-0AB0			Fictitious NAMUR sensor varies by device manufacturer		
U_o	9.6 V	\leq	U_i	27.3 V	okay
I_o	16 mA	\leq	I_i	84.1 mA	okay
P_o	38 mW	\leq	P_i	576 mW	okay
L_o / R_o	30 μ H / ohm	\geq	L_{Cable} / R_{Cable}	25 μ H / ohm	okay

Result of the comparison: the equipment can be interconnected.

Calculation of the maximum cable length

	Co [nF]		Ci [nF] (cell)		C [nF] (cable)	max. permitted cable length at C'= 2 nF/m	max. permitted cable length at C'= 1 nF/m
Group II B	28000	-	683	=	27317	13650 m	27300 m
Group II C	3600	-	86	=	3514	1760 m	3520 m

The max. permitted cable length is 13.650 m for gas group II B and 1.760 m for gas group II C (Notice - depending on the cable type used).

Note

Specific information for Germany according to DIN EN 60079-14 (national preamble):

This type of calculation is only recommended if the connected equipment contains only concentrated inductances or only concentrated capacitances. For mixed electrical circuits, this type of calculation is permitted when the specified values for L_o and C_o for the supplying equipment represent pairs of values for mixed electrical circuits. This must be expressly indicated in this way in the examination certificate. This must be complied with particularly for Zone 0 applications.

3.5.5.6 Example of interconnecting an intrinsically safe item of equipment with an associated item of equipment.

Verification of intrinsic safety

Verification of intrinsic safety of the interconnection of a SIWAREX R weighing cell with a SIWAREX IS Ex-i interface

Equipment	Characteristics
Weighing cell SIWAREX R Type 7MH5 101-... RN-..., rated load 10t	EC-type examination certificate KEMA 00 ATEX 1133 X
	Type of protection II 2 G Ex ib IIC T6
Ex-i interface SIWAREX IS Type 7MH4710-5CA	EC-type examination certificate TÜV 01 ATEX 1722 X
	Type of protection: II (2) G [Ex ib] IIC

Interconnection

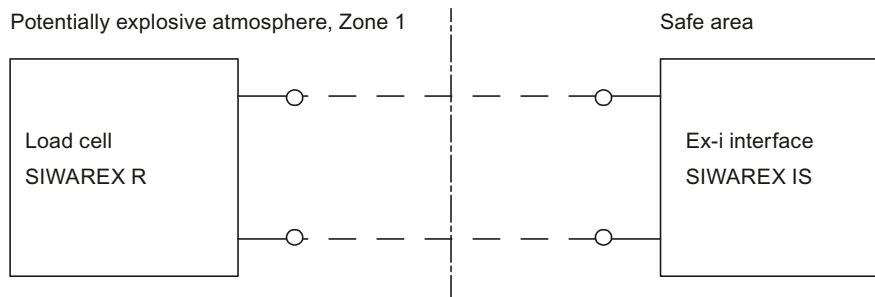


Figure 3-19 Interconnecting a SIWAREX R load cell with a SIWAREX IS Ex-i interface

The interface is associated equipment and may only be installed outside the explosion-endangered area.

Comparison of the safety-related maximum values

Ex-i interface 7MH4710-5CA			Load cellNominal load 10 t		
Uo	14.4 V	≤	Ui	19.1 V	okay
Io	137 mA	≤	Ii	323 mA	okay
Po	1025 mW	≤	Pi	1250 mW for T6	okay
Po	1025 mW	≤	Pi	1930 mW for T4	okay

Result of the comparison: the interconnection of these devices is permitted for the temperature ranges T4 and T6.

Calculation of the maximum cable length

	Lo [mH]	-	Li [mH] (cell)	=	L [mH] (cable)	max. permitted cable length at L'=1 uH/m
Gas group II B	2	-	0	=	2	2000 m
Gas group II C	0,5	-	0	=	0,5	500 m

	Co [nF]	-	Ci [nF] (cell)	=	C [nF] (cable)	max. permitted cable length at C'= 200 pF/m	max. permitted cable length at C'= 100 pF/m
Gas group II B	2000	-	0,4	=	1999	9 995 m	19 990 m
Gas group II C	450	-	0,4	=	449	2 245 m	4 490 m

The max. permitted cable length is 2000 m for gas group II B and 500 m for gas group II C. In this example, the cable length is limited by the inductances of the electrical circuit. The capacitances would permit longer cables for both cable types with 100 and 200 pF/m.

Commissioning (hardware)

4.1 Installing electrical systems

4.1.1 Installing in Zone 1

4.1.1.1 Areas of Zone 1

Definition

Areas that correspond to Zone 1 are often defined in the vicinity of filling and discharge openings.

The electrical equipment for Zone 1 - except for cables and wires - must meet the requirements of the individual ignition protection types and be certified by an approved inspection body. This does not apply to simple electrical equipment according to EN 60079-11,

- which is supplied intrinsically safe and
- is passive or where the manufacturer has specified that the source does not exceed the values 1.5 V, 0.1 A or 25 mW.

Only the equipment specified for each zone (device categories) may be used.

4.1.1.2 Protection against accidental contact and equipotential bonding

Direct contact

Protection against direct contact is initially a personal protection measure. In explosion-endangered areas, this protection has the additional function of preventing explosive sparks.

Equipotential bonding

The installation regulation, EN 60079-14, requires equipotential bonding within explosion-endangered areas of Zones 0 and 1 to prevent the occurrence of explosive sparks or heating due to differences in potential. The equipotential bonding is to be designed according to the network system complying with DIN VDE 0100 Part 410 and dimensioning complying with DIN VDE 0100 Part 540. For additional information see IEC 60364-4-41.

Complete equipotential bonding is achieved in that not only the housing of the electrical equipment is connected by equipotential bonding conductors to the protective conductors or ground, but also all other accessible, conducting construction parts such as structural design, metallic containers, pipes etc. (see below). External conducting parts that do not belong to the construction or installation of the system (e.g. door hinges, window frames) do not need to be integrated into the equipotential bonding. This also applies to housings/enclosures if their securing elements mean that they already have reliable contact to the equipotential bonding (of construction parts or pipes). The connections for the equipotential bonding must be reliable, e.g. designed with secured bolt connections.

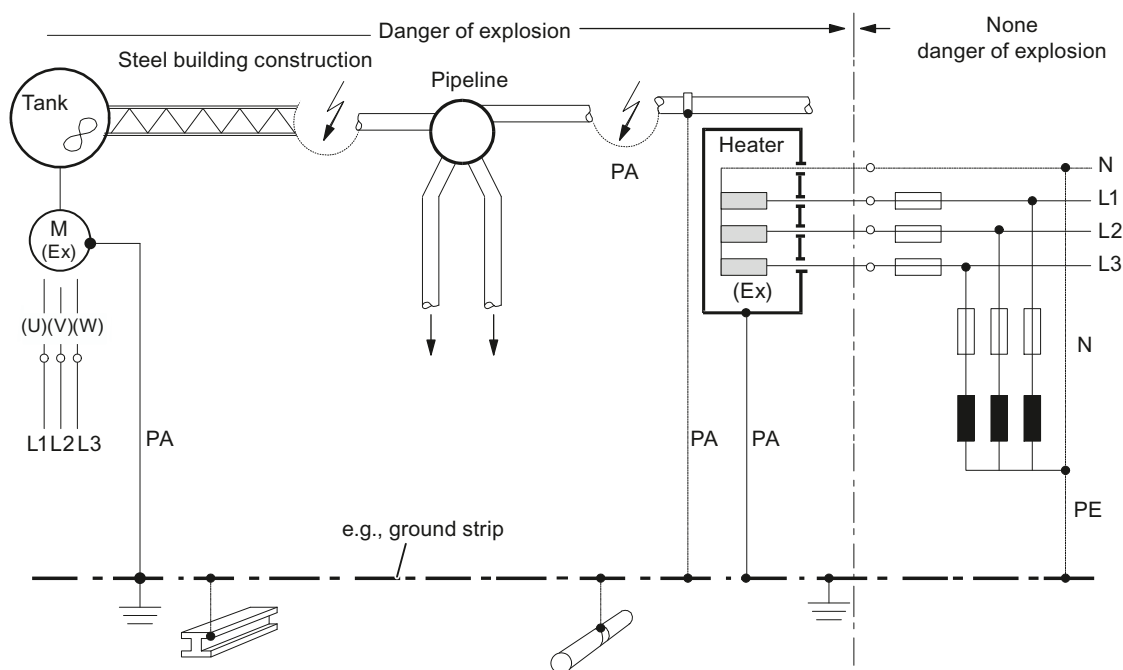


Figure 4-1 Equipotential bonding in the potentially explosive area

4.1.1.3 Cables and wires

Selection

In the selection of cables and wires based on design, only those that are able to withstand the expected mechanical, chemical and thermal influences are to be used. Cables and wires with thermoplastic sheath, duroplastic sheath, elastomer sheath or mineral-insulated with metal sheath may be used for fixed routing.

Cable branches must meet the requirements for explosion-protected areas.

Connection

The connection of cables and wires to the electrical equipment must take place in accordance with the requirements for the relevant ignition protection type and unused openings must be sealed off.

Routing

When routing cables and wires through openings to non-explosion-endangered areas, it must be ensured that the openings are tightly enough sealed (e.g. powder cups, mortar seal). At positions that are particularly endangered, cables and wires are to be protected against thermal, mechanical or chemical strain by e.g. protective tubes, protective hoses or covers.

Cables and wires for fixed-location routing must have flash-over specifications that pass the tests complying with IEC 60332-1.

4.1.1.4 Intrinsically safe equipment in Zone 1

Requirements for cables and wires

The requirements for cables and wires in intrinsically safe electrical circuits include that cables and wires must always be insulated and withstand a testing voltage wire against wire, wire against shielding and shielding against wire of at least 500 VAC. The diameter of a single wire within the explosion-endangered area must not be less than **0.1 mm**.

If the requirements of DIN EN 60074-14 Paragraph 12 are adhered to (e.g. wire insulation, testing voltage, shielding), routing more than one intrinsically safe electrical circuit in a cable or wire is permitted.

Cables and wires of intrinsically safe electrical circuits must be identified. If they are identified in color, light-blue must be used. The connecting components of the intrinsically safe electrical circuits must also be identified as intrinsically safe. The connecting components of intrinsically safe electrical circuits must also be clearly separated from the non-intrinsically safe connecting components.

Selection of equipment

In the selection of equipment for systems with intrinsically safe electrical circuits, only associated equipment of category 1 or 2 with safety level 'ia' or 'ib' may be used. The safety levels are defined in EN 60079-11.

Note

Associated electrical equipment of the 'intrinsic safety' ignition protection type must be located outside of the explosion-endangered area.

Simple electrical equipment (e.g. switches, resistors) do not need to be labeled, but they must meet the requirements of EN 60079-11 (IEC 60079-11) and EN 60079-0 (IEC 60079-0) to the extent that the intrinsic safety depends on this.

Requirements for the intrinsically safe electrical circuit

Intrinsically safe electrical circuits can be installed grounded or ungrounded. In the case of grounded or non-isolated circuits, compliance with regulations for equipotential bonding is required.

Moreover, in Zone 1 and Zone 2, conductors or single-core non-sheathed cables of intrinsically safe and non-intrinsically safe electrical circuits may not be routed together in cables, wires, pipes or conductor bundles. Single-core non-sheathed cables of the intrinsically safe and non-intrinsically safe electrical circuits must be routed separately in conduit subways or separation by an intermediate layer of insulating material between them is required. This additional separation can, for example, be eliminated if cables with corresponding sheath insulation are used.

The intrinsic safety must not be impaired by external electrical or magnetic fields. It therefore makes sense to use shielded and/or twisted cables.

Verification of intrinsic safety

For verification of the intrinsic safety of an electrical circuit, the electrical specifications of the examination certificate or operating instructions of the equipment must be adhered to.

Cables can be represented as concentrated capacitances. For intrinsically safe electrical circuits, it is sufficient to determine the maximum capacitance between two neighboring wires. In the case of commercially available cables and wires, a capacitance of 200 nF/km can be roughly assumed.

If intrinsically safe electrical circuits are interconnected with more than one active item of equipment, the 'intrinsic safety' must also be ensured with fault analyses. Here, verification by calculation or technical measurement verification is to be provided.

4.1.1.5 ET 200iSP in Zone 1

ET 200iSP

The ET 200iS distributed I/O module is an item of electrical equipment for Zone 1. Intrinsically safe sensors, actuators and HART field devices of the device categories 1G, 2G for Zones 0,1 as well as device categories 1D, 2D for the Zones 20 and 21 can be connected to the ET 200iS. Special care as regards separation is required here.

