HAZARDOUS AREAS TECHNICAL GUIDE

When good enough just isn't good enough

Weidmüller

HAZARDOUS AREAS TECHNICAL GUIDE

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SECTION 1 INTRODUCTION

Weidmüller is the leading manufacturer of components for electrical connection technology. We develop, produce and sell a wide spectrum of products from terminal blocks through connectors to relay sockets and I/O sockets for every type of application.
The Weidmüller group is strongly represented worldwide with manufacturing sites, sales companies and representatives in 70 countries all over the world.

Within the European Union we offer products designed and manufactured to the European standards for Electrical Apparatus for Potentially Explosive Atmospheres, the new ATEX directive, already in use since 1996 and mandatory throughout EU countries since July 2003.
Weidmüller offers the most comprehensive range of ATEX certified enclosures, rail mounted terminals and accessories.
In addition to our leading manufacturing competence in the precision mechanics sector we offer a market and customer orientated portfolio of products for our target groups in industrial and process technology as well as transportation engineering.

This publication provides a brief overview of the essential aspects of explosion protection. Ultimately, safety in a potentially explosive atmosphere is a team effort. Manufacturers have a responsibility to ensure only safe equipment is placed on the market. Installers must follow the instructions provided and use the equipment only for its intended purpose. Finally, the user has a duty to inspect and maintain the equipment in a safe working order. The directives, and national and international standards provide a basis for a safer future.

SECTION 2
DIRECTIVES, STANDARDS AND REGULATIONS

2.1 EC directives

Free movement of goods is a cornerstone of the single market. The mechanisms in place to achieve this aim are based on prevention of new barriers to trade, mutual recognition and technical harmonisation.

The 'old' directive was restricted to electrical equipment for hazardous areas, and was strictly based on technical standards regulated by test authorities. When technical progress allowed for new product development, the lack of standards made it basically impossible to obtain certification.

The 'new approach' directives are based on the following principles:

- *Harmonisation is limited to Essential Health and Safety Requirements (EHSR)*
- *Only products fulfilling the EHSR may be placed on the market and put into service*
- *Harmonised standards which are transposed into national standards, are presumed to conform to the corresponding EHSR*
- *Application of harmonised standards or other technical specifications remains voluntary, and manufacturers are free to choose any technical solution that complies with the EHSR*
- *Manufacturers may choose between different conformity assessment procedures provided for in the applicable directive*

Equipment that complies with the new directives may carry the CE mark. The two directives concerned with hazardous areas are called the ATEX 95 and ATEX 137. ATEX is an abbreviation from the French Atmosphères Explosibles.

2.1.1 Directive 94/9/EC – ATEX 95

2.1.1.1 Scope and general definitions

ATEX 95, formerly known as ATEX 100a, is aimed at manufacturers. It applies to equipment and protective devices intended for use in potentially explosive atmospheres. Safety and controlling devices for use outside the hazardous area but essential for the safe operating of equipment inside it are also covered. The directive applies to electrical as well as mechanical equipment and applies to gases, vapours and dust atmospheres. Compliance is compulsory since 1 July 2003. In the UK, ATEX 95 is implemented through Statutory Instrument 192. In Germany, the implementation is through the new ExVO.

'Equipment' means machines, apparatus, fixed or mobile devices, control components and instrumentation thereof, and detection or prevention systems which, separately or jointly, are intended for the generation, transfer, storage, measurement, control and conversion of energy for the processing of material, and which are capable of causing an explosion through their own potential sources of ignition.

'Protective systems' means design units which are intended to halt incipient explosions immediately, and/or to limit the effective range of explosion flames and explosion pressures. Protective systems may be integrated into equipment or separately placed on the market for use as autonomous systems.

'Components' means any item essential to the safe functioning of equipment and protective systems but with no autonomous function.

'Safety devices, controlling devices and regulating devices' means devices intended for use outside potentially explosive atmospheres but required for or contributing to the safe functioning of equipment and protective systems with respect to the risks of explosion.

'Assembly' means a combination of two or more pieces of equipment, together with components if necessary, placed on the market and/or put into service as a single functional unit. Assemblies can be placed on the market in different ways.

> **Assemblies with a fully specified configuration of parts** are put together and placed on the market as a single functional unit by the manufacturer of the assembly. The manufacturer assumes responsibility for compliance with the directive and must therefore provide clear instructions for assembly, installation, operation and maintenance, etc.
> **Assemblies forming a modular system.** In this case, the assembly is not necessarily completed by the manufacturer of the product and placed on the market as a single functional unit. However, the user/installer selects and combines the parts from a manufacturer of origin for a given range, the manufacturer is still responsible for the compliance of the assembly with the directive.

'Installation' means a combination of two or more pieces of equipment which were already placed on the market independently by one or more manufacturers. Installing and combining the equipment on the user's premises is not considered manufacturing and therefore the resulting installation is outside the scope of ATEX 95 but will be subject to the legal requirements applicable such as ATEX 137.

The directive does not cover the following applications:

- *Medical devices intended for use in a medical environment*
- *Equipment and protective systems where the explosion hazard results exclusively from the presence of explosive substances or unstable chemical substances*
- *Equipment intended for use in domestic and non-commercial environments where potentially explosive atmospheres may only rarely be created, solely as a result of the accidental leakage of fuel gas*
- *Personal protective equipment covered by directive 89/686/EEC (1)*
- *Seagoing vessels and mobile offshore units together with equipment on board such vessels or units. FPSOs are not considered mobile offshore units*
- *Means of transport, i.e. vehicles and their trailers intended solely for transporting passengers by air or by road, rail or water networks, as well as means of transport insofar as such means are designed for transporting goods by air, by public road or rail networks or by water. Vehicles intended for use in a potentially explosive atmosphere shall not be excluded*

2.1.1.2 Groups and categories of apparatus

Apparatus are divided into groups and categories:
Group I applies to mining operations and group II applies to all other areas.
Group I is further subdivided into categories M1 and M2. Group II is subdivided into categories 1, 2 and 3. The equipment selection is shown in the table below:

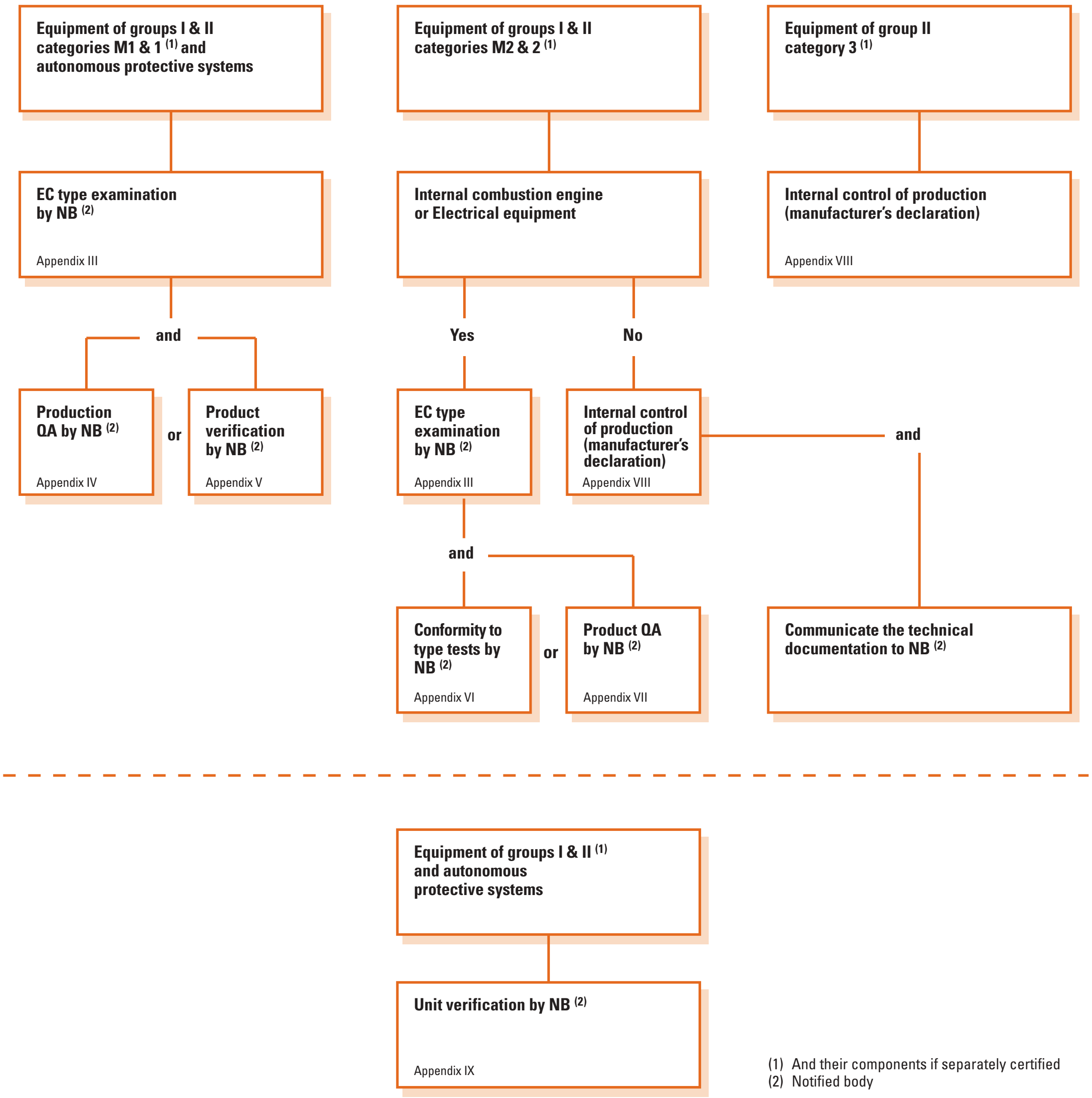
EQUIPMENT SELECTION (ATEX)