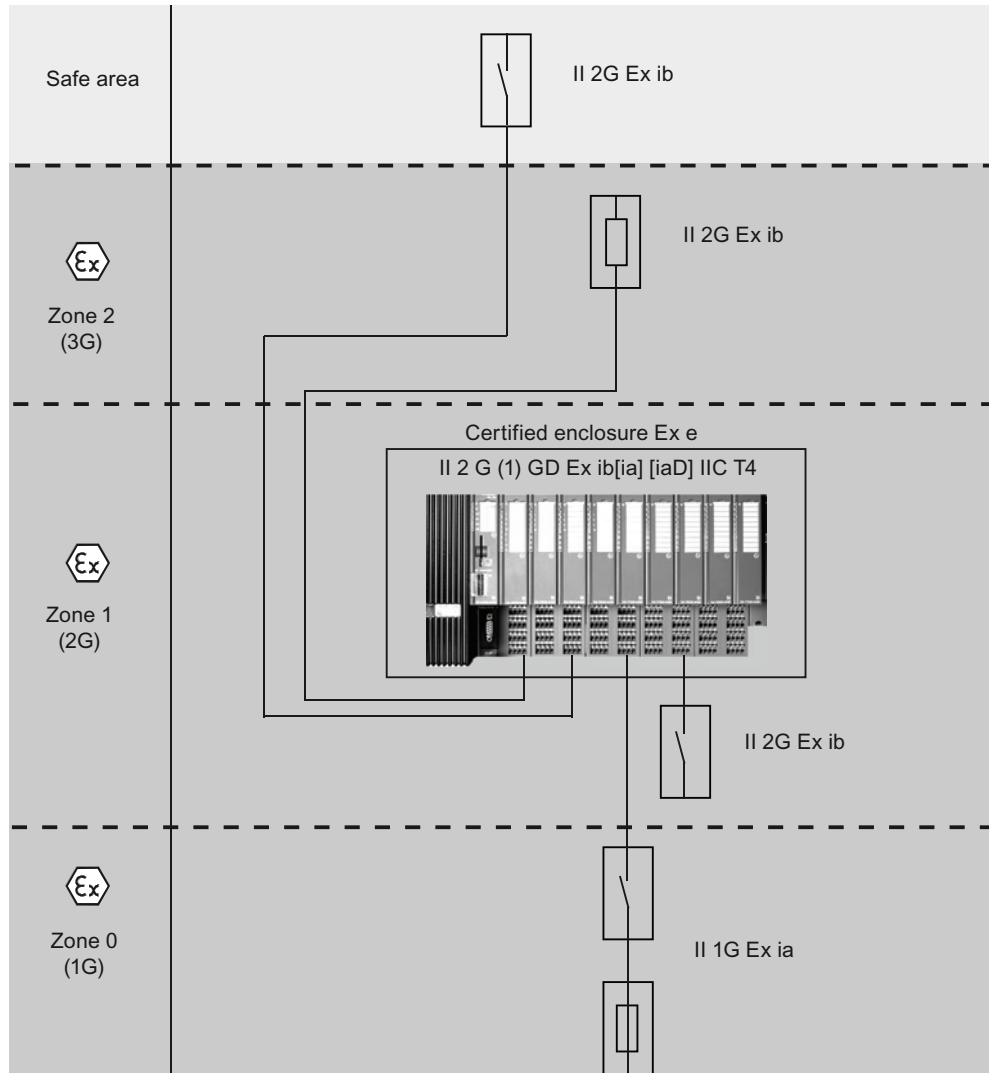


Figure 4-2 ET 200iSP in Zone 1

Requirements for ET 200iSP in Zone 1

- The PROFIBUS-DP must be separated with an RS 485-IS coupler. The field bus isolating transformer must be installed in the safe area or in Zone 2 (category 3G).
- The PROFIBUS RS 485-IS must be connected with the RS 485-IS PROFIBUS bus connector (6ES7972-0DA60-0XA0). The terminating resistor is integrated in the above PROFIBUS bus connector.
- Normal bus cables (which are to be used as intrinsically safe wires) must be marked as Ex i bus cables.
- The ET 200iS must be fitted in a housing/enclosure with Ex e ignition protection type (increased safety).

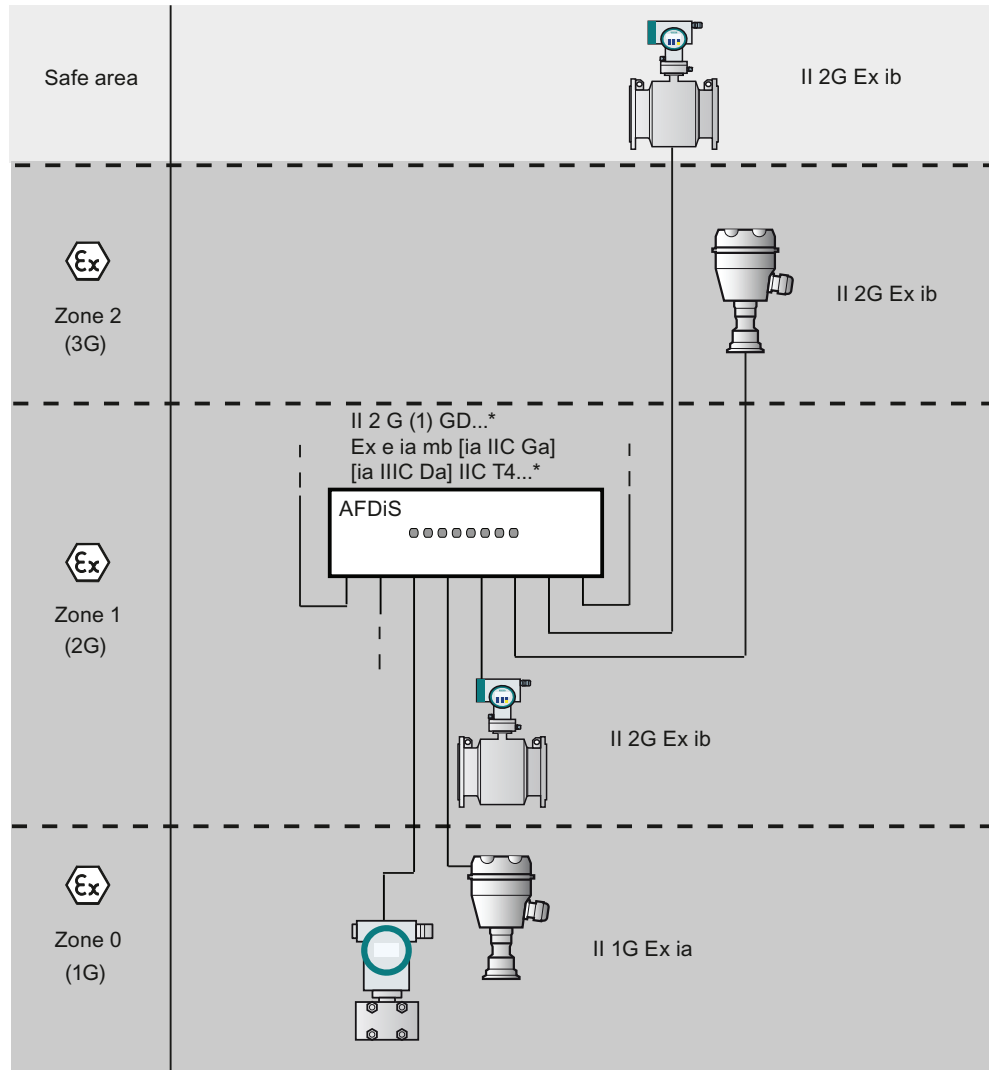
Additional information

For further additional information refer to the ET 200S Distributed I/O System (<http://support.automation.siemens.com/WW/view/en/28930789>) Operating Instructions.

4.1.1.6 AFDiS in Zone 1

AFDiS

The active field distributor AFDiS is electrical equipment for Zone 1. The intrinsically safe PA field devices (e.g. measuring devices, sensors, actuators) of device categories 1G, 2G for the Zones 0, 1 as well as device categories 1D, 2D for the Zones 20, 21 may be connected to the intrinsically safe connections.



* Complete designation: See Operating Instructions "DP/PA coupler, Active field distributors, DP/PA-Link and Y-Link"

Figure 4-3 ADFiS in Zone 1

Additional information

Please refer to the operating instructions DP/PA Coupler, Active Field Distributor, DP/PA Link and Y Link (<http://support.automation.siemens.com/WW/view/en/1142696>) for more information.

4.1.2 Installing in Zone 21

4.1.2.1 Areas of Zone 21

Definition

Zone 21 includes areas that occur in mills, warehouses for coal, etc. Explosive dust can also emerge from the openings in the vicinity of filling points and thus be a Zone 21 area.

Explosive dust-air mixtures can also form from sulphur gas, sulphur gas crackle and the formation of smolder spots. Especially in the case of dust deposits, correct assessment of the danger is frequently underestimated.

The equipment for Zone 21 must correspond to category 2D or 1D.

4.1.2.2 Cables and wires

Selection

Install cables and wires that will resist the anticipated chemical, mechanical and thermal influences in explosion-protected areas. Cables and wires with thermoplastic sheath, duroplastic sheath, elastomer sheath or mineral-insulated with metal sheath may be used for fixed routing.

The sheaths of flexible cables and wires for connection to equipment must be conventional or high-resistance polychloroprene, high-resistance rubber or plastic insulation to installation in areas where there is danger of dust explosions. They must also be designed to prevent dust penetration.

Accessories such as tap boxes used to connect cables and wires must comply with the protection type of the zone in which they are installed.

If dust deposits on cables and wires for a flammable mixture, the surface temperature of the sheath must remain below the smoldering temperature of the dust mixture. Otherwise the explosive atmosphere may ignite. This the reason for planning to reduce the current loading on the cables and wires.

Connection

The connection of cables and wires to the electrical equipment must take place in accordance with the requirements for the relevant ignition protection type. Unused openings must be sealed.

Cable inlets must comply with the requirements of IEC 61241-0 Section 27. Make sure that the sealing capacity in the equipment housing is not affected by the cable inlets.

The plugs and plug connections in Zone 21 must comply with the requirements according to IEC 61241-0 and IEC 61241-14 chapter 11.

Routing

When routing cables and wires through openings to non-explosion-endangered areas, it must be ensured that the openings are tightly enough sealed (e.g. powder cups, mortar seal).

At positions that are particularly endangered, cables and wires are to be protected against thermal, mechanical or chemical strain by e.g. protective tubes, protective hoses or covers. The space between the cable and pipe must be sealed to ensure sufficient protection.

Cables and wires for fixed-location routing must have flash-over specifications that pass the tests complying with IEC 60332-1.

Electrostatic charges caused by friction of dust particles on the surfaces of cables and wires must be prevented by suitable measures during routing. The cable must generally be routed to ensure that as little dust as possible is deposited.

4.1.2.3 Intrinsically safe equipment in Zone 21

Requirements for cables and wires

The requirements for cables and wires in intrinsically safe electrical circuits include the requirement that cables and wires always be insulated and withstand a test voltage wire-to-wire and wire-to-ground of at least 500 VAC. The diameter of a single wire within the explosion-endangered area must not be less than **0.1 mm**.

If certain requirements are adhered to (e.g. wire insulation, testing voltage, shielding), routing more than one intrinsically safe electrical circuit in a cable or wire is permitted.

Cables and wires of intrinsically safe electrical circuits must be labeled, e.g. by means of light-blue sheaths. The connection parts of the intrinsically safe electrical circuits must also be labeled as intrinsically safe, e.g. by light-blue paint.

Intrinsically safe wires and cables can also be labeled in other ways. However, if color identification is used, the color light blue must be used.

Selection of equipment

In the selection of equipment for systems with intrinsically safe electrical circuits, only associated equipment of category 1 or 2 with safety level 'iaD' or 'ibD' according to EN 61241-11 may be used.

Note

Associated electrical equipment of the 'intrinsic safety' ignition protection type must be located outside of the explosion-endangered area.

In principle, intrinsically safe equipment whose intrinsic safety may be adversely affected by the penetration of dust must be fitted with a housing of at least degree of protection IP 6X. If parts of one of the electrical circuits are not protected by a housing, such as uninsulated measurement probes, they must be tested for compliance with the EN 61241-11 standard.

Additional requirements apply for some equipment, such as rotating machines, switchgear, fuses and plugs.

Requirements for the intrinsically safe electrical circuit

Intrinsically safe electrical circuits can be installed grounded or ungrounded. In the case of grounded or non-isolated circuits, compliance with regulations for equipotential bonding is required.

Moreover, in Zone 21 conductors or single-core non-sheathed cables of intrinsically safe and non-intrinsically safe electrical circuits must not be routed together in cables, leads, pipes or conductor bundles. Single-core non-sheathed cables of the intrinsically safe and non-intrinsically safe electrical circuits must be routed separately in conduit subways or separation by an intermediate layer of insulating material between them is required. This additional separation can, for example, be eliminated if cables with corresponding sheath insulation are used.

The intrinsic safety must not be impaired by external electrical or magnetic fields. It therefore makes sense to use shielded and/or twisted cables.

Verification of intrinsic safety

For verification of the intrinsic safety of an electrical circuit, the electrical specifications of the examination certificate or operating instructions of the equipment must be adhered to.

Cables can be represented as concentrated capacitances. For intrinsically safe electrical circuits, it is sufficient to determine the maximum capacitance between two neighboring wires. In the case of commercially available cables and wires, a capacitance of 200 nF/km can be roughly assumed.

If intrinsically safe electrical circuits are interconnected with more than one active item of equipment, the 'intrinsic safety' must also be ensured with fault analyses. Here, verification by calculation or technical measurement verification is to be provided.

4.1.2.4 ET 200iSP in Zone 21

ET 200iSP

The ET 200iS distributed I/O module is an item of electrical equipment for Zone 1. Intrinsically safe sensors, actuators and HART field devices of the device categories 1G, 2G for Zones 0,1 as well as device categories 1D, 2D for the Zones 20 and 21 can be connected to the ET 200iS. Special care as regards separation is required here.

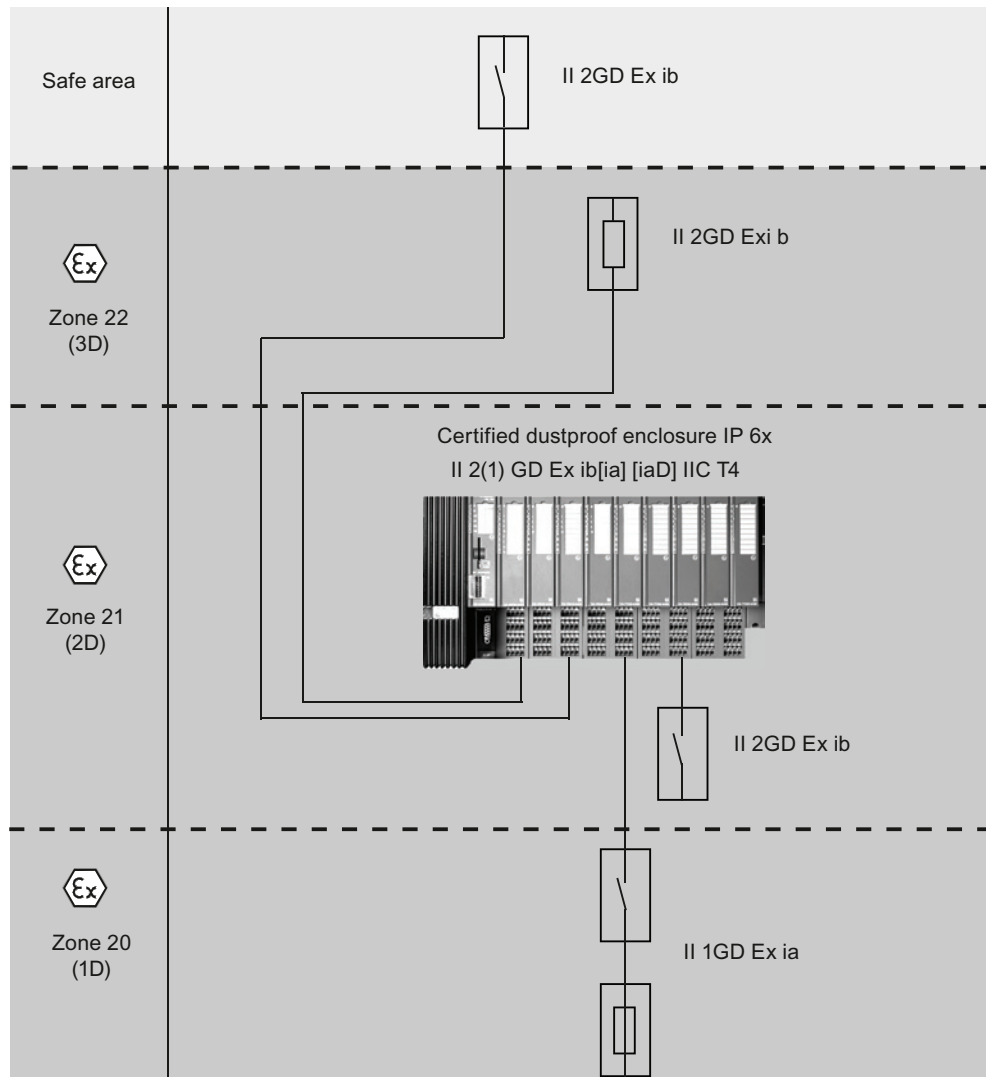


Figure 4-4 ET 200iSP in Zone 21

Requirements for ET 200iSP in Zone 21

- The PROFIBUS-DP must be separated with an RS 485-IS coupler. The field bus isolating transformer must be installed in the safe area or in Zones 21 or 22 (category 2D or 3D).
- The PROFIBUS RS 485-IS must be connected with the RS 485-IS PROFIBUS bus connector (6ES7972-0DA60-0XA0). The terminating resistor is integrated in the bus connector.
- Normal bus cables (which are to be used as intrinsically safe wires) must be marked as Ex i bus cables.
- The ET 200iSP must be fitted in a certified dustproof housing/enclosure with degree of protection IP 6x (dustproof).

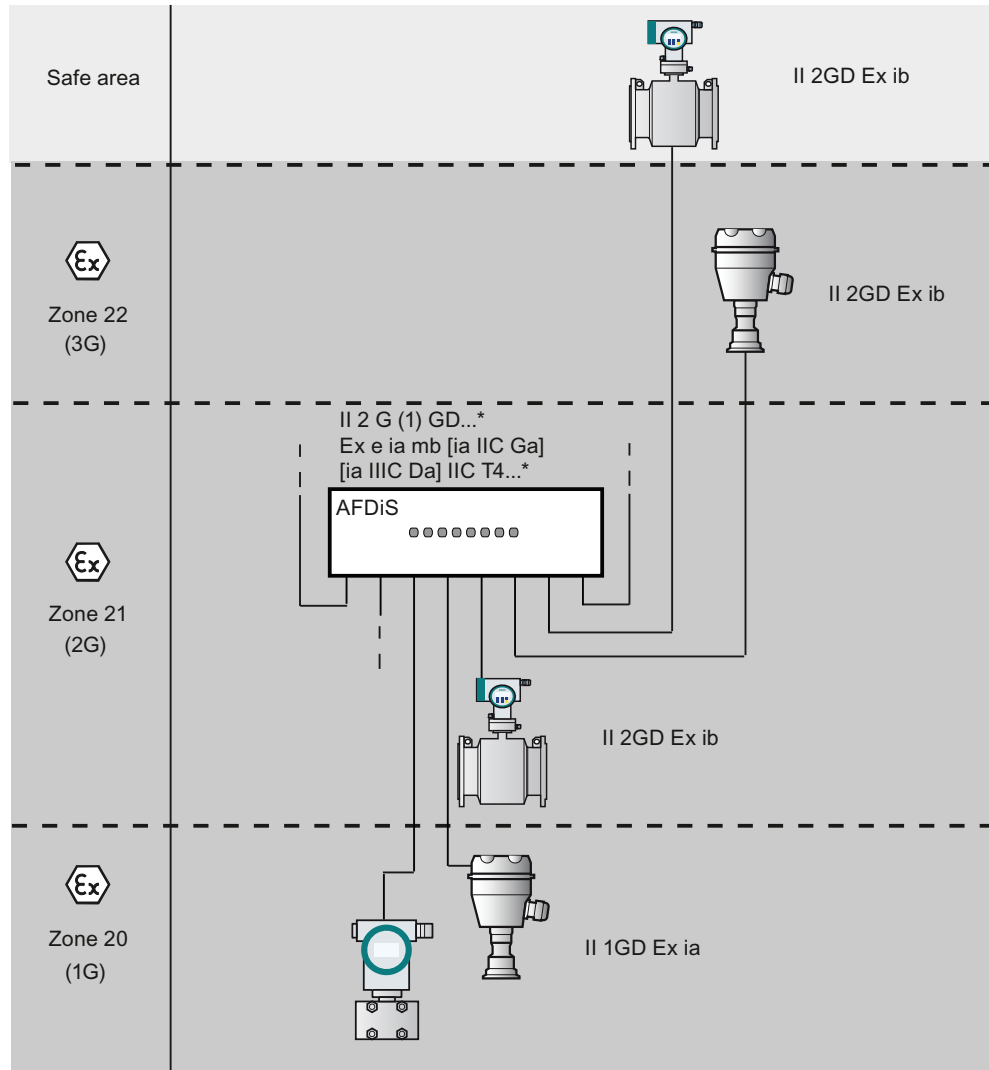
Additional information

Additional information can be found in the ET 200iSP operating instructions on the Web (<http://support.automation.siemens.com/WW/view/en/28930789>).

4.1.2.5 AFDiS in Zone 21

AFDiS

The active field distributor AFDiS is electrical equipment for Zone 21. The intrinsically safe PA field devices (e.g. measuring devices, sensors, actuators) of device categories 1G, 2G for the Zones 0, 1 as well as device categories 1D, 2D for the Zones 20, 21 may be connected to the intrinsically safe connections.



* Complete designation: See Operating Instructions DP/PA coupler, Active field distributors, DP/PA-Link and Y-Link

Figure 4-5 ADFiS in Zone21

Additional information

Please refer to the operating instructions DP/PA Coupler, Active Field Distributor, DP/PA Link and Y Link (<http://support.automation.siemens.com/WW/view/en/1142696>) for more information.

4.1.3 Installing in Zone 0 and Zone 20

4.1.3.1 Installing in Zone 0 and Zone 20

Definition

Additional requirements apply for installing in Zone 0 or Zone 20 compared to those for Zone 1 or Zone 21 (see EN 60079-14).

Areas that correspond to Zone 0 normally occur within containers, tanks and in the direct vicinity of filling stations.

Areas that correspond to Zone 20 occur in areas such as grain silos.

Only equipment of category 1 G/D may be used in Zone 0 or Zone 20 and it must be specially certified and approved for this purpose.

Cables and wires

Increased requirements also apply to cables and wires and their routing.

Systems with intrinsically safe electrical circuits

For systems with intrinsically safe electrical circuits the intrinsically safe and associated electrical equipment must be devices of category 1 with safety level ia.

4.1.4 Installing in Zone 2

4.1.4.1 Areas of Zone 2

Definition

Zone 2 includes areas near flanged connections on pipes, production and storage areas for flammable and explosive materials.

Electrical equipment suitable for Zone 0 or 1 may be used initially in Zone 2. Electrical equipment must be specified by the manufacturer for Zone 2.

4.1.4.2 ET 200iSP in Zone 2

Connections

The ET 200iS distributed I/O module is an item of electrical equipment for Zone 1. Intrinsically safe sensors, actuators and HART field devices of the device categories 1G, 2G, 3G for Zones 0,1 and 2 as well as device categories 1D, 2D, 3D for the Zones 20,21 and 22 can be connected to the ET 200iS. Special care as regards separation is required here.