	CATEGORY OF EQUIPMENT	ATMOSPHERE	LEVEL OF PROTECTION	PERFORMANCE OF PROTECTION	CONDITIONS OF OPERATION
APPARATUS GROUP I (MINES)	M1	Methane, dust	Very high	2 independent protection methods, or safe with 2 faults	Equipment remains energised and functioning
	M2	Methane, dust	High	Suitable for normal operation and severe operating conditions	Equipment is de-energised
APPARATUS GROUP II (SURFACE)	1	Gas, vapour, mist, dust	Very high	2 independent protection methods or safe with 2 faults	Equipment remains energised and functioning in zones 0, 1, 2 (G) and/or 20, 21, 22 (D)
	2	Gas, vapour, mist, dust	High	Suitable for normal operation and frequently occurring disturbances, or safe with 1 fault	Equipment remains energised and functioning in zones 1, 2 (G) and/or 21, 22 (D)
	3	Gas, vapour, mist, dust	Normal	Suitable for normal operation	Equipment remains energised and functioning in zones 2 (G) and/or 22 (D)

2.1.1.3 CE mark

Up to now, free movement of goods for hazardous areas was indicated by the distinctive community mark Ex. Since 1 July 2003 only product carrying the CE mark may be placed on the market and put into service. Through the application of the conformity assessment procedures, manufacturers can issue an EC Declaration of Conformity, stating compliance with the relevant directive(s) and apply the CE mark on their equipment. The Ex will still appear on the label, but its only function is to indicate that the product is intended for use in potentially explosive atmospheres or is contributing to its safety.

The figure below shows the conformity assessment procedures.



2.1.1.4 Other directives that may be applicable

Products might be in the scope of other directives, and the CE mark might have to be applied even if ATEX 95 states it is not allowed. The EC Declaration of Conformity is the only way to find out which directives have been applied to a product.

Electromagnetic Compatibility 89/336/EEC (EMC) applies to any product in a hazardous area that could cause interference or is susceptible. Products for use in hazardous areas are explicitly excluded from the **Low - Voltage Directive 73/23/EEC (LVD)** but all LVD objectives have to be covered by ATEX 95. The standards used for compliance can be listed on the declaration. However, products that are used outside the hazardous area but are contributing to the safety inside have to comply with both directives. The **Machinery Directive 98/37/EC** contains only general requirements against explosions. Therefore, ATEX 95 takes precedence regarding explosion protection but the Machinery Directive has to be applied to all other relevant risks concerning machines.

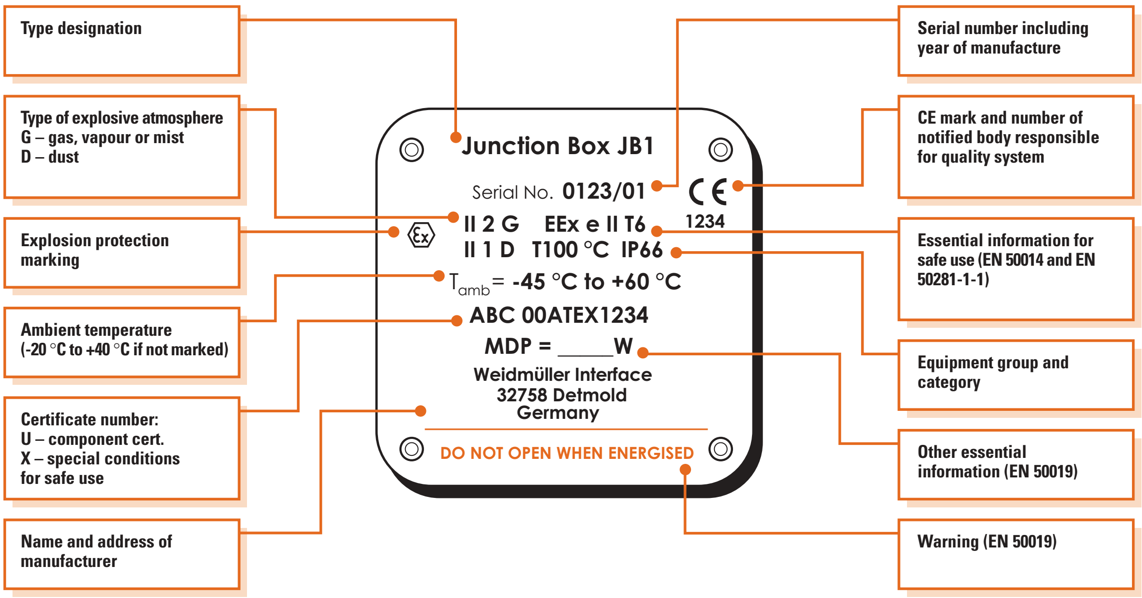
2.1.1.5 Marking

All equipment and protective systems must be marked legibly and indelibly with the following minimum information:

- *Name and address of the manufacturer*
- *CE mark*
- *Designation of series or type*
- *Serial number, if any*
- *Year of construction*
- *The community mark* Ⓔx

- *For group II, the letter 'G' for explosive gas atmospheres and/or the letter 'D' for explosive dust atmospheres*
- *In addition, other relevant safety information needs to be added*

Example of marking see figure below.



2.1.1.6 Instructions

All equipment and protective systems must be accompanied by instructions, including at least the following information:

- *A recapitulation of the information with which the equipment or protective system is marked, except for the serial number, together with any appropriate additional information to facilitate maintenance (e.g. address of the importer, repairer, etc.)*
- *Instructions for safe:*
  - *Putting into service*
  - *Use*
  - *Assembling and dismantling*
  - *Maintenance (servicing and emergency repair)*
  - *Installation*
  - *Adjustment*
- *Where necessary, an indication of the danger areas in front of pressure-relief devices*
- *Where necessary, training instructions*
- *Details which allow a decision to be taken beyond any doubt as to whether an item of equipment in a specific category or a protective system can be used safely in the intended area under the expected operating conditions*
- *Electrical and pressure parameters, maximum surface temperatures and other limit values*
- *Where necessary, special conditions of use, including particulars of possible misuse which experience has shown might occur*
- *Where necessary, the essential characteristics of tools which may be fitted to the equipment or protective system*

The manufacturer or his authorised representative established in the Community must draw up the instructions in one of the Community languages. On being put into service, all equipment and protective systems must be accompanied by a translation of the instructions in the language or languages of the country in which the equipment or protective system is to be used, and by the instructions in the original language.
Either the manufacturer must make this translation, or his authorised representative established in the Community, or the person introducing the equipment or protective system into the language area in question.

2.1.2 Directive 1999/92/EC – ATEX 137

2.1.2.1 Scope

ATEX 137, previously known as ATEX 118a, is aimed at the employers, and requires them to protect workers from the risks of explosive atmospheres. The directive does not apply to:

- *Areas used directly for and during the medical treatment of patients*
- *The use of appliances burning gaseous fuels in accordance with directive 90/396/EEC*
- *The manufacture, handling, use, storage and transportation of explosives or chemically unstable substances*
- *Mineral-extracting activities at mines, quarries and offshore installations (directives 92/91/EEC and 92/104/EEC)*
- *The use of means of transport by land, water and air, to which the pertinent provisions of the international agreements (e.g. ADNR, ADR, ICAO, IMO, RID), and the Community directives giving effect to those agreements, apply. Means of transport intended for use in a potentially explosive atmosphere shall not be excluded.*

2.1.2.2 Requirements

Since 30 June 2003, places with potentially explosive atmospheres must be:

Warning sign for places where explosive atmospheres may occur

- *Classified into zones*
  Zones 0, 1 and 2 for gases and vapours. Zones 20, 21 and 22 for dusts.
- *Equipment selected in accordance with ATEX 95*
- *Marked with an 'EX' sign, where necessary*
  In workplaces where safety restrictions apply throughout the site, e.g. refineries, the sign might be applied at the entrance of the site. Individual signs around the potential explosive atmospheres would not be required.
- *Verified by a competent person before first-time use*
- *Safety measures must be coordinated in shared workplaces*
  Usually it is the employer that creates the potential explosive atmosphere that is responsible for the coordination
- *Provide information, instructions and training to the employees*

In the UK, ATEX 137 is implemented through the 'Dangerous Substances and Explosive Atmospheres Regulations' (DSEAR). In Germany, the implementation is through the new ElexV. Existing equipment that is in use before 30 June 2003 with a risk assessment that indicates that they are safe for use in a hazardous area, can continue to be used. Workplaces in use before 30 June 2003 have until 30 June 2006 to implement the minimum requirements of ATEX 137. Any modifications and changes to existing workplaces after 30 June 2003 must comply immediately.

WORK EQUIPMENT AND WORKPLACES – DIRECTIVE 1999/92/EC

SCOPE	DETAILS	COMPLIANCE * RA — Risk Assessment
WORK EQUIPMENT	Already in use or made available for the first time before 30 June 2003	May continue to be used provided the RA* indicates it is safe
WORK EQUIPMENT	Made available for the first time after 30 June 2003	ATEX 95 applies (selection on the basis of categories)
WORKPLACES	First time after 30 June 2003 OR modifications, extensions or restructuring after 30 June 2003	ATEX 137 applies
WORKPLACES	Already in use before 30 June 2003	Classify into zones, mark with a sign, provide protective clothing, duty of coordination by 30 June 2006

2.1.2.3 Selection of equipment and protective systems

If the explosion protection document based on a risk assessment does not state otherwise, equipment and protective systems for all places in which explosive atmospheres may occur must be selected on the basis of the categories set out in ATEX 95. The following categories of equipment must be used in the zones indicated, provided they are suitable for gases, vapours or mists and/or dusts as appropriate:

- *Zone 0 or zone 20 use category 1 equipment*
- *Zone 1 or zone 21 use category 1 or 2 equipment*
- *Zone 2 or zone 22 use category 1, 2 or 3 equipment*

2.2 North America

In North America, Canada has adopted the IEC Standards for Explosion Protection of electrical apparatus and, given them a unique CSA identity. The USA has also adopted the zone classification concept, and new standards have been published based on IEC, but not exactly the same. The publication of the new National Electrical Code (NEC®) 2002 has incorporated more detail regarding zone classification. It will help users select the right equipment and offers an alternative to divisions.
The protection concepts in the USA are discussed in more detail in section 6.