Special conditions apply to device categories 3G/3D in Zones 2/22

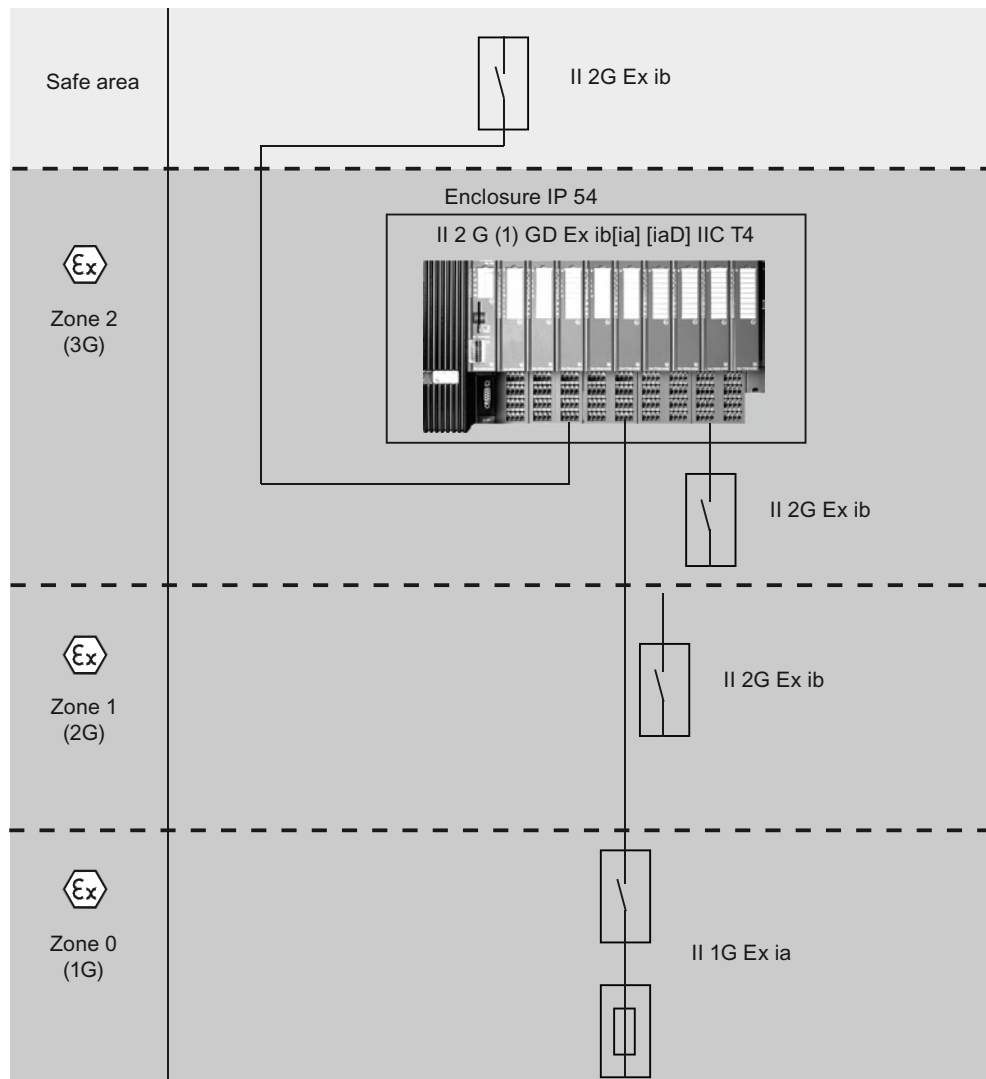


Figure 4-6 ET 200iSP in Zone 2

Requirements for ET 200iSP in Zone 2

- The PROFIBUS-DP must be separated with an RS 485-IS coupler.
The field bus isolating transformer must be installed in the safe area or in Zone 2 (category 3G).
- The PROFIBUS RS 485-IS bus cable must be connected to the ET 200iS with a bus connecting plug with 1.5 Mbaud.
- The PROFIBUS RS 485-IS must be terminated with an active terminating resistor.
- Normal cables (which are to be used as intrinsically safe wires) must be marked as Ex i bus cables.
- The ET 200iSP must be fitted in a housing/enclosure with at least degree of protection IP 54.

Additional information

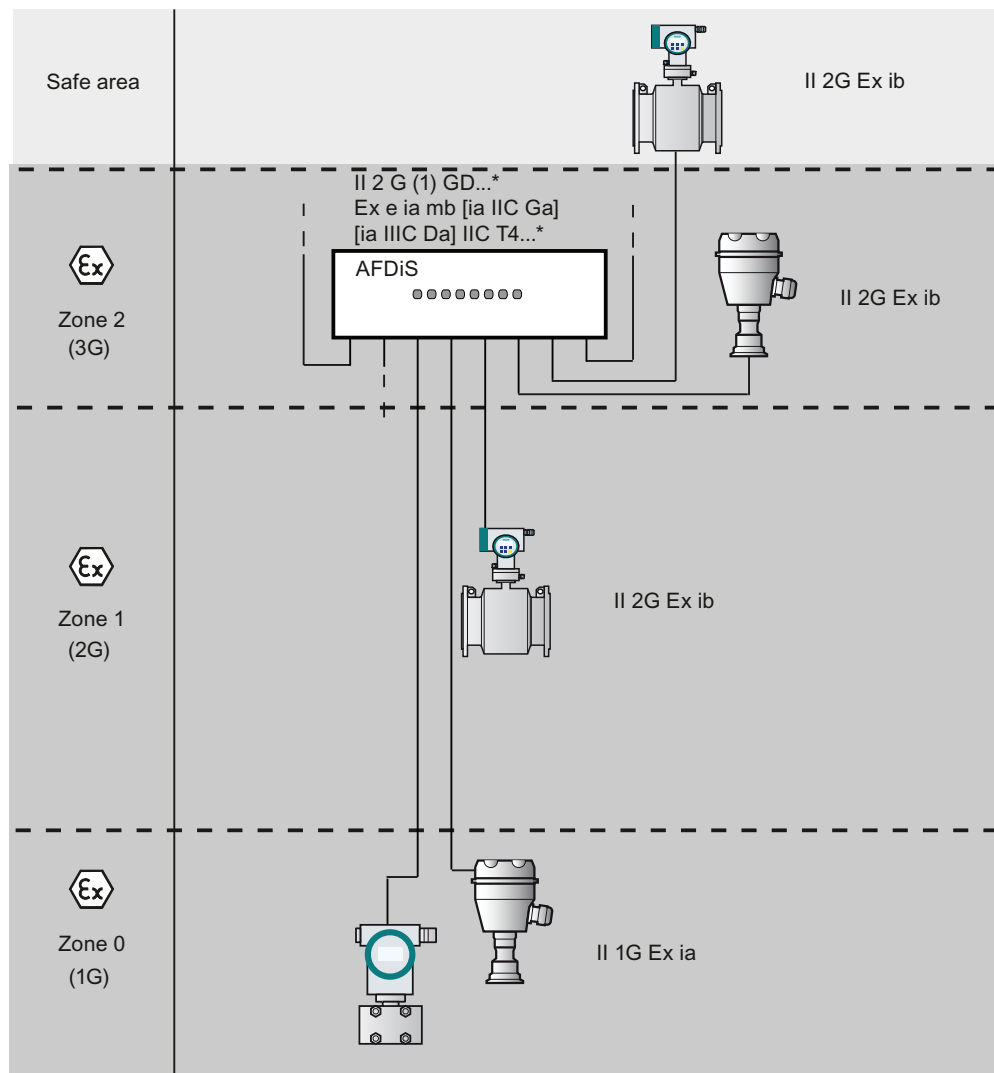
Additional information can be found in the ET 200iSP operating instructions on the Web (<http://support.automation.siemens.com/WW/view/en/28930789>).

4.1.4.3 AFDiS in Zone 2

AFDiS

The active field distributor AFDiS can also be installed in Zone 2. The intrinsically safe PA field devices (e.g. measuring devices, sensors, actuators) of device categories 1G, 2G, 3G for the Zones 0, 1 and 2 as well as device categories 1D, 2D, 3D for the Zones 20, 21 and 22 may be connected to the intrinsically safe connections.

Special conditions apply to device categories 3G/3D in Zones 2/22



* Complete designation: See Operating Instructions DP/PA coupler, Active field distributors, DP/PA-Link and Y-Link

Figure 4-7 AFDiS in Zone 2

Additional information

Please refer to the operating instructions DP/PA Coupler, Active Field Distributor, DP/PA Link and Y Link (<http://support.automation.siemens.com/WW/view/en/1142696>) for more information.

4.1.4.4 S7-300, ET 200M and ET 200S in Zone 2

Approval

The following approval is available for the S7-300 automation system, the ET 200M and ET 200S distributed I/O modules:

S7-300, ET 200M, ET 200S:

II 3 G Ex nA IIC T4, T5

This means that it refers to non-sparking equipment for installation in Zone 2.

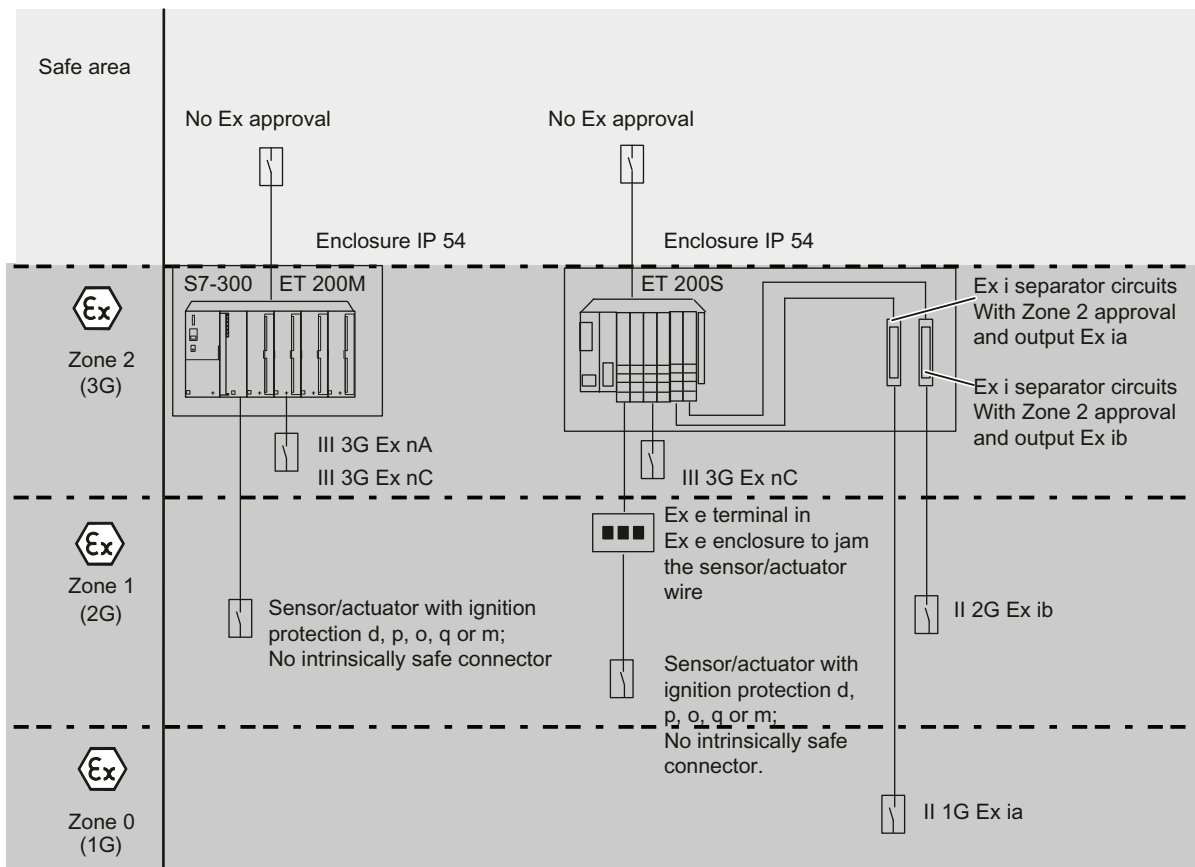


Figure 4-8 S7-300, ET 200M and ET 200S in Zone 2

Requirements for S7-300, ET 200M and ET 200S in Zone 2

- The station must be installed in a control cabinet or metal housing/enclosure. This must ensure at least degree of protection IP 54 (according to EN 60529). The environmental conditions in which the system is installed are to be taken into account here. A manufacturer declaration for zone 2 must be available for the enclosure (in accordance with EN 60079-15).
 - If a temperature > 70 °C is reached on the cable or at the cable entry of this housing/enclosure under operating conditions or if the temperature at the wire branch is >80 °C under operating conditions, the temperature properties of the cables must match the actual measured temperatures.
 - Measures must be implemented to ensure that the nominal voltage cannot be exceeded by more than 40% due to transients.
 - The inputs and outputs of the modules/submodules are non-intrinsically safe, which means that all devices, including switches etc., that are connected to the inputs and outputs of the modules/submodules in Zone 2 must be approved for a suitable ignition protection type.
 - If sensors/actuators are connected for Zone 1, they must have ignition protection type Ex d, p, o, q or m and be approved for Zone 1. They must not have intrinsically safe connections. These sensors/actuators can also be connected if the S7-300, ET 200M or ET 200S is located in the safe area. Follow the operating instructions for the sensor.
 - Ex i separator circuits with Zone 2 (3G) approval
 - and the Ex ia outputs enable the use of II 2G Ex ia sensors/actuators in Zone 0.
 - and the Ex ib outputs enable use of II 2G Ex ib sensors/actuators in Zone 1.
- It is taken for granted that S7-300, ET 200M and ET 200S with the Ex i separator circuits can also be located in the safe area. For the Ex i separator circuits, the requirements for the housing/enclosure must be complied with. See associated operating instructions.
- The utilized cable inlets must correspond to the required IP degree of protection and section 7.2 in accordance with EN 60079-15.
 - Ambient temperature range: 0 °C to 60 °C

Additional information

For additional requirements, see "*Special conditions for EC-type examination certificate*" or associated manual.