2.3 International IECEx scheme

2.3.1 IECEx scheme objective

The objective of the IECEx scheme is to facilitate international trade in electrical equipment intended for use in explosive atmospheres (Ex equipment):

- *Reduced testing and certification costs to manufacturer*
- *Reduced time to market*
- *International confidence in the product assessment process*
- *One international database listing*

2.3.2 IECEx international certification scheme

The aim of the IECEx scheme is to facilitate international trade in electrical equipment intended for use in explosive atmospheres (Ex equipment) by eliminating the need for multiple national certifications while preserving an appropriate level of safety.

The IECEx scheme provides the means for manufacturers of Ex equipment to obtain certificates of conformity that will be accepted at national level in all participating countries. A certificate of conformity may be obtained from any certification body accepted into the scheme. The certificate will attest that the equipment design conforms to the relevant IEC standards and that the product is manufactured under a quality plan assessed by an ACB (accepted certification body). Manufacturers holding certificates of conformity may affix the IECEx Mark of Conformity to equipment that they have verified as complying with the certified design.

For the IECEx scheme to achieve its long term objective, every national standard for which application is made by participating countries will need to be identical to the corresponding IEC standard, and the IECEx Certificates of Conformity issued by all accepted certification bodies will need to be recognised in all participating countries as equivalent to their own national certification.

For countries whose national standards are not yet identical to the IEC standards, a transitional period will be necessary. The transitional period, which could be different for different standards, is to allow time for:

- *The IEC standards and the national standards to be made identical, and*
- *National acceptance of IECEx Certificates of Conformity and the IECEx Mark of Conformity.*

Accepted certification bodies in participating countries during the transitional period will be required to accept IECEx assessment and test reports produced by other accepted certification bodies for the purpose of issuing their own national certification, which may include national differences.

The final objective of the IECEx scheme is worldwide acceptance of:

- *One standard*
- *One certificate*
- *One mark*

2.3.3 Scheme participation levels

The scheme provides for two levels of participation:

- *Full participation*
- *Participation at a transitional level*

2.3.3.1 Full participation

Participation at this level provides for the issuing of an IECEx Certificate of Conformity as well as a licence to use the IECEx mark. An IEC Certificate of Conformity can only be issued against an IEC standard. Therefore IECEx Certificates of Conformity cannot cover national differences. In this context national differences are the differences or deviations between a national and an IEC standard.

To ensure integrity and equity in the scheme are maintained, strict obligations on a country's participation at this level are part of the rules, i.e.:

- *The corresponding national standard must be identical to the IEC standard for which participation is sought and*
- *The IECEx Certificate of Conformity must be given equal treatment to the country's national certification.*

2.3.3.2 Participation at a transitional level

Right now, the range of differing national Ex standards means that large-scale participation at the full level is some time away.
To cater for today's needs, there is provision for participation at an intermediate or transitional level for those countries:

- *Whose national standards are not yet identical to IEC standards or*
- *Which do not yet accept IECEx Certificates of Conformity as equal to their own national certification.*

Participation at the transitional level provides for the mutual acceptance of ATRs (assessment and test report) for the purpose of issuing national certification. While national differences exist, the individual countries may require additional 'top-up' testing unless the differences are already covered in the ATR.

2.3.4 How the system will work during transition

The basics of the system are in place and ATRs have already been issued. The following countries are currently participating in the scheme:
Australia, Canada, China, Denmark, Finland, France, Germany, Hungary, Italy, Korea, Netherlands, Norway, New Zealand, Romania, Russia, Slovenia, South Africa, Sweden, Switzerland, UK, USA and Yugoslavia.
The certification process is clarified with an example. An Ex e junction box is manufactured in the UK and destined for use in oil refineries. The manufacturer sends the junction box to an ExTL (Ex testing laboratory) in the UK, which tests it for conformity to IEC standards and possible national deviations. Following a successful test, the ACB issues an IECEx ATR. Both the ExTL and ACB can be one and the same organisation. Wishing to sell the junction box in Canada and in China, the UK manufacturer sends these IECEx documents to a Canadian and a Chinese certification body in the IECEx scheme. Provided the national differences are covered in the ATR, the Canadian and Chinese bodies will each issue a certificate without re-testing the equipment because they recognise the UK laboratory as a member of the IECEx scheme and have full confidence in the testing and assessment that has already been done. The UK manufacturer may now affix the national mark of conformity of the Canadian and Chinese bodies to the junction box, and is free to export it to both Canada and China.
Some certification bodies may require a factory inspection in addition to the ATR. In response to this industry need, the IECEx has introduced a quality assessment report. In our example, this will mean that the UK testing and certification body will be able to conduct both product testing and assessment, as well as the factory inspection acceptable to the bodies in both Canada and China.

2.3.5 Complying with additional requirements

The national certification authorities will continue to be responsible for requirements other than explosion protection, i.e. EMC, machinery, general electrical safety, etc.
Also, the IECEx scheme does not cover the installation and maintenance requirements in the different countries. Neither does it mean that the division classification system will have to be eliminated in the USA. The two systems will coexist for the foreseeable future, together with their specific installation and product requirements. In the EC, only ATEX-certified equipment could be installed since 1 July 2003. Therefore, products imported in Europe via the IECEx scheme would have to comply with the EHSR in accordance with directive 94/9/EC.

SECTION 3
BASIC PRINCIPLES OF EXPLOSIVE ATMOSPHERES

3.1 Explosive atmosphere

An 'explosive atmosphere' is a mixture with air, under atmospheric conditions, of flammable substances in the form of gases, vapours, mists or dusts in which, after ignition has occurred, combustion spreads to the entire unburned mixture. The ATEX directive does not define atmospheric conditions, but normally a temperature range of -20 ºC to +60 ºC and a pressure range of between 0.8 and 1.1 bar is accepted. It should be noted that electrical products are usually designed and tested for use in an ambient temperature range of -20 ºC to +40 ºC in conformity with EN 50014.

3.2 Ignition sources

The following ignition sources are examples that can cause an explosion in the right circumstances:

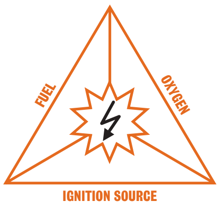
- *Electric arcs and spark*
- *Flames*
- *Hot surfaces*
- *Electrostatic sparks*
- *Thermite sparks*
- *Mechanical friction*
- *Mechanical sparks produced by grinding*
- *Smouldering deposits*
- *Compression ignition*
- *Electromagnetic radiation*
- *Chemical reactions*
- *Ultrasonics*

The mechanical ignition sources and their protection concepts are not considered in this guide.

3.3 The hazard triangle

The hazard triangle is used to understand the three basic conditions that must be satisfied to create a fire or explosion.

1. *Fuel must be present in sufficient quantity and concentration. This could be a flammable liquid, vapour or combustible dust.*
2. *Supply of oxygen. As we are considering an explosive atmosphere at atmospheric conditions, the surrounding air contains about 20% oxygen.*
3. *An ignition source.*



Successfully suppressing or separating one or more of these three components can avoid a fire or explosion. We will be looking at a number of protection concepts for gases and vapours as well as dust atmospheres, all of which use these simple principles.

SECTION 4
GASES AND VAPOURS

4.1 Characteristics of gases and vapours

4.1.1 Principles

Electrical apparatus for use in flammable gases and vapours are divided into groups:
Group I is for electrical or mechanical apparatus for mines susceptible to fire damp. Group I equipment will not be discussed in this guide.
Group II is for electrical and mechanical apparatus used in places other than mines.
Gases of group II are further divided into subdivisions, i.e. IIA, IIB and IIC. The subdivisions are based on experimental work conducted with flameproof and intrinsically safe apparatus.
The gases are categorised by one (or both) of two methods. For flameproof enclosures it is based on the Maximum Experimental Safe Gap (MESG) and for intrinsically safe apparatus it is based on the Minimum Ignition Current (MIC).

Maximum Experimental Safe Gap (MESG)
The gas inside the test chamber is ignited. A gap exists between the cover and the chamber with a gap length of 25 mm. The hot burning gas is now forced through the narrow gap. If the escaping gas ignites the surrounding gas, the test will have to be repeated with a smaller gap. The gap, which prevents the ignition of the surrounding gas, is the MESG.

Minimum Ignition Current (MIC)
In order to ignite a gas or vapour, a spark needs a certain amount of energy. The intrinsically safe quality of a circuit is based on the fact that the energy available in the circuit is insufficient to ignite the gas. The necessary minimum energy content is a specific characteristic of flammable gases and vapours. The gases are subsequently classified with a ratio relative to that of methane (MIC = 85 mA).

GAS SUBDIVISION	GAP	RATIO OF METHANE MIC
IIA	>0.9	>0.8
IIB	0.5 to 0.9	0.45 to 0.8
IIC	<0.5	<0.45

Explosive limits
Basically, all gases and vapours require oxygen to make them flammable. Too much or too little oxygen and the mixture will not ignite. The only exception is acetylene, which does not require oxygen to ignite. The upper and lower concentration is known as the 'explosive limit'.
Lower Explosive Limit (LEL): the concentration of gas in air, below which the gas atmosphere is not explosive.
Upper Explosive Limit (UEL): the concentration of gas in air, above which the gas atmosphere is not explosive.