4.1.4.5 S7-300 Ex modules

Approval

The following approval is available for the S7-300 automation system (also Ex I/O modules), the ET 200M distributed I/O:

S7-300 Ex I/O modules:

II 3 (2) G Ex nA [ib] IIC T4

This means that non-sparking equipment is involved and this may be installed in Zone 2:

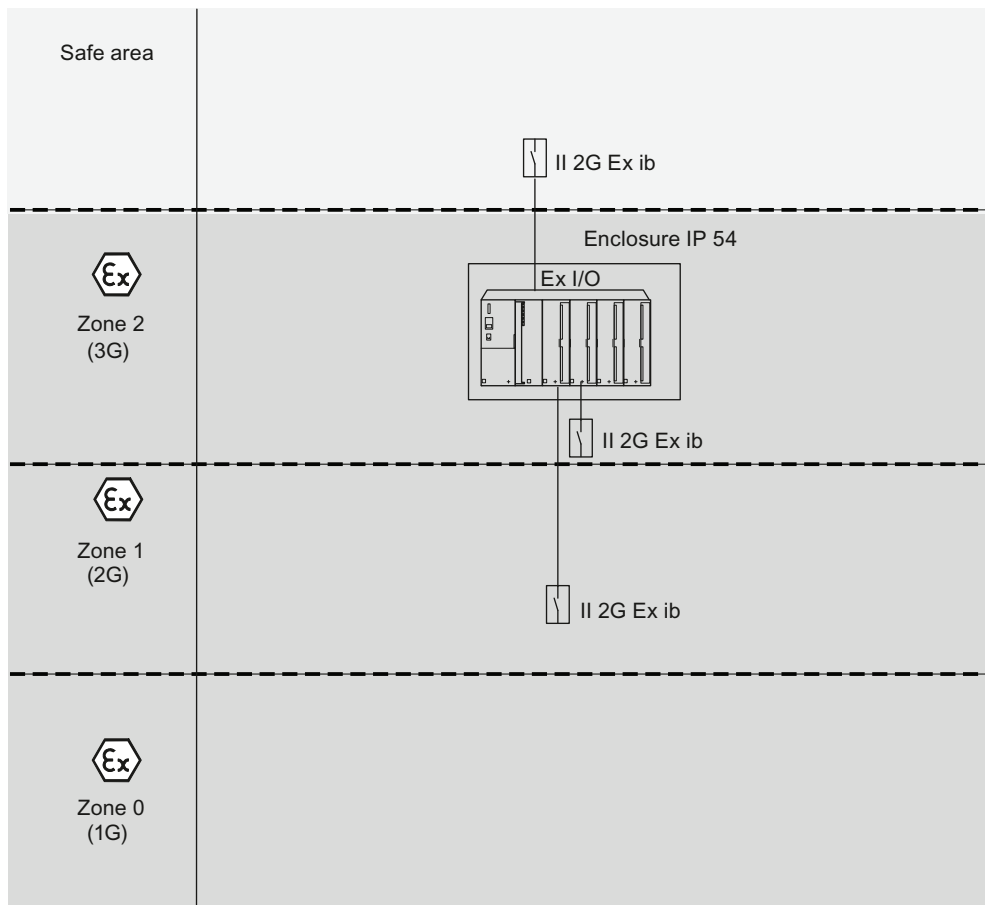


Figure 4-9 S7-300 Ex I/O modules in Zone 2

Requirements for S7-300 Ex I/O modules in Zone 2

- The station must be installed in a control cabinet or metal housing/enclosure. This must ensure at least degree of protection IP 54 (according to EN 60529). The environmental conditions in which the system is installed are to be taken into account here. A manufacturer declaration for zone 2 must be available for the enclosure (in accordance with EN 60079-15).
- If a temperature $> 70\text{ °C}$ is reached on the cable or at the cable entry of this housing/enclosure under operating conditions or if the temperature at the wire branch is $>80\text{ °C}$ under operating conditions, the temperature properties of the cables must match the actual measured temperatures.
- Measures must be implemented to ensure that the nominal voltage cannot be exceeded by more than 40% due to transients.
- During installation, the cable guide must be used or a minimum gap of 50 mm (thread dimension) must be provided between the intrinsically safe and non-intrinsically safe electrical circuits by inserting a partition, or the connection parts must have additional insulation (e.g. heat-shrinkable sleeve).

Additional information

For additional requirements, see "*Special conditions for EC-type examination certificate*" or associated manual.

4.1.5 Installing in Zone 22

4.1.5.1 Areas of Zone 22

Definition

Zone 22 includes areas in which an explosive atmosphere is only expected in the event of malfunctions, for example due to stirred-up dust. During normal operation there is no explosion hazard.

Equipment for Zone 22 must comply with category 3D, 2D or 1D and be fitted with a housing/enclosure of at least degree of protection IP 54.

4.1.5.2 ET 200iSP in Zone 22

ET 200iSP

The ET 200iS distributed I/O module is an item of electrical equipment for Zone 1. Intrinsically safe sensors, actuators and HART field devices of the device categories 1G, 2G, 3G for Zones 0,1 and 2 as well as device categories 1D, 2D, 3D for the Zones 20,21 and 22 can be connected to the ET 200iS. Special care as regards separation is required here.

Special conditions apply to device categories 3G/3D in Zones 2/22

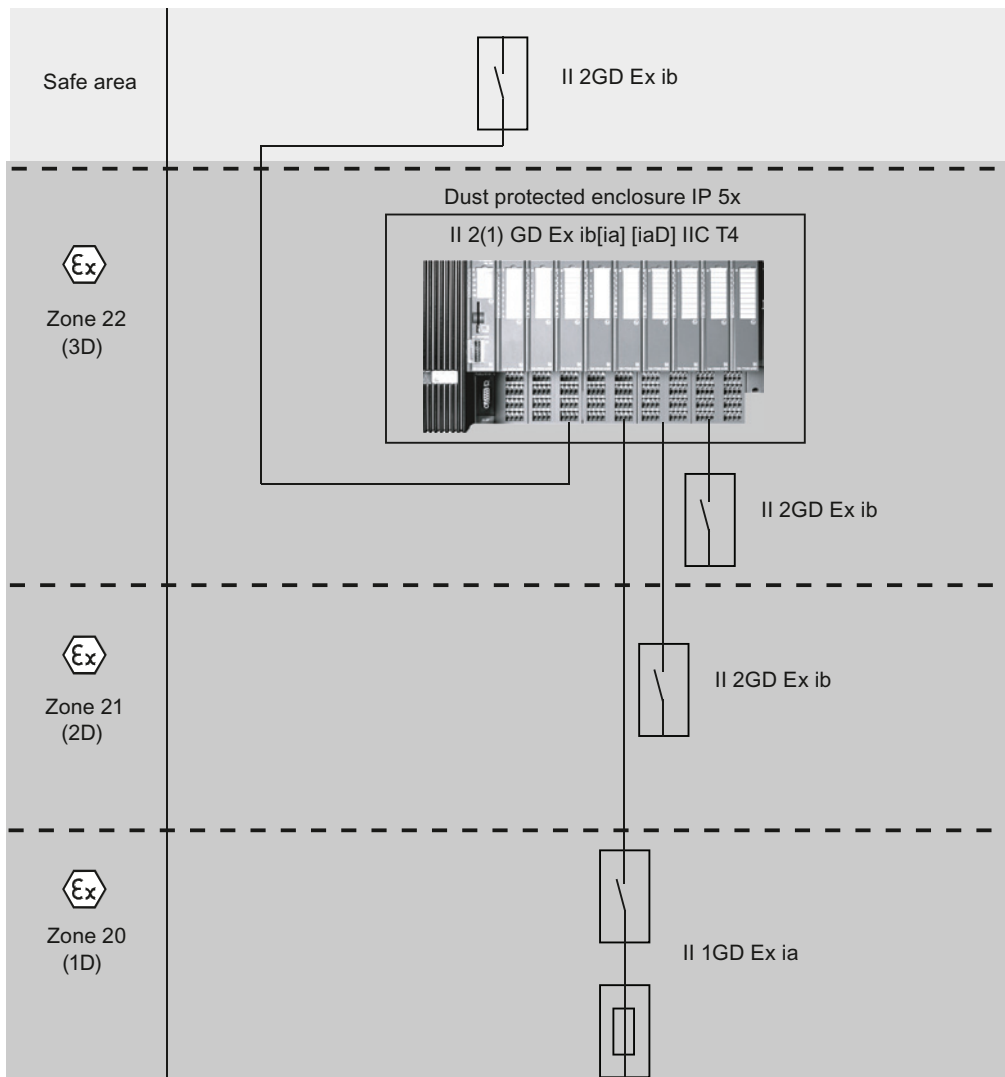


Figure 4-10 ET 200iSP in Zone 22

Requirements for ET 200iSP in Zone 22

- The PROFIBUS-DP must be separated with an RS 485-IS coupler.
The field bus isolating transformer must be installed in the safe area or in Zone 22 (category 3D).
- The PROFIBUS RS 485-IS must be connected with the RS 485-IS PROFIBUS bus connector (6ES7972-0DA60-0XA0). The terminating resistor is integrated in the above PROFIBUS bus connector.
- Normal cables (which are to be used as intrinsically safe wires) must be marked as Ex i bus cables.
- The ET 200iSP must be fitted in a housing/enclosure with degree of protection IP 5x in the event of non-conductive dust. Otherwise is housing/enclosure with at least degree of protection IP 6x is required.

Additional information

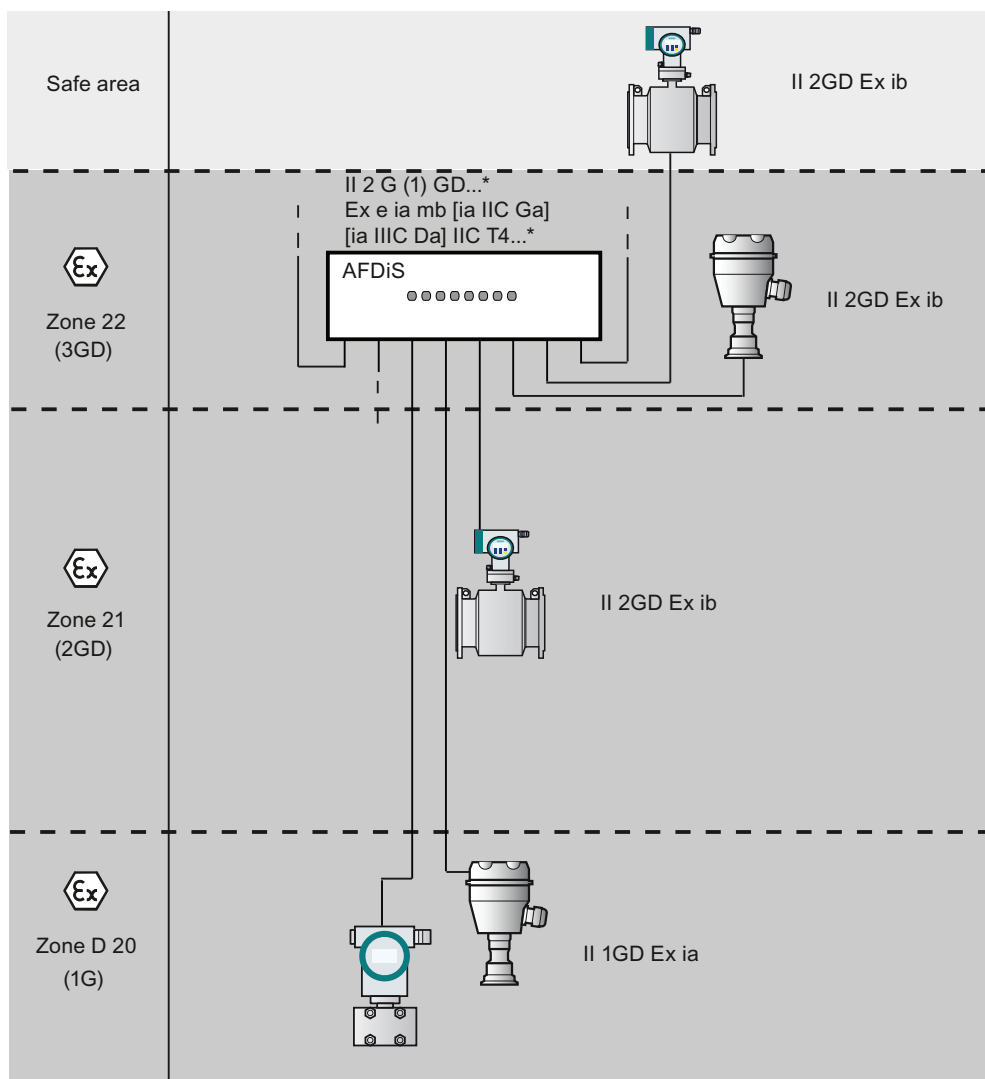
Additional information can be found in the ET 200iSP operating instructions on the Web.

4.1.5.3 AFDiS in Zone 22

AFDiS

The active field distributor AFDiS can also be installed in Zone 22. The intrinsically safe PA field devices (e.g. measuring devices, sensors, actuators) of device categories 1G, 2G, 3G for the Zones 0, 1 and 2 as well as device categories 1D, 2D, 3D for the Zones 20, 21 and 22 may be connected to the intrinsically safe connections.

Special conditions apply to device categories 3G/3D in Zones 2/22



* Complete designation: See Operating Instructions DP/PA coupler, Active field distributors, DP/PA-Link and Y-Link

Figure 4-11 AFDiS in Zone 22

Additional information

Please refer to the operating instructions DP/PA Coupler, Active Field Distributor, DP/PA Link and Y Link (<http://support.automation.siemens.com/WW/view/en/1142696>) for more information.

4.1.6 Installing in the USA and Canada

4.1.6.1 Installation and construction requirements

Installation regulations

Electrical equipment and systems for use in hazardous locations are covered by the National Electrical Code (NEC) in the USA, and the Canadian Electrical Code (CEC) in Canada. These assume the character of installation regulations for electrical systems in all areas and they refer to a number of further standards from other institutions that contain regulations for the installation and construction of suitable equipment.

The installation methods for the NEC's Zone concept largely correspond to those of the traditional Class/Division system. A new stipulation in the NEC 1996 is the use of metal-clad (MC) cables in addition to rigid conduits and mineral-insulated cables of Type MI in Class I, Division 1 or Zone 1.

Construction requirements

The regulations of the National Electrical Code and the Canadian Electrical Code specify which equipment or types of protection can be used in the individual hazardous areas.

In North America, different standards and regulations apply to the construction and testing of explosion-proof electrical systems and equipment. In the US, these are primarily the standards of Underwriters Laboratories Inc. (UL), Factory Mutual Research Corporation (FM) and the International Society for Measurement and Control (ISA). In Canada, it is the Canadian Standards Association (CSA).

4.2 Bus Systems in the Ex Area

4.2.1 PROFIBUS

Overview

PROFIBUS is the uniform, open digital communication system for all areas of application in production and process automation.

- PROFIBUS PA was specified for process automation. It meets the requirements of the chemical industry. PROFIBUS PA is becoming increasingly important for the connection between automation and process control systems and field devices such as transmitters for pressure, temperature and filling level.
- PROFIBUS RS 485-IS provides other possibilities for the PROFIBUS for application-oriented solutions. Fast processes and the transfer of large data volumes become possible with the RS 485 in process automation.
- Fieldbus Foundation (FF bus) is specialized in the field of measurement and control technology in applications of chemical and process engineering and is used mainly in the USA.

4.2.2 Intrinsically safe field bus PROFIBUS PA

Characteristics

PROFIBUS PA is the version of the PROFIBUS for applications in Process Automation and has been specially optimized for the requirements of process engineering. Major properties are above all the interchangeability of devices of different manufacturers, two-wire technology and the possibility of use in explosion-endangered areas.

PROFIBUS PA is standardized in EN 61158-2. The physical layer also corresponds to the international standard IEC 61158-2. The most important properties are shown in the following table.

Technical Data

Feature	Physical layer complying with IEC 61158-2, variant H1
Transmission rate	31.25 kbps
Topology	Line or tree
Power supply	DC supply via bus cables
Explosion protection	yes, by intrinsically safe design
Number of devices	max. 32 (not Ex) approx. 9 with gas group IIC (Ex) approx. 23 with gas group IIB (Ex)
max. cable length	1900 m
max. track length	120 m per stub
Redundancy	Possible

Operating principle

An important step for practical use of the PROFIBUS-PA in explosion-endangered areas was the development of the FISCO model (**F**ieldbus **I**ntrinsically **S**afe **C**oncept) by the Federal Physical Technical Institute. This was commissioned by various companies, including Siemens AG. It stipulates that a bus wire may only be supplied from one device, the segment coupler. All other bus nodes (field devices, bus termination) must be passive and only take up power. The mean basic current taken up is 10 mA. The signal amplitudes of the digitally modulated basic current are 19 and 1 mA.

In the meantime, the FISCO model has also become part of the explosion protection standards. It is internationally standardized as IEC 60079-27, in Europe as EN 60079-27.

Rules for the layout of an intrinsically safe PROFIBUS PA segment in explosion-endangered areas

Important for the user are the rules for project engineering and installation of a PROFIBUS PA system for applications in explosion-endangered areas, as well as the associated advantages in interconnection of the individual devices. Particularly simple interconnection rules apply for PROFIBUS devices that are certified as complying with the FISCO model in accordance with standard IEC 60079-27. The type plate should bear the description "FISCO Supply" for a bus supply device (segment coupler) or "FISCO Device" for a bus node (e.g. field device). In this case, the devices can be interconnected without any other calculations with regard to the explosion protection requirements.

Cable types that correspond to the FISCO specification should be used as bus cables so that only the maximum permitted lengths specified there must be complied with. If other cables are used, a special verification of intrinsic safety with the given cable parameters and cable lengths must be kept. No additional capacitances or inductances (except a certified bus termination) may be connected in the bus circuit.

Cable parameters complying with the FISCO specification

Parameters	Ex ia IIC	Ex ib IIC / IIB	Ex ic IIC / IIB
Loop resistance	15 ... 150 ohm/km	15 ... 150 ohm/km	
Inductance per unit length	0,4 ... 1 mH/km	0.4 ... 1 mH/km	
Capacitance per unit length	45 ... 200 nF/km	45 ... 200 nF/km	
Stub length	= 60 m	= 60 m	
Cable length	= 1 km	= 5 km	

Intrinsically safe FISCO devices are to be configured in line with the standard in such a way that they meet the requirements for gas group IIC and IIB. This means they can be supplied by any segment couplers. The certified type of the supplying coupler as IIB or IIC device then determines the type of PROFIBUS segment and thus also the permitted gas group of the application.

The number of devices permitted on a bus wire is calculated from the total current of all (passive) bus nodes and the maximum current of the supply device/segment coupler used; it can thus produce different values for various applications.

Bus termination

A PROFIBUS wire must have a bus termination on both sides to prevent signal reflections on the cable. As a rule, a bus termination is already integrated in the segment coupler, which means that a bus termination element is only required at the other end of the wire. For Ex applications, only an Ex-certified termination element may be used.

A bus termination according to FISCO consists of an RC series circuit with the following parameters:

- Resistance R: 90 ... 100 ohm
- Capacitance C: 0 ... 2.2 μ F

Shielding and grounding

The structure of PROFIBUS PA systems is to be set up with shielded cables to ensure uninterrupted operation in accordance with EMC requirements. To achieve this, a continuous connection of all cable shields with the ground connections of the devices and the usually metallic housing/enclosure is necessary. Housings/enclosures of field devices and bus couplers can be connected with the local ground during operation for functional and/or safety reasons. In explosion-endangered areas, however, multiple grounding is only permitted if there is optimized equipotential bonding between the explosion-endangered area and non-explosion-endangered area. If this is not ensured (e.g. in the case of bus nodes spatially spread across a wide area), the bus may only be grounded at one position to avoid dangerous compensating current in ground loops. Here, it is convenient to connect the cable shields only in the explosion-endangered area with the local ground (equipotential bonding) and to make the grounding in the non-explosion-endangered area capacitive (see figure below).

The following requirements must be met by the decoupling capacitor:

- Fixed dielectric (e.g. ceramic)
- C = 10 nF
- Testing voltage = 750 VAC / 1100 VDC

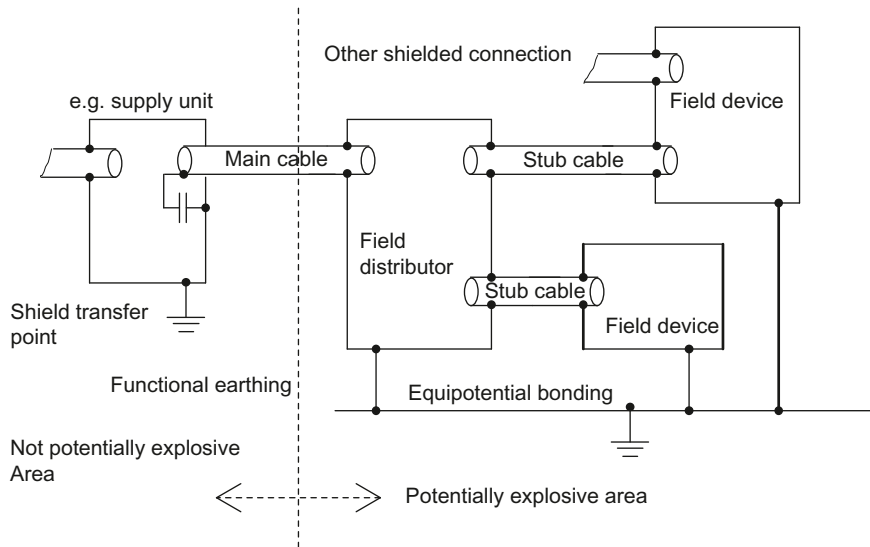


Figure 4-12 Grounding of PROFIBUS PA

4.2.3 PROFIBUS RS 485-IS

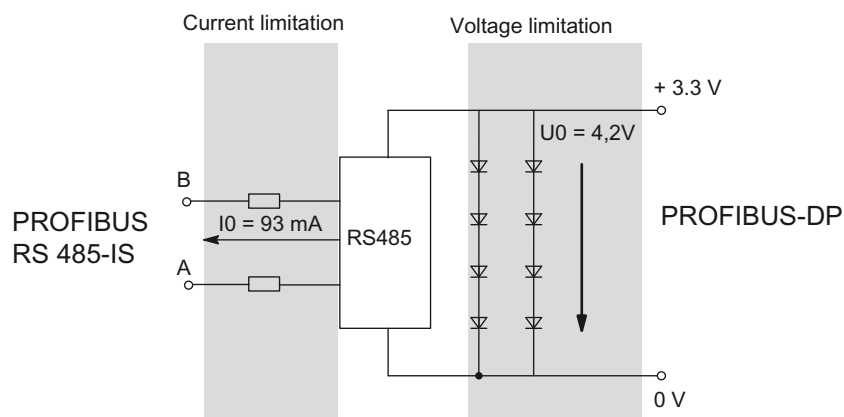
Characteristics

- Fast processes and the transfer of large data volumes, as the PROFIBUS RS 485-IS supports baud rates of up to 1.5 MB.
- Up to 32 nodes can be connected to a PROFIBUS RS 485-IS segment.
- All participants in the PROFIBUS RS 485-IS segment are active nodes.
- PROFIBUS RS 485-IS is easy to integrate in an existing PROFIBUS-DP network. The existing PROFIBUS structure can still be used (via the field bus isolating transformer).

Operating principle

The PROFIBUS-DP is implemented in the PROFIBUS RS 485-IS by the field bus isolating transformer RS 485-IS coupler (6ES7972-0AC80-0XA0). It restricts voltage and current (safety engineering). This ensures that minimum ignition energy does not occur in electrical circuits in the event of a fault.

The following illustration shows the circuit diagram of the RS 485-IS coupler.



Circuit diagram of the RS 485-IS coupler

Ex-i specifications of the RS 485-IS coupler	
U_0	4.2 V
I_0	93 mA
P_0	100 mW
U_i	$\pm 4.2 \text{ V}$
L_i	0
C_i	0
U_M	AC 250 V

Rules for structure

- The RS 485-IS coupler (6ES7972-0AC80-0XA0) can be installed in the safe area or in Zone 2 (category 3G/3D).
- The PROFIBUS RS 485-IS must be terminated with an active terminating resistor.
- Cables complying with IEC 61158/61784, cable type A, can be connected to the PROFIBUS RS 485-IS.
- The maximum cable length (type A) depends on the baud rate

Baud rate kbps	Length of the bus segment in m at
≤ 187.5	1000
500	400
1500	200

- In addition, special conditions from the EC-type examination certificate are to be observed. These concern both the RS 485-IS coupler itself and the nodes of the PROFIBUS RS 485-IS.