GAS	LEL – UEL	GAS GROUP
Acetylene	1.5% to 100%	IIC
Ethylene	2.7% to 34%	IIB
Hydrogen	4.0% to 75%	IIC
Methanol	6.7% to 36%	IIA
Propane	2.0% 9.5%	IIA

Explosive range of some gases

Ignition energy
This is the spark energy in Joules, required to ignite the gases.
The ignition energy of some typical gases is:

GAS	IGNITION ENERGY µJ	GAS GROUP
Acetylene	19	IIC
Ethylene	19	IIC
Hydrogen	85	IIB
Methanol	290	IIA
Propane	260	IIA

Flashpoints are normally associated with liquids, but a few materials give off vapours when still in the solid state. The flashpoint of a flammable substance is the minimum temperature at which the material gives off vapours in a quantity such that it is capable of forming an ignitable vapour/air mixture.

Vapour density of a gas is given relative to that of air. Many gases are lighter than air. Any vapour release will rise and dilute rapidly. When indoors, these gases will collect in the roof space. Where gases are heavier than air, they will fall to the lowest point and fill sumps, trenches or hollows in the ground. These gases can remain there long after the release has been stopped and continue to pose a danger.

4.1.2 Temperature classification

The maximum surface temperature of electrical or mechanical apparatus must always be lower than the ignition temperature of the surrounding gases or vapours mixed with air at normal pressure. The ignition temperature of a flammable substance is the minimum temperature at which the material will ignite and sustain combustion. This is also known as the 'autoignition temperature'. The ignition temperature of different gases varies considerably. A mixture of air with hydrogen will ignite at 560 °C but a mixture of air with gasoline will ignite at 280 °C.

To help manufacturers design their equipment, apparatus are given a temperature classification consisting of 6 temperatures ranging from 85 °C (T6) to 450 °C (T1). The 6 'T' classes are given in table below:

MAXIMUM SURFACE TEMPERATURE FOR GROUP II ELECTRICAL APPARATUS

TEMPERATURE CLASS	MAXIMUM SURFACE TEMPERATURE OF APPARATUS IN °C	IGNITION TEMPERATURE OF THE FLAMMABLE SUBSTANCES IN °C
T1	450	>450
T2	300	>300 ≤450
T3	200	>200 ≤300
T4	135	>135 ≤200
T5	100	>100 ≤135
T6	85	>85 ≤100

Apparatus will be marked according to the maximum surface temperature of any relevant part that might be in contact with the flammable gas. For 'flameproof' and 'pressurised' equipment, the maximum surface temperature is on the outside of the enclosure, whereas for 'Increased safety' the hottest point is inside. The temperature classification for group II electrical apparatus will be either:

- *T class as given in table above*
- *Actual maximum surface temperature*
- *Specific gas for which it is designed*

Apparatus suitable for, e.g. T3 temperature class can also be used in T1 and T2.
Electrical apparatus shall normally be designed for use in an ambient temperature of -20 °C and +40 °C. When designed for use in a different range, the ambient temperature must be stated by the manufacturer and specified in the certificate. The marking must include either the special temperature range, e.g. -35 °C≤Ta≤+55 °C, or the letter 'X' after the certificate number. The table below gives the classification of some gases in explosion groups and temperature classes.

I	T1	T2	T3	T4	T5	T6
I	Methane					
II A	Acetone Ammonia Benzene Carbon monoxide Ethane Methanol Natural gas Propane	Butane Ethanol	Cyclohexane Kerosene Petroleum Turpentine Pentane	Acetaldehyde Ethyl ether Paraffin		
II B		Ethylene Formaldehyde	Hydrogen sulphide			
II C	Hydrogen	Acetylene				Carbon disulphide

4.2 Area classification

4.2.1 General

Installations in which flammable materials are manufactured, handled or stored should be designed, operated and maintained so that any releases of flammable material and the extent of hazardous areas are kept to a minimum. In situations where there may be an explosive gas atmosphere, the following steps should be taken:

- *Eliminate the likelihood of an explosive gas atmosphere occurring around the source of ignition; or*
- *Eliminate the source of ignition*

Where this is not possible, protective measures, process equipment, systems and procedures should be selected so the likelihood of both being present at the same time is acceptably small. In the first instance, it is preferable to eliminate the presence of a flammable atmosphere.
This is possible by:

- *Substituting with a non-flammable substance; or*
- *Raising the flashpoint above the process temperature, e.g. by adding water*
- *Lowering the process temperature, e.g. cooling*
- *Limiting the concentration below the LEL, e.g. dilution/ventilation or inerting*
- *Explosion-proof design (containment)*

In practice, however, it is very difficult to ensure that an explosive gas atmosphere will never occur. In this case, apparatus with special protective measures should be used.

4.2.2 Definitions of zones

4.2.2.1 Zone 0

A place in which an explosive atmosphere is present continuously, for long periods or frequently.

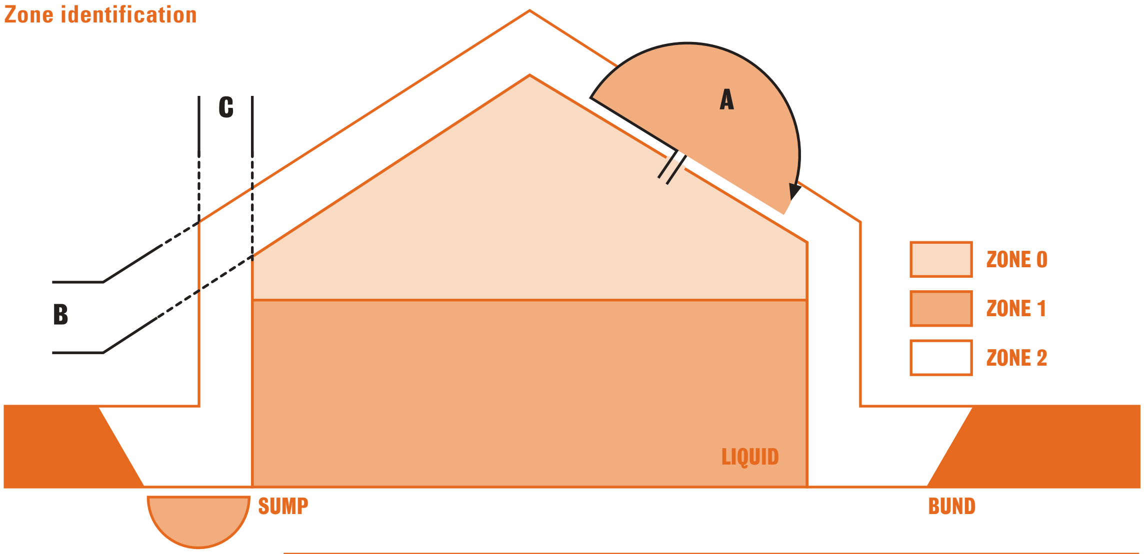
4.2.2.2 Zone 1

A place in which an explosive atmosphere is likely to occur in normal operation, occasionally.

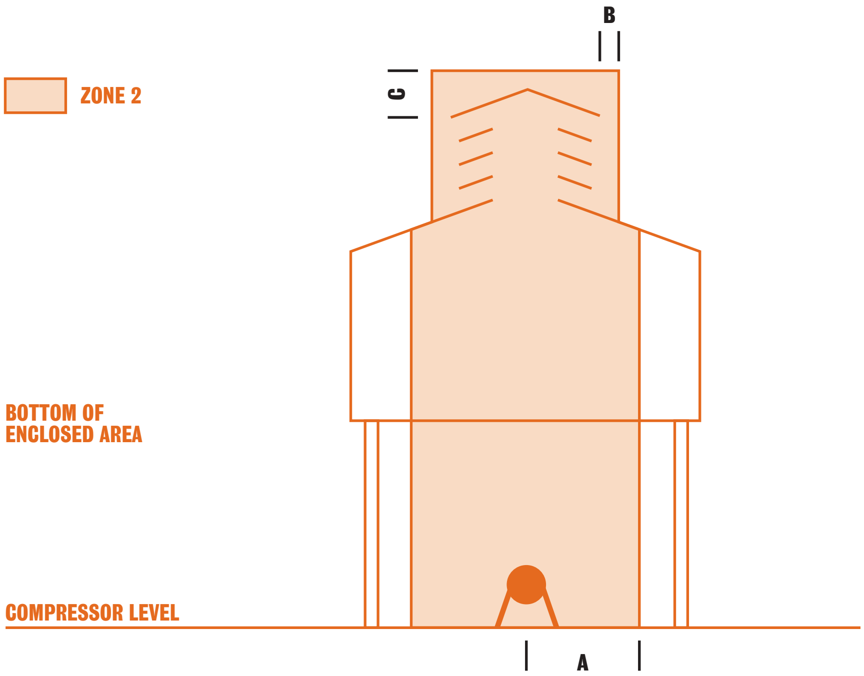
4.2.2.3 Zone 2

A place in which an explosive atmosphere is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

4.2.2.4 Zone identification



VENTILATION	Type: Natural	Degree: Medium	Availability: Good
SOURCE OF RELEASE	Liquid surface within the vessel	Vent opening and other openings in the roof	Flanges etc. inside bund and over-filling of the tank
GRADE OF RELEASE	Continuous	Primary	Secondary
PRODUCT	Flashpoint: Below process and ambient temperature	Vapour density: Greater than air	Vapour density: Greater than air
EXTENT OF ZONE	A = 3 m from vent openings	B = 3 m above the roof	C = 1 m horizontally from the tank



VENTILATION	Type: Natural	Degree: Medium	Availability: Good
SOURCE OF RELEASE	Compressor seals, valves and flanges close to the compressor		
GRADE OF RELEASE	Secondary		
PRODUCT	Gas: Hydrogen	Gas density: Lighter than air	Vapour density: Greater than air
EXTENT OF ZONE	A = 3 m horizontally from source of release	B = 1 m horizontally from ventilation openings	C = 1 m above ventilation openings

4.2.3 Grades of release, extent of zones, ventilation

4.2.3.1 Grades of release

The basic elements for establishing the hazardous zone types are the identification of the source of release and the determination of the grade of release. Each item of process equipment, e.g. tank, pump, pipeline, vessel, etc., should be considered as a potential source of release. Items, which contain flammable material but cannot release it to the atmosphere, e.g. all-welded pipelines, are not considered to be sources of release.
Releases are categorised as follows:

Continuous grade of release
A release which is continuous or is expected to occur for long periods.
Example of continuous grade of release:

- *Surface of a flammable liquid in a fixed roof tank*
- *Surface of an open reservoir, e.g. oil/water separator*

Primary grade of release
A release which can be expected during normal operation, occasionally.
Example of primary grade of release:

- *Seals of pumps, compressors or valves that are expected to release flammable material, particularly during start-up*
- *Water drainage points on vessels which contain flammable liquids*
- *Sample points from which analytical samples are drawn*
- *Relief valves, vents and other openings which are expected to release during normal operation*

Secondary grade of release
A release which is not expected to occur in normal operation and, if it does occur, is likely to do so for short periods. Example of secondary grade of release:

- *Seals of pumps, compressors or valves that are not expected to release flammable material during normal operation*

- *Flanges, connections and pipe fittings where release of flammable materials is not expected during normal operation*
- *Relief valves, vents and other openings which are not expected to release during normal operation*

A continuous grade of release normally leads to a zone 0, a primary grade to zone 1 and a secondary grade to zone 2.

4.2.3.2 Extent of zone

Quite a number of factors can influence the extent of the zone. If the gas is lighter than air, it rises on release and can become trapped in the roof space; or if the gas is heavier than air, it will fall and spread at ground level. This has an impact on the location of the site – is it on a hill or in a hollow?
When sources of release are in an adjacent area, the migration can be prevented by:

- *Physical barriers*
- *Static overpressure in the area adjacent to the hazardous area.*
- *Purging the area with a significant airflow.*

4.2.3.3 Ventilation

Gas or vapour released into the atmosphere can be diluted by dispersion or diffusion into the air until its concentration is below the LEL. Suitable ventilation rates can influence the type of zone.
There are two types of ventilation available:

- *Natural ventilation*
- *Artificial ventilation, general or local*

Natural ventilation is created by the movement of air caused by the wind and/or by temperature gradients. Artificial ventilation is provided by artificial means, e.g. fans or extractors. With the use of artificial ventilation, it is possible to achieve:

- *Reduction in the extent of the zone*
- *Shortening of the time of persistence of an explosive atmosphere*
- *Prevention of the generation of an explosive atmosphere*

Ventilation is the preferred option for gas turbines, as it prevents the formation of an explosive atmosphere. In order that the dilution ventilation ensures a negligible risk of an explosive atmosphere at all times, the ventilation system has safety features such as: a 100% standby fan; or an uninterruptible power supply to the ventilation fans; interlocks so that the gas turbines cannot start without sufficient ventilation; plus proven automatic isolation of fuel supply if ventilation fails. The effectiveness of the ventilation in controlling the dispersion and persistence of the explosive atmosphere will depend on the degree and availability of ventilation and the design of the system.

The three degrees of ventilation

High ventilation (VH)
Can reduce the concentration at the source of release virtually instantaneously, resulting in a concentration below the LEL. A zone will be very small (even negligible).

Medium ventilation (VM)
Can control the concentration, resulting in a stable situation in which the concentration beyond the zone boundary is below the LEL during release. The extent and type of the zone depend on the design parameters.

Low ventilation (VL)
Cannot control the concentration whilst release is in progress and/or cannot prevent undue persistence of a flammable atmosphere after release has stopped.

Availability of ventilation
Three levels of availability of ventilation should be considered.

Good
Ventilation is present virtually continuously.
Natural ventilation, which is generally obtained outdoors, is considered to be good when the wind speed is greater than 0.5 m/s (approx 1.1 mile per hour).

Fair
Ventilation is expected to be present during normal operation. Discontinuities are permitted, provided they occur infrequently and for short periods.

Poor
Ventilation which does not meet the standard of fair or poor. Discontinuities are not expected to occur for long periods. Ventilation which is less than poor is ignored.

Influence of ventilation on type of zone

GRADE OF RELEASE	VENTILATION						
	DEGREE						
	HIGH			MEDIUM			LOW
	AVAILABILITY						
	GOOD	FAIR	POOR	GOOD	FAIR	POOR	GOOD, FAIR OR POOR
CONTINOUS	(zone 0 NE) Non-Haz [1]	(zone 0 NE) zone 2 [1]	(zone 0 NE) zone 1 [1]	zone 0	zone 0 + zone 2	zone 0 + zone 1	zone 0
PRIMARY	(zone 1 NE) Non-Haz [1]	(zone 1 NE) zone 2 [1]	(zone 1 NE) zone 2 [1]	zone 1	zone 1 + zone 2	zone 1 + zone 2	zone 1 or zone 0 [3]
SECONDARY	(zone 2 NE) Non-Haz [1]	(zone 2 NE) Non-Haz [1]	zone 2	zone 2	zone 2	zone 2	zone 1 and even zone 0 [3]

1) Zone 0 NE, 1 NE, 2 NE indicates a theoretical zone which would be of negligible extent

2) The zone 2 area created by a secondary grade release may exceed that attributable to a primary or continuous grade release; in which case, the greater distance should be taken

3) Will be zone 0 if the ventilation is so weak and the release is such that in practice an explosive atmosphere exists virtually continously

Note: '+' signifies 'surrounded by'

4.3 Gas explosion protection concepts for electrical equipment

4.3.1 Zones of use

Since 1 July 2003, equipment for use in zone 0 must conform to the requirements of category 1 in accordance with ATEX 95 and ATEX 137. Equipment for use in zone 1 and zone 2 must comply with category 2 and category 3 respectively. Several methods may be used to make equipment safe for use in an explosive atmosphere.

The following table gives an overview of the available concepts and their principles.

ELECTRICAL EQUIPMENT FOR GASES, VAPOURS AND MISTS (G)

TYPE OF PROTECTION	SYMBOL	CATEGORY	CENELEC	BASIC CONCEPT OF PROTECTION
Increased safety Non-sparking	e nA	M2 & 2 3	EN 50019 EN 50021	No arcs, sparks or hot surfaces
Flameproof Enclosed break Quartz/sand filled	d nC q	M2 & 2 3 2	EN 50018 EN 50021 EN 50017	Contain the explosion, prevent flame propagation
Intrinsic safety Intrinsic safety Energy limitation	ia ib nL	M1 & 1 M2 & 2 3	EN 50020/39 EN 50020/39 EN 50021	Limit the energy of the spark and the surface temperature
Pressurised Restricted breathing Simple pressurisation Encapsulation Encapsulation (cat. 1) Oil immersion	p nR nP m ma o	2 3 3 2 1 2	EN 50016 EN 50021 EN 50021 EN 50028 EN 50284 EN 50015	Keep the flammable gas out
Category 1G	-	1	EN 50284	Two independent methods of protection
Category M1	-	M1	EN 50303	

4.3.2 Protection concepts

4.3.2.1 Increased safety 'e'

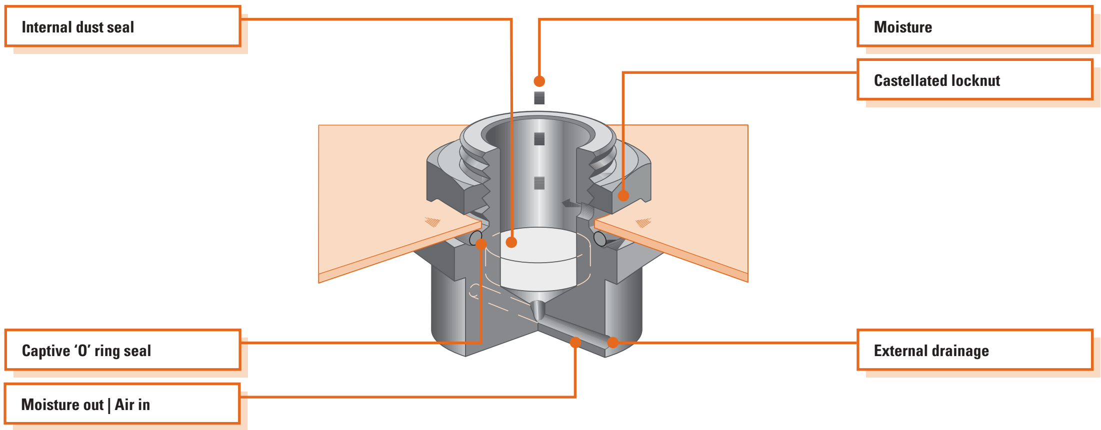
Basic principles
Increased safety is intended for products in which arcs and sparks do not occur in normal or under fault conditions. The surface temperatures of the relevant parts are controlled below incendive values. Increased safety is achieved by reducing current ratings and enhancing insulation values and creepage and clearance distances above those required for normal service. Maximum voltage for the protection concept is 11 kV (d.c. or a.c. r.m.s.). The protection concept provides a high level of safety in accordance with ATEX 95, making it suitable for categories 2 and M2, gas groups I and II.
Typical products are junction boxes, luminaries, induction motors, transformers and heating devices. The key design features for increased safety are:

- *Enclosures must be constructed such that they can withstand the mechanical impact test and provide a specified degree of ingress protection. Non-metallic materials must comply with the following requirements:*
    - *Thermal endurance to heat*
    - *Thermal endurance to cold*
    - *Resistance to light*
    - *Insulation resistance*
    - *Thermal index (TI)*
- *Terminals must be generously dimensioned for the intended connections and ensure that the conductors are securely fastened without the possibility of self-loosening.*

- *Clearance between bare conductive parts must not be less than the values specified for the rated voltage.*
- *Creepage distances must not be less than the values specified for the rated voltage and the comparative tracking index (CTI) of the insulating material.*
- *Electrical insulating materials must have mechanical stability up to at least 20 K above the maximum service temperature.*
- *Temperatures of parts of equipment must be limited so as not to exceed values that could affect the thermal stability of the material and the temperature classification of the equipment.*

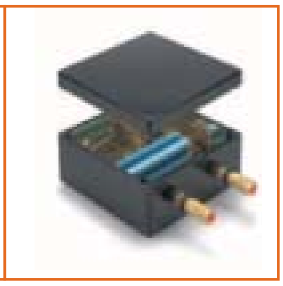
Junction boxes

Ex e enclosures that contain bare conductive parts require an ingress protection of IP54. If only insulated conductive parts are fitted, IP44 will suffice. In practice, however, users require enclosures with an ingress protection of IP65 or 66. Enclosures may be provided with drain holes or ventilation openings to prevent the accumulation of condensation. The ingress protection may be reduced but no less than IP44 when fitted with bare conductive parts or IP24 when fitted with insulated conductive parts. However, breather drains maintaining IP65 or 66 are available on the market (see figure at the end of the page).

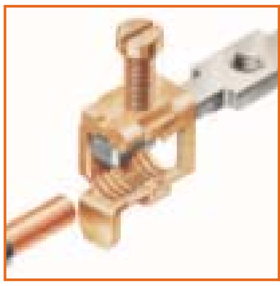


One of the main advantages of increased safety enclosures is the availability in different construction materials such as, stainless, mild steel, aluminium, glass fibre-reinforced polyester, polycarbonate, etc. Examples of typical Ex e enclosures are shown in the following figures.



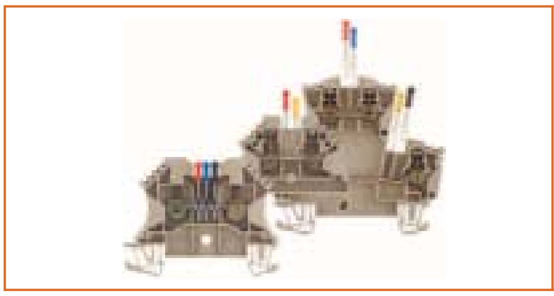



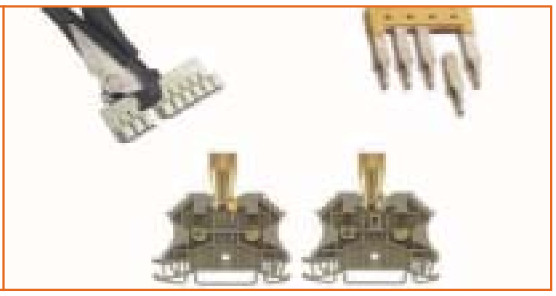
The basic requirements for **Ex e terminals** are in accordance with EN 60947-7-1 and EN 60947-7-2. For use in hazardous areas, standards EN 50014 and EN 50019 also apply. Ex terminals are classified as components in ATEX 95, which means that they are not CE-marked.
Different types of connection are now possible. The Weidmüller clamping yoke, tension clamp and Insulation Displacement Connection (IDC) clamping system provide protection against self-loosening, and the design is such that stranded cable does not have to be crimped with ferrules. The cross-section of the cable and other connection data specified in the selection tables are included in the EC type examination certificate. The specified values of the current carrying capacity are based on an ambient temperature of 40 °C. At rated current (+10%), the surface temperature of the current bar of the terminal block is maximum 40 K. The maximum operating temperature in a hazardous area atmosphere of the insulating material Wemid and Melamine (KRG) is 100 °C, and 80 °C for Polyamide (PA).



Terminal blocks for intrinsically safe circuits are considered simple apparatus therefore Ex i certification is not required. Some terminals are a colour variant of the Ex e terminals, hence they are Ex e certified. They are light blue in accordance with the industry standard for intrinsic safety. When combined with non-IS circuits, the terminals should be separated by at least 50 mm or with a partition. Metal partitions must be earthed.

Accessories that can be fitted to the terminals are also listed on the EC type examination certificate. The latest standards have made it possible to use pluggable cross-connections. When using the WDU 2.5 from Weidmüller, it is even possible to fit 3 rows of cross-connections in parallel. Users can fit cross-connections on-site, but have to follow the instructions provided by the manufacturer. Fitting cross-connections might result in lower voltages.





Ex e junction boxes have a maximum surface temperature which is normally inside the enclosure. This defines the temperature classification of the enclosure.
The temperature is determined by testing and depends on two factors:

- *Number of terminals and wiring inside*
- *Temperature rise of terminals and wiring above ambient temperature*

Normal ambient temperature is -20 ºC to +40 ºC. Higher ambient temperatures could mean a higher T class or reducing the current through the terminals.
Enclosures are allocated a maximum dissipated power figure, which is used to calculate the number of terminals that can be fitted. Based on the rated current and the total resistance of cable and terminal, the user or manufacturer calculates the dissipated power per terminal. This figure multiplied by the number of terminals must always be lower than the MDP figure allocated to the enclosure. Alternatively, the user can be provided with a table for each enclosure size, indicating the maximum number of terminals or conductors based on the rated current and cross-section, i.e. the 'defined arrangement method'. For the smaller cross-sections, the power dissipation depends on the cable size, as the resistance of a quality terminal is negligible. Therefore, the number in the table is in fact the number of cable pairs that can be connected in the enclosure, i.e. the user might decide to fit terminals which can terminate a cable size of 4 mm^2 but instead uses 2.5 mm^2 for the wiring. In that case, it is not the number of 4 mm^2 terminals that is important but the number of 2.5 mm^2 cable pairs that are being connected.

KLIPPON TB 303015

CURRENT (A)	CONDUCTOR SIZE							
0	1.5	2.5	4	6	10	16	25	35
8	85							
10	41							
12		63						
14		37						
16		27	108					
18			42					
20			31					
23				46				
25				33				
32					57			
35					32			
45						56		
50						27		
58								
63							44	
68								
75								
80								50

KLIPPON TB 303015

CURRENT (A)	CONDUCTOR SIZE							
0	1.5	2.5	4	6	10	16	25	35
8	97							
10	10							
12		72						
14		43						
16		31	123					
18			49					
20			35					
23				54				
25				39				
32					66			
35					38			
45						65		
50						31		
58								
63							51	
68								
75								
80								58

Example: KLIPPON TB 303015 fitted with maximum number of SAK 4 terminals, i.e. 2 banks of 21 terminals. The wiring is with 2.5 mm^2 cable and the rated current for my application is 14 Amps. From the table, you find that theoretically, you could connect 43 pairs of 2.5 mm^2 cable, but physically you are only able to fit 42 terminals in the enclosure. Therefore, maximum number of cable pairs that can be connected is 42.
When using the same enclosure, the maximum number of WDU 4 terminals that can be fitted is 2 banks of 27. However, in order to remain within the T6 classification, the number of terminals would have to be restricted to the maximum number of 2.5 mm^2 cable pairs that can be connected, i.e. 43. Alternatively, if you would be able to reduce

the rated current for the application to 12 Amps, the maximum number of cable pairs that could be connected would be 54, which is the maximum number of WDU 4 terminals.
Other examples and the calculation method for mixed content are detailed in Appendix IV.

Ex ed control stations

All sparking devices such as switches, contactors, lamps, thermal relays, etc. are packaged individually in a flameproof enclosure. The electrical connection is made via Ex e terminals included in the design or by means of an encapsulated cable. These components are then installed in an Ex e enclosure.

Cable entry devices

Cable glands must maintain at least IP54. Threaded entries with minimum 6 mm thread engagement do not require an additional sealing washer. However, to maintain higher IP ratings a sealing washer is recommended. Metal cable glands do not require certification but should comply with a recognised standard e.g. EN 50262. Plastic cable glands require an EC type examination certificate by a notified body. Unused entries must be fitted with suitable stopping plugs. The plug must require the use of a tool to remove it. Some countries prefer the flexibility of transit systems in enclosures. The system can be certified as part of the enclosure or assembly certification, or have its own component approval.

4.3.2.2 Flameproof 'd'

Basic principles

Flameproof enclosures are intended for equipment, which produces arcs, sparks or hot surfaces that may be incendive in normal operation or industrial components that cannot otherwise be made suitable for use in a hazardous area. The surrounding explosive atmosphere can enter the enclosure and internal explosions are expected during the life of the equipment. The enclosure therefore has to be strong enough not to fracture or distort under the pressures generated. Any constructional joints in the enclosure are dimensioned such that they do not transmit the explosion from the inside to the surrounding atmosphere. These are called flamepaths.
The equipment is designed according to EN 50018 and is suitable for gas groups I and II, categories 2G and M2.
Typical products are electric motors and actuators, luminaries, loudspeakers and switchgear.
The key design features are:

- *Enclosures must be sufficiently strong to withstand the internal explosion*
- *Joints and gaps have critical dimensions*
- *Covers have warning labels if the enclosure contains parts that store energy or achieve temperatures in excess of the temperature classification*
- *Fasteners must conform to dimensional and strength requirements*
- *Enclosure materials must be fully specified, and non-metallic materials must be fully defined and have a suitable thermal index (TI)*
- *Cable and conduit entries must meet constructional requirements so that the flameproof properties are maintained*

Flamepaths, gaps, flanges and threaded joints

A flamepath is any small joint or gap in a flameproof enclosure through which the hot gases of an internal explosion might pass. When escaping through the gaps, the hot gases are sufficiently cooled down so that they do not ignite the surrounding atmosphere. The standard specifies the maximum permissible gaps for flanges, spigots and other types of joints based on experimental testing.