Bus termination

The changed electrical specification distinguishes the bus termination of the RS 485-IS from the normal PROFIBUS-DP. The changed resistance values and changed arrangement of the bus termination in the case of integration in RS 485-IS nodes or in external bus terminating resistors are to be complied with.

The supply voltage of the bus termination is reduced due to the explosion protection. The principle of the bus termination shown in the following illustration is configured for a nominal supply voltage of U+ 3.3 V.

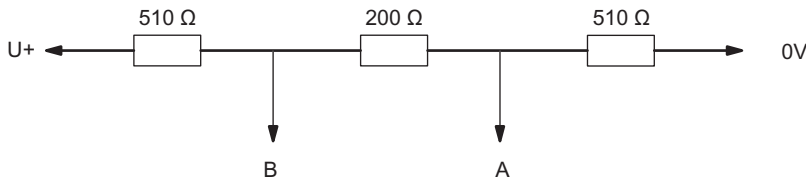


Figure 4-13 RS 485-IS bus termination

Equipotential bonding

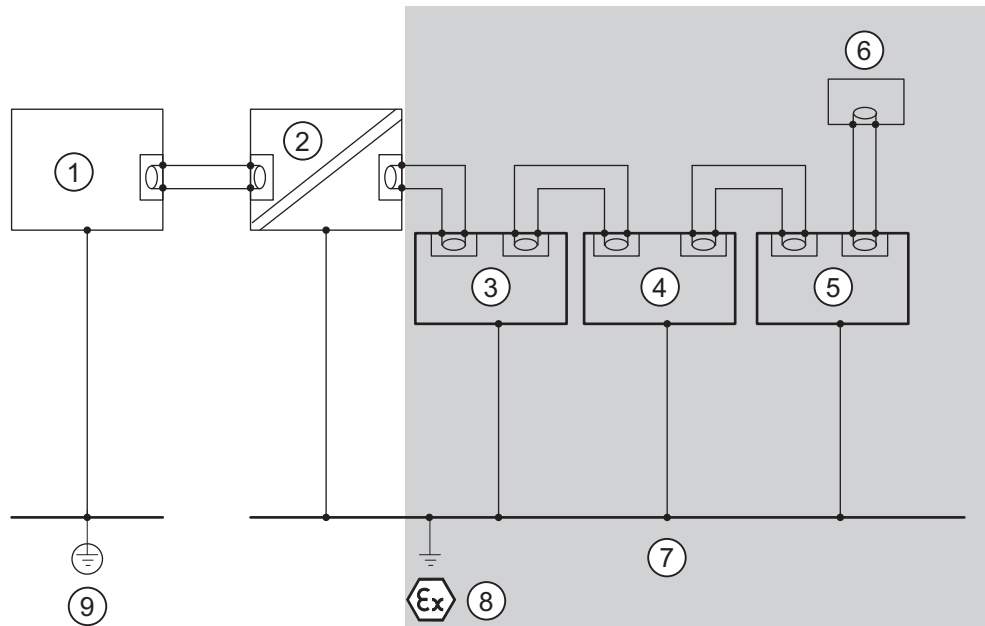


Figure 4-14 Equipotential bonding in the explosion-endangered area

Legend for illustration:

- ① Automation system
- ② RS 485-IS coupler (field bus isolating transformer)
- ③-⑤ Node
- ⑥ RS 485 bus termination resistor (integrated in PROFIBUS RS 485-IS terminal plug) (6ES7972-0DA60-0XA0)
- ⑦ Equipotential bonding
- ⑧ Explosion-endangered area
- ⑨ Safe area

Rule for equipotential bonding

Equipotential bonding is compulsory in the explosion-endangered area according to EN 60079-14. The measures listed there (inclusion of protective conductors, protective tubes, metallic cable shields, cable armoring and metallic construction parts) can be supplemented by the following measures:

- Routing the bus cable on metallic cable beds
- Inclusion of the cable beds in the equipotential bonding system
- Safe, current-bearing and high-frequency (low-impedance) interconnection of the cable beds and to metallic construction parts.

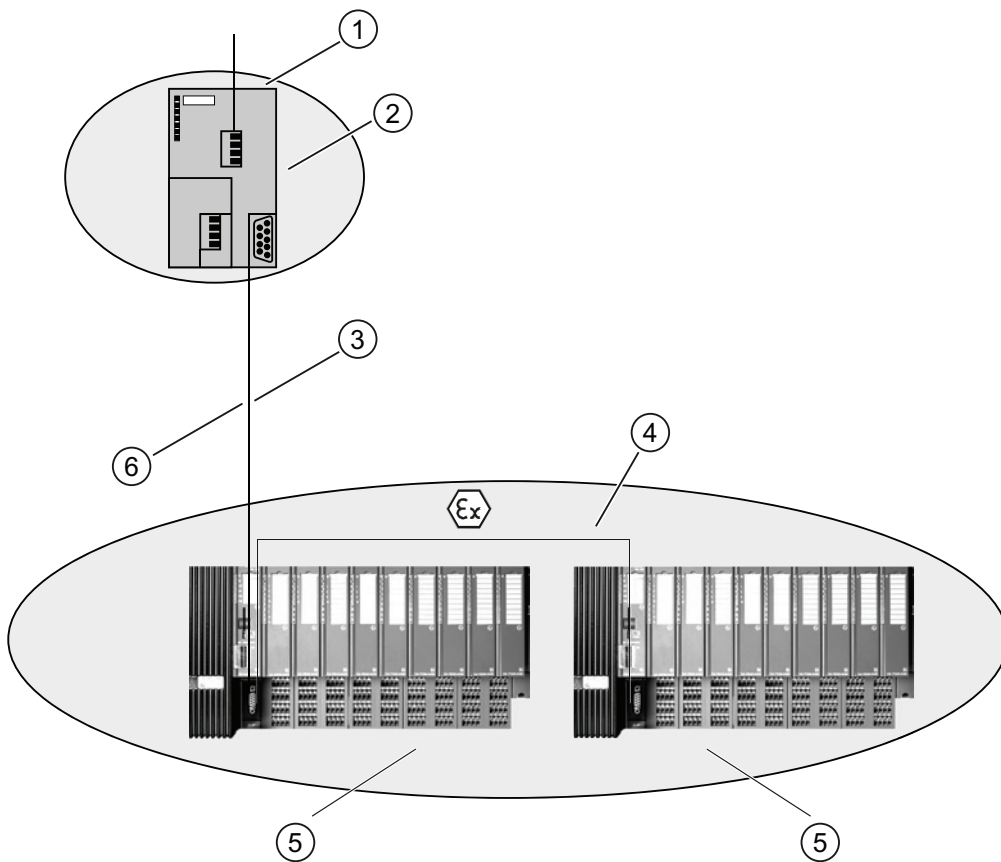
Use of the RS 485-IS coupler with ET 200iSP

The ET 200iS distributed I/O module is connected to the PROFIBUS RS 485-IS.

Please note the following points when using the RS 485-IS coupler with the ET 200iSP:

- A maximum of 31 ET 200iSP modules can be connected to the PROFIBUS RS 485-IS segment.
- The maximum length of the PROFIBUS RS 485-IS coupler (total line) is 1000 m.

More information can be found in the documentation of the RS 485-IS coupler and the ET 200iSP.



PROFIBUS RS 485-IS segment

- ① PROFIBUS-DP
- ② RS 485-IS coupler (field bus isolating transformer)
- ③ PROFIBUS-DP bus line
- ④ Explosion-endangered area: Zone 1
- ⑤ Enclosure degree of protection Ex e
- ⑥ PROFIBUS RS 485-IS

Additional information

You will find more information

- *PROFIBUS RS 485-IS User and Installation Guideline Draft Profibus Guideline* on the Internet (<http://www.profibus.com/>).
- *Installation regulations EN 60079-14*

4.2.4 Fieldbus Foundation (FF bus)

Characteristics

The FF bus was developed in the USA as a counterpart to the European PROFIBUS. Whereas PROFIBUS in its various versions of PROFIBUS-DP and PROFIBUS PA covers broad areas of automation engineering, the FF bus is specialized in the area of measurement and control technology in applications for chemical and process engineering. The protocols of both bus systems are different and also the implemented functions are different on the two systems.

Operating principle

For explosion-protected versions the FF bus on the physical layer also builds on the FISCO model, i.e. the electrical interface on these devices is identical to that of PROFIBUS PA devices. As far as approval is concerned, this means a major simplification, as the same standards with regard to explosion protection can be applied in the USA as in Europe.

Repair and maintenance

5.1 Operation, maintenance, malfunctions and repair of electrical systems

5.1.1 Operation and maintenance

Operator's duties

According to (German) work safety regulations, the operation and maintenance of electrical systems in explosion-endangered areas are the sole responsibility of the operator. This means that the operator must keep the system in proper working order, operate it properly and continuously monitor it. The operator must also perform the necessary maintenance and repair work immediately. The operator is responsible for ensuring that the required safety measures are implemented.

Systems that require monitoring

Systems in explosion-endangered areas are classified as systems requiring monitoring in accordance with §1 Par. 2 Clause 1 No. 3 of the work safety regulations.

A system requiring monitoring may only be commissioned for the first time or after a major change if the system has been inspected by an approved testing body (see work safety ordinance) to ensure that it is in proper working order, taking account of the intended method of operation. The inspection concerns the assembly, installation, setup conditions and reliable function. In consultation with the approval body, this inspection can also be carried out by a suitably qualified person.

Inspection

It is taken for granted that the generally recognized rules for engineering and in particular electrical engineering are to be complied with for proper operation.

To maintain a system in perfect condition, the (German) work safety regulation prescribes a check of a system at a maximum interval of **3 years**.

Note

The supervisory authority can stipulate additional monitoring measures in individual cases.

5.1.2 Malfunction

Report

If an explosion occurs as a result of operation of the electrical system, the operator must report this incident to the supervisory authority. The supervisory authority can then demand an investigation of the cause of the explosion and the state of the system. As a consequence, additional protective measures can be necessary to prevent further malfunctions.

5.1.3 Repair

Protective measures

Repair work is only permitted in compliance with the prescribed protective measures for explosion-endangered areas. It is prohibited, for example, to work on live electrical equipment in explosion-endangered areas. Work on intrinsically safe electrical circuits is an exception here.

The work may only be carried out by specially qualified personnel.

Once the repair work has been completed, normal operation may only be resumed after the efficiency of the required explosion protection measures has been ensured. The supervisory authority or suitably qualified person must issue a certificate or apply their test symbol to the equipment.

Alternatively, the system requiring monitoring can be inspected by the manufacturer following repair. The manufacturer confirms that the system requiring monitoring corresponds to the major characteristics for explosion protection stipulated by the work safety ordinance.

The following table describes examples of a few of the most important tasks in the explosion-endangered area. If there is a 'fire certificate', more advanced work can also be performed.

Notes for work on explosion-protected electrical equipment

All work must be conducted according to EN 60079-17 and EN 60079-19.

Type of work to be carried out	Ignition protection type of the equipment	Work in explosion-endangered areas		
		Zone 0 (EPL Ga)	Zone 1 (EPL Gb)	Zone 2 (EPL Gc)
Tools	Valid for all types of protection	Permitted with non-sparking tool (e.g., copper-beryllium)	The only tools permitted are those that do not produce sparks or high temperatures during operation.	All work is permitted except for when a sudden explosion danger occurs
Mechanical work (drilling, hammering, grinding, separating)		Not permitted	Spark formation and non-permissible heating are forbidden	All work is permitted except for when a sudden explosion danger occurs
Opening the housing/enclosure	Ex ia with approval for Zone 0	Not permitted	Permitted	Permitted
Connecting and disconnecting cables				
Current, voltage, and resistance measurement		Permitted with measuring devices that are certified for Zone 0; note inductances and capacitances!	Permitted with equipment that are certified at least for Zone 1.	Permitted
Opening the housing/enclosure	Ex ib	not applicable	Permitted	All work is permitted except for when a sudden explosion danger occurs
Connecting and disconnecting cables				
Current, voltage, and resistance measurement			Permitted with certified equipment	Permitted
Opening the housing/enclosure	Ex ic (nL)	not applicable	not applicable	Permitted
Connecting and disconnecting cables				
Current, voltage, and resistance measurement				Permitted with certified equipment
Opening the housing/enclosure	Ex e	not applicable	Only permitted in de-energized state (for exception, see voltage measurement)	All work is permitted except for when a sudden explosion danger occurs
Connecting and disconnecting cables			Only permitted in de-energized state	
Current, voltage, and resistance measurement			Only voltage measurement is permitted with certified equipment (short-time measurement); other measurements only in accordance with Ex "e" installation	

		Work in explosion-endangered areas		
Opening the housing/enclosure	Ex p	Not permitted	Only permitted in de-energized state and taking into account the specified time span for the equipment -	All work is permitted except for when a sudden explosion danger occurs
Connecting and disconnecting cables			Only permitted in de-energized state	
Measuring current, voltage, and resistance			Only permitted if certified test equipment are connected and EX "p" type of protection is ensured.	
Opening the housing/enclosure	Ex d	Not permitted	Only permitted in de-energized state and taking into account the specified time span for the equipment -	All work is permitted except for when a sudden explosion danger occurs
Connecting and disconnecting cables			Only permitted in de-energized state	
Measuring current, voltage, and resistance			Work not possible because it requires the casing to be open. Exception: With separate terminal compartment in Ex "e".	
Opening the housing/enclosure	Ex nA	not applicable	not applicable	All work is permitted except for when a sudden explosion danger occurs
Connecting and disconnecting cables				
Current, voltage, and resistance measurement				

Appendix

A.1 Safety Specifications

Safety specifications for flammable gases and vapors

The following table shows the ignition temperatures and allocation to the relevant temperature classes and explosion groups for different materials.