PERMISSIBLE FLANGE GAPS AND JOINTS

TYPE OF JOINT	MINIMUM WIDTH IN MM	MAXIMUM GAP (MM) FOR VOLUME V IN CUBIC CM											
		V ≤ 100			V 101 to 500			V 501 to 2000			V > 2001		
		IIA	IIB		IIA	IIB		IIA	IIB		IIA	IIB	
Flanged, cylindrical or Spigot (NOT IIC)	>6.0	0.3	0.2		—	—		—	—		—	—	
	9.5	0.3	0.2		0.3	0.2		—	—		—	—	
	12.5	0.3	0.2		0.3	0.2		0.3	0.2		0.2	0.15	
	>25.0	0.4	0.2		0.4	0.2		0.4	0.2		0.4	0.20	
Joints group IIC		Sub Div IIC			Sub Div IIC			Sub Div IIC			Sub Div IIC		
Important: See Note 1. flanges in group IIC		Flange	Spigot		Flange	Spigot		Flange	Spigot		Flange	Spigot	
	6.0	0.10	0.10		—	—		—	—		—	—	
	9.5	0.10	0.10		0.10	0.15		—	—		—	—	
	12.5	0.10	0.15		0.10	0.15		0.04	0.15		—	—	
	25.0	0.10	0.18		0.10	0.18		0.04	0.18		0.04	0.18	
	40.0	—	0.20		—	0.20		—	0.20		—	0.20	
Cylindrical joints for shaft glands of rolling element bearings		IIA	IIB	IIC	IIA	IIB	IIC	IIA	IIB	IIC	IIA	IIB	IIC
		0.45	0.30	0.15	—	—	—	—	—	—	—	—	—
		0.45	0.35	0.15	0.40	0.25	0.15	—	—	—	—	—	—
See Note 2.		0.50	0.40	0.25	0.45	0.30	0.25	0.45	0.30	0.25	0.30	0.20	—
		0.60	0.45	0.25	0.60	0.40	0.25	0.60	0.40	0.25	0.60	0.30	0.25
		0.75	0.60	0.30	0.75	0.45	0.30	0.75	0.45	0.30	0.75	0.40	0.30

Note 1.
Flanged joints are not permissible at all for explosive mixtures of acetylene. They may only be used with other group IIC gases as noted.
For preference, do not use flange widths greater than 9.5 mm for group IIC. Use Spigot.

Note 2.
For plain sleeve bearings in group IIA and IIB reduce the figure quotet to 2 thirds of the values given. For additional details refer to BS EN 50018.

The table on page 24 shows the values based on volume, gas subdivision, and type of joint. Cylindrical threads must have at least 5 full threads of engagement. In practice, 6 threads are usually provided. If the thread has an under-cut, a non-detachable and non-compressible washer shall be fitted to ensure the right thread engagement.

If an internal explosion does happen, some of the hot gases will pass through the gaps in the enclosures. It is very important that these gases pass freely into the atmosphere. Therefore, a minimum distance is required between the gap and any solid obstruction.

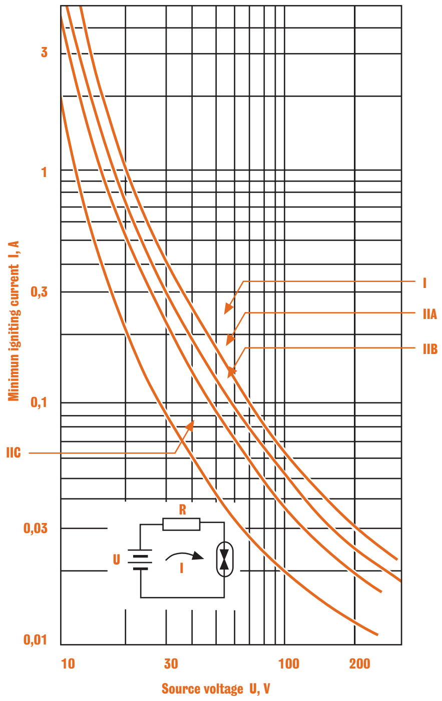
APPARATUS GROUP	MINIMUM DISTANCE
IIA	10 mm
IIB	30 mm
IIC	40 mm

Cable entry devices
The design of the cable entry shall be such that hot gases are not able to ignite the surrounding atmosphere following an internal explosion either through the gland or through the cable. Cable glands also have to conform to the requirements of threaded joints. 5 fully engaged threads are required, but 6 are usually provided.
Cables may be brought into the flameproof enclosure directly via a cable gland. This is called 'direct entry'. All cable entry holes must be threaded. If the gas is IIC or the cable is not filled properly, a sealing compound must be used in the gland.
Alternatively, the manufacturer might provide a terminating chamber and connect the components in the flameproof enclosure with the components in the terminating chamber through bushings. This is called 'indirect entry'. The terminating chamber is usually an Ex e enclosure.

4.3.2.3 Intrinsic safety 'i'

Basic principles
Intrinsic safety is intended for products in which the level of electrical energy circulating or stored in the product is insufficient to ignite a surrounding explosive atmosphere even under fault conditions. Because of the method by which intrinsic safety is achieved, it is necessary to ensure that not only the electrical apparatus exposed to the potentially explosive atmosphere but also other electrical apparatus with which it is interconnected is suitably constructed. The equipment is designed according to EN 50020 and is suitable for gas groups I and II, categories 1G or M1 (ia) and 2G or M2 (ib). Typical areas of use are control and instrumentation circuits with low voltage and current.
Depending on the design and purpose, apparatus are subdivided into two types:
Intrinsically safe electrical apparatus is apparatus in which all the circuits are intrinsically safe.
Associated electrical apparatus is apparatus in which the circuits are not all intrinsically safe but which contain circuits that can affect the safety of intrinsically safe circuits connected to it. Associated electrical apparatus may either be:

- *Electrical apparatus that has an alternative standard type of protection suitable for its use in the appropriate potentially explosive atmosphere, or*
- *Electrical apparatus that is not protected and therefore cannot be used within a potentially explosive atmosphere.*



The limiting ignition curves for the different subdivisions are determined with the help of a spark test apparatus. The figure above shows the curves for a resistive circuit. Also, the stored energy in a circuit has to be taken into consideration, e.g. capacitance or inductance. In the event of a short circuit, this energy could be released in addition to the energy from the associated apparatus.

Categories
Intrinsically safe apparatus and associated apparatus are divided into two groups, 'ia' and 'ib'. In the determination of category 'ia'or 'b', failure of the components is to be considered.

Category 'ia'
Intrinsically safe circuits in electrical apparatus of category 'ia' must not be capable of causing an ignition during normal operation when two faults occur.
The following safety factors have been taken into consideration:
Safety factor 1.5 During normal operation and with one fault
Safety factor 1.0 During normal operation and with two faults

Category 'ib'
Intrinsically safe circuits in electrical apparatus of category 'ib' must not be capable of causing an ignition during

normal operation when one fault occurs.
The following safety factors have been taken into consideration:

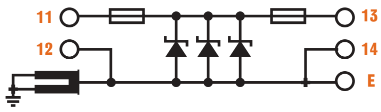
Safety factor 1.5	During normal operation
Safety factor 1.0	During normal operation and with one fault

Types of interface

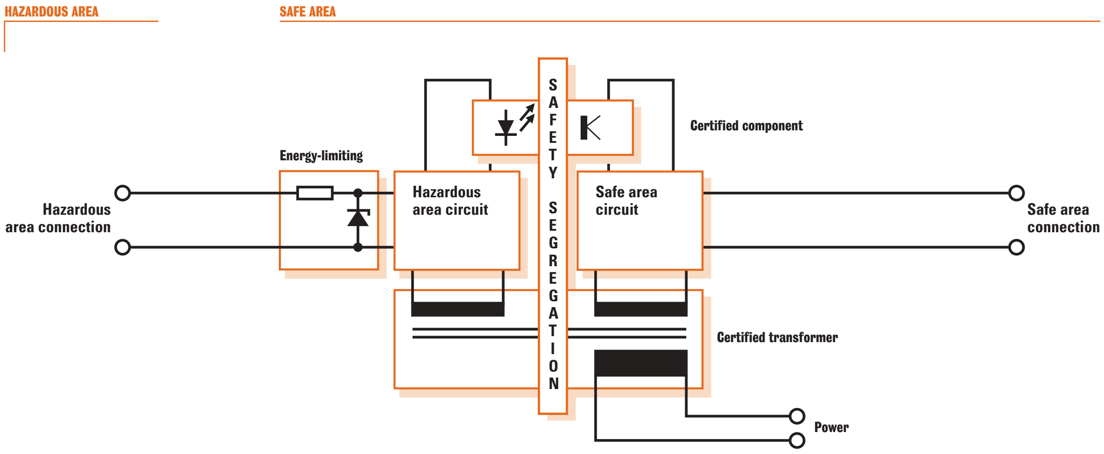
There are two types of interface, namely the zener barrier and the galvanic isolator.

Zener barrier

This type of interface has been around for a long time. The figure on the right illustrates how the barrier is constructed. The fuse restricts the fault power, the zeners restrict the voltage and the resistor restricts the current. Barriers are usually described by their safety parameters 28 V 116 mA 240 R where Uo = 28 V and the current limiting resistor is 240 R.