Material designation	Ignition temperature in °C	Temperature class	Explosion group
Dichlorethane	440	T 2	II A
Acetyl aldehyde	140	T 4	II A
Acetone	540	T 1	II A
Acetylene	305	T 2	II C
Ammonia	630	T 1	II A
Petrol fuel Boiling start < 135 °C	220 to 300	T 3	II A
Benzene (pure)	555	T 1	II A
Cyclohexanone	430	T 2	II A
Diesel fuels ¹	220 to 300	T 3	II A
Jet fuels	220 to 300	T 3	II A
Acetic acid	485	T 1	II A
Acetic anhydride	330	T 2	II A
Ethane	515	T 1	II A
Ethyl acetate	460	T 1	II A
Ethyl alcohol	425	T 2	II A / II B
Ethyl chloride	510	T 1	II A
Ethylene	425	T 2	II A
Ethylene oxide	440 (self-disintegration)	T 1	II A
Ethyl ether	170	T 4	II A
Ethyl glycol	235	T 3	II A
Heating oil EL	220 to 300	T 3	II A
Heating oil L ¹	220 to 300	T 3	II A
Heating oils M and S	220 to 300	T 3	II A
i-amyl acetate	380	T 2	II A
Carbon oxide	605	T 1	II A / II B
Methane	595 (650)	T 1	II A
Methanol	455	T 1	II A
Methyl chloride	625	T 1	II A
Naphthalene	540	T 1	II A

Material designation	Ignition temperature in °C	Temperature class	Explosion group
n-butane	365	T 2	II A
n-butyl alcohol	340	T 2	II A
n-hexane	240	T 3	II A
n-propyl alcohol	405	T 2	-
Oleic acid	360 (self-disintegration)	T 2	-
Phenol	595	T 1	II A
Propane	470	T 1	II A
Carbon bisulphide	95	T 6	II C
Carbon bisulphide	270	T 3	II B
Special petrol Initial boiling point < 135 °C	220 to 300	T 3	II A
Town gas (lighting gas)	560	T 1	II B
Tetraline (Tetrahydronaphthalene)	425	T 2	-
Toluene	535	T 1	II A
Hydrogen	560	T 1	II C

¹ These substances are not explosive at an ambient temperature of up to 40 °C.

Ignition and smoldering temperature of dusts from natural products

Name of solid	Ignition temperature [°C]	Smoldering temperature [°C]
Cotton	560	350
Sawdust	400	300
Animal feed	520	295
Corn	420	290
Soy	500	245
Tobacco	450	300
Starch	440	290

Ignition and smoldering temperature of technical chemical products

Name of solid	Ignition temperature [°C]	Smoldering temperature [°C]
Polyester	560	-
Rubber	570	-
Detergent	330	-
Polyethylene	360	-
Polyvinyl acetate	500	340
Aluminum	530	280
Agnesium	610	410
Sulphur	280	280

A.2 Verification of intrinsic safety

Intrinsically safe electrical equipment

Table A- 1 Intrinsically safe electrical equipment

Operating unit					
Room no.					
System no.					
System name					
Device name					
Component no.					
Manufacturer					
Type					
Serial no., factory no.					
Approval certificate					
Ignition protection type					
Zone at installation site					
Long cable					
Maximum values of the supplying output	U_o	I_o	P_o	L_o	C_o
	[V]	[mA]	[mW]	[mH]	[nF]
Maximum value of the (passive) input	U_i	I_i	P_i	L_i	C_i
	[V]	[mA]	[mW]	[mH]	[nF]

Comparison of the safety maximum values

Maximum values of the supplying output		Maximum value of the (passive) input	okay?
$U_o =$	\leq	$U_i =$	
$I_o =$	\leq	$I_i =$	
$P_o =$	\leq	$P_i =$	
$L_o =$	\geq	$L_i + L_{cable} =$	
$C_o =$	\geq	$C_i + C_{cable} =$	
$L_o / R_o =$	\geq	$L_{cable} / R_{cable} (L_i \neq 0) =$	

Regulation for calculating the maximum cable length

Table A- 2 Regulation for calculating cable length

Maximum values of the supplying output		Maximum values of the (passive) input incl. cable
L_o	\geq	$L_i + L_{cable}$
C_o	\geq	$C_i + C_{cable}$
L_o / R_o	\geq	$L_{cable} / R_{cable} (L_i \neq 0)$

Calculation of the maximum cable length

Table A- 3 Calculation of the maximum cable length

	L_o [mH]		L_i [mH] (cell)		L [mH] (cable)	max. permitted cable length at $L'=1$ uH/m
Group II B		-		=		
Group II C		-		=		

	C_o [nF]		C_i [nF] (cell)		C [nF] (cable)	max. permitted cable length at $C'= 200$ pF/m	max. permitted cable length at $C'= 100$ pF/m
Group II B		-		=			
Group II C		-		=			

A.3 Equipment in areas with dust clouds

Calculation of the maximum surface temperature with dust clouds

A safety clearance between the surface temperature of electrical equipment and the lowest ignition temperature of the dust present in the zone must be maintained for use of equipment in Zones 20, 21 or 22. The ignition temperature of a dust cloud is calculated with specified procedures in accordance with EN 50281-2-1 or IEC 61241-2-1.

The following rule must be applied regardless of the zone in which the equipment is used.

Definition

The maximum surface temperature of the equipment must not exceed two thirds of the ignition temperature (in °C) of the dust/air mixture.

$T_{\max} = 2/3 T_{Cl}$ Here T_{Cl} is the ignition temperature of the dust cloud, in °C

Example

The maximum surface temperature of a saw is calculated as an example. The ignition temperature of sawdust present in the area as a dust cloud is 400 °C.

The following maximum surface temperature is calculated as follows:

$$T_{\max} = 2/3 * 400^{\circ}\text{C} = 266.66^{\circ}\text{C}$$

Therefore, the surface temperature must not exceed a value of 266 °C.

A.4 Equipment in areas with dust layers

Calculation of the maximum surface temperature with dust layers

A safety clearance between the surface temperature of electrical equipment and the smoldering temperature of a dust layer present in the zone must be maintained for use of equipment in Zones 20, 21 or 22. The smoldering temperature of a dust layer of up to 5 mm thick is calculated with the specified procedure in accordance with EN 61241-0.

The following rule must be applied regardless of the zone in which the equipment is used.

Definition

The maximum surface temperature of the equipment in accordance with this test procedure must not exceed a value that is 75 K under the smoldering temperature of the dust layer of up to 5 mm thick.

$T_{\max} = T_{5\text{ mm}} - 75\text{ K}$ Here $T_{5\text{ mm}}$ is the smoldering temperature of a 5 mm dust layer in °C

Example

The maximum surface temperature of an item of equipment in operation under a dust layer of anthracite is calculated as an example.

The smoldering temperature of anthracite is 280 °C for a dust layer of 5 mm.

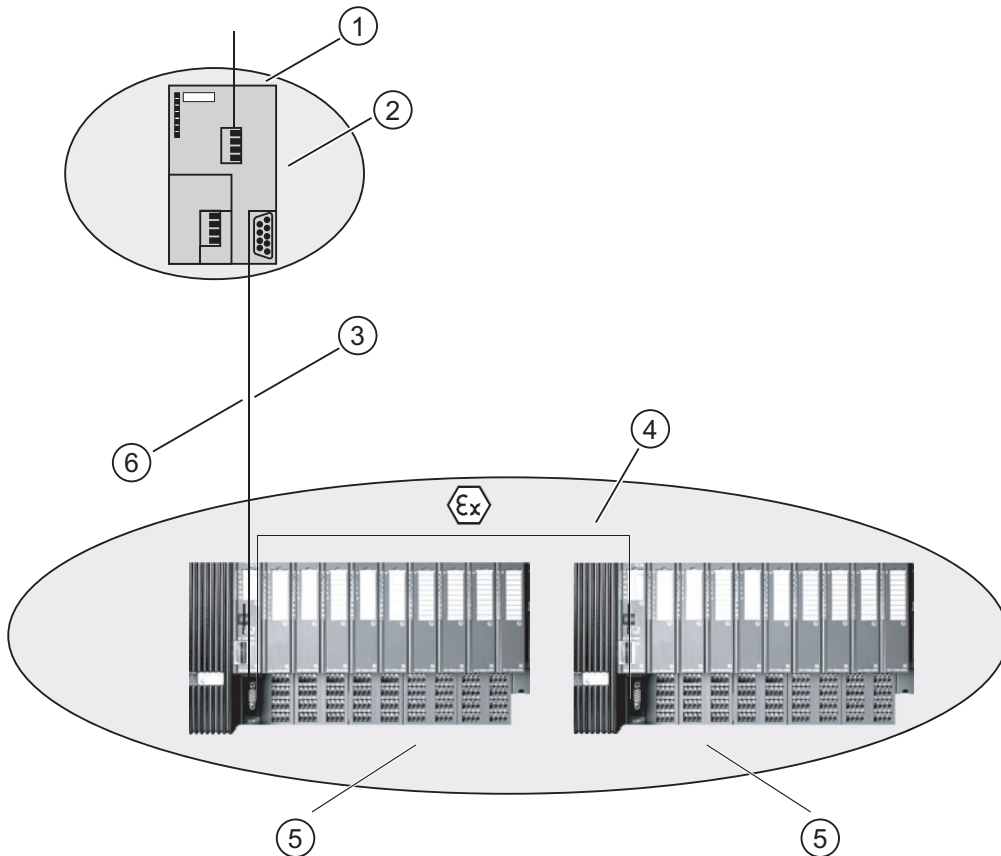
The following maximum surface temperature is calculated as follows:

$$T_{\max} = 280^{\circ}\text{C} - 75^{\circ}\text{C} = 205^{\circ}\text{C}$$

Therefore, the surface temperature must not exceed a value of 205°C.

Example

Dust deposits to a thickness of 50 mm are permitted if there is sufficient heat dissipation in the other directions. In these cases the smoldering temperature of the material can be taken from the diagram. The value depends on the thickness of the layer.



For example, if a deposit of anthracite dust 35 mm thick is expected, the smoldering temperature as per the above diagram is 220 °C. The maximum surface temperature of the equipment is calculated with the following values:

$$T_{\max} = 220^{\circ}\text{C} - 75^{\circ}\text{C} = 145^{\circ}\text{C}$$

If the dust layer is 35 mm thick, the surface temperature of the equipment must not exceed 145°C.

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Glossary

Adiabatic compression

With compression, no heat exchange with the environment takes place.

Electrical equipment

This refers to system components that in whole or in part serve to apply electrical energy. These include, among other things, system components for generation, forwarding, distributing, storing, measuring, regulating, converting and consuming electrical energy. Electrical systems are formed by interconnecting electrical equipment.

Explosion

An **explosion** is defined as an exothermic reaction (releasing heat) in explosive mixtures or in an explosive atmosphere. This reaction runs because of the temperature rise as a result of the released heat at high speed (scale of m/s) and with sudden pressure and explosive effect.

Crackle, on the other hand, is when the speed of the spread of the reaction is in the cm/s range. If the reaction runs with the highest pressure and explosive effect and at a speed of several km/s, it is referred to as **detonation**.

Explosion-endangered area

This is an area in which there is an explosion hazard or where due to local and operating conditions a dangerous explosive atmosphere can occur.

Fire certificate

Verification that at the time of work there is no explosive atmosphere at the work location.

Inert gas

A gas that does not form chemical compounds, e.g. argon.

Oxidising agent

Substance that draws electrons from the reaction partner (oxidises) and is reduced itself.

Vapor-proof housing/enclosure

No vapors, gases or mists can penetrate this housing/enclosure.

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