Galvanic isolation interface



The figure illustrates how the interface is constructed. The actual power limitation part of the isolator contains all the elements of the zener barrier. The power supply is via a transformer, and the return signal can be via an optocoupler, transformer or relay. The hazardous area circuit has effectively been isolated from the safe area circuit.
Discussions on the pros and cons of both interfaces are ongoing. Earthing for a zener barrier is essential for it to remain safe, unlike the isolator where earthing is not a requirement. The table below lists the relative merits of barriers and isolators. The significance depends on the installation.

BARRIERS	ISOLATORS
Simple	Complex
Versatile	Application specific
Low power dissipation	High power dissipation
Tightly controlled power supply	Wide range of power supply
High packing density	Lower packing density
Safety earth fundamental	Safety earth not essential
Reference 0V imposed on system	Isolation between signals
Isolated from earth in hazardous area (500 V)	May be earthed in hazardous areas
Accuracy and linearity (0.1%)	Lower accuracy and linearity (0.25%)
Lower cost	Increased cost
Good frequency response	Limited frequency response
Vulnerable to lightning and other surges	Less vulnerable to lightning and other surges
Cannot be repaired	Can be repaired

Although barriers are accepted worldwide, there are a number of countries that have additional requirements, e.g. Germany insists on using galvanic isolators for circuits connected to zone 0.

Simple electrical apparatus and components

Simple electrical apparatus and components (e.g. thermocouples, photocells, junction boxes, switches, plugs and sockets, resistors, LEDs) may be used in intrinsically safe systems without certification, provided that they do not generate or store more than 1.2 V, 0.1 A, 20 µJ and 25 mW in the intrinsically safe system in the normal or fault conditions of the system and, also, none of these components located in the hazardous area can dissipate more than 1.3 W at 40 °C ambient temperature. Simple electrical apparatus and components should also meet the insulation,

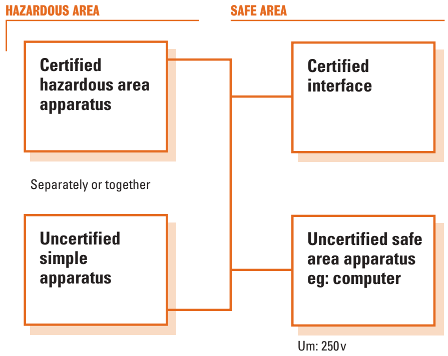
creepage and clearance and enclosure requirements specified in EN 50014, e.g. choice of aluminium alloy and surface resistance of less than 1G Ω. The temperature classification awarded to simple electrical apparatus and components complying with these requirements, is generally T4 (135 °C). Junction boxes and switches, however, may be awarded T6 (85 °C) because, by their nature, they do not contain heat-dissipating components. A wide variety of 'feed through' and 'disconnect' terminals can be fitted in simple apparatus enclosures. Disconnect terminals that do not require the conductors to be removed from the terminals for test and calibration purposes are particularly useful during operational conditions. Examples are shown in the figure on the right. It is important that the external terminal connections maintain 3 mm clearance between bare metal parts of the same IS circuit and 6 mm between bare metal parts of different IS circuits. Some users prefer a certified junction box for IS circuits. A number of manufacturers can supply Ex ia certified enclosures.

Intrinsically safe electrical systems

An intrinsically safe system consists of one or more interfaces (zener barriers or isolators), one or more items of field equipment, and interconnecting wiring in which any circuits intended for use in a potentially explosive atmosphere are intrinsically safe circuits. Where a colour is used in association with intrinsically safe equipment, it should preferably be light blue.

Individual systems

Where the user or installer buys the components separately, and builds his own system, he will be responsible for ensuring that the combination of barrier and hazardous area equipment is safe. The 'system design engineer' will be required to document the circuit with its interfaces, field equipment and cable parameters. According to ATEX 95, this type of assembly is defined as an installation, and as such does not requiring CE mark. If the field device(s) only include simple apparatus, the information needed to construct a safe system is included in the certification of the barrier.



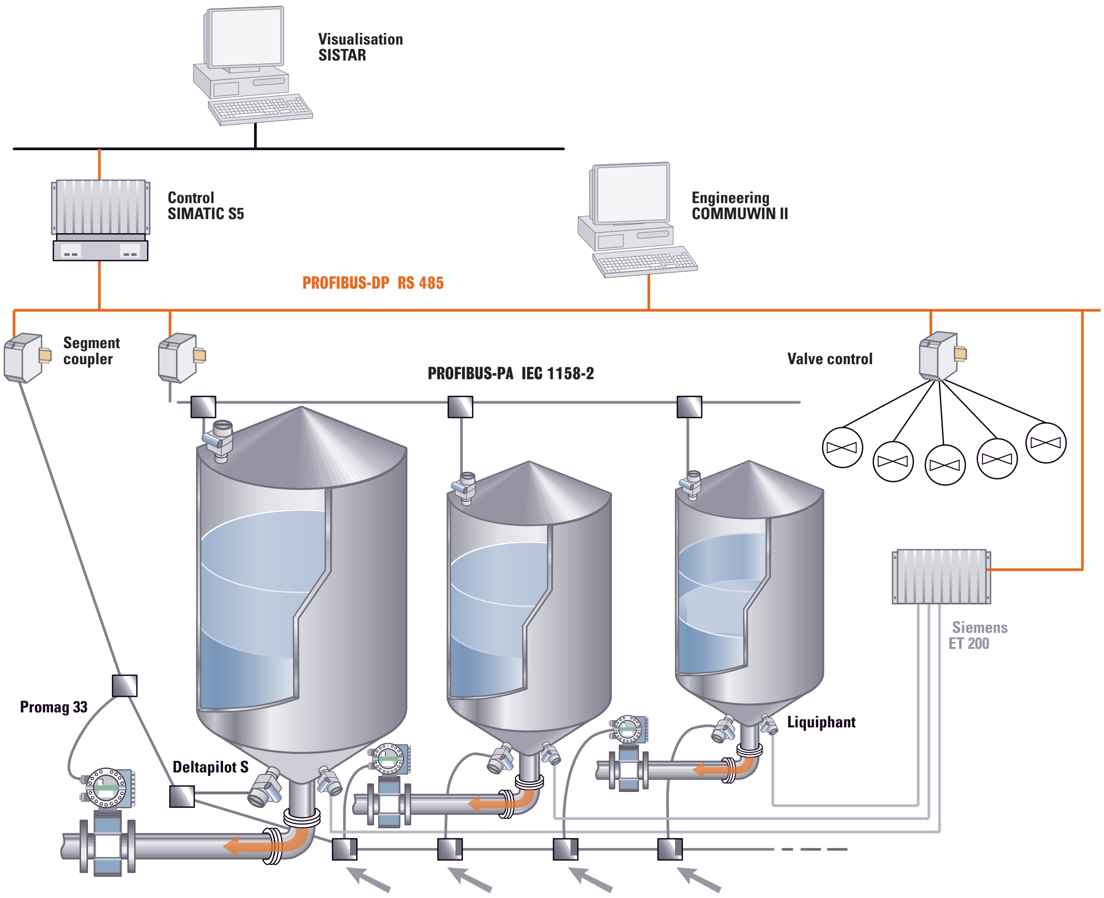
Where the field device is a certified item, e.g. a temperature transmitter or a solenoid valve, extra checks are necessary. The certificate of the field device will include its maximum input parameters, which will specify one or more of the values Ui, Li and Pi. Compatibility must be checked by ensuring that the maximum input figures of the field device are not exceeded by the maximum output values of the chosen barrier. If the system includes more than one item of certified apparatus, compatibility with the barrier must be checked separately. The addition of simple apparatus will not affect the compatibility, except that the system temperature might be derated to T4. The system will be categorised according to the least favourable components of the barrier category and the apparatus category.
For example, a barrier of [EExia]IIC with a field device of EEXiaIICT6 will categorise the system as EExiaIICT6. The addition of a piece of simple apparatus such as a diode or resistor will change the system category to EExiaIICT4.

System certificate

In some cases, the supplier of the field device might have obtained, in addition to the apparatus certificate, a system certificate that defines a number of barrier types and cable parameters of a typical system in which the device may be used. A system certificate relieves the system designer of much of the responsibility of choosing the individual components, provided the defined system is suitable for the application.
If the system certificate does not include the desired arrangement, this does not mean that the arrangement is not possible, but simply that it will need to be examined separately as in the previous paragraph.
ATEX 95 does not require a system certificate. However, if it is the intention of the manufacturer to put the arrangement on the market as a single unit, the assembly will be CE-marked.

Fieldbus

The use of bus systems in hazardous areas offers the same advantages as in a safe area. The difference is the extra restrictions and cost for compliance with the hazardous area standards.
Intrinsically safe bus systems currently available are Fieldbus foundation, WorldFip, Profibus-PA and IS-78 LonWorks.
The following figure shows a Profibus-PA system.



The bus systems are outside the scope of this publication except for some bus accessories. The bus systems themselves need to be terminated on both ends. An example of such a terminator is shown in the figure below.

Also, in the event that IS field equipment needs servicing or replacing, it would be extremely inconvenient if the bus were interrupted. Intrinsically safe certified T-connectors are now available which allow for the field equipment to be disconnected with the bus being interrupted. They are available in single or multiple quick-connect versions.

Cable entry devices

Cable entry devices in junction boxes of type of protection 'e' or 'n' which contain only intrinsically safe circuits do not have to be certified, and do not have to maintain the 'e' or 'n' protection requirements of the enclosure. The ingress protection should be at least IP20.
Where 'e' and 'i' circuits are combined in one enclosure, the cable entry devices must comply with the requirements for increased safety. Intrinsically safe and non-intrinsically safe circuits have to be separated by at least 50 mm.

4.3.2.4 Pressurisation 'p'

Pressurised apparatus achieves separation of ignition sources from explosive atmospheres by purging the atmosphere inside the apparatus with air or an inert gas and then maintaining a positive pressure of 0.5 mbar inside the equipment to prevent the ingress of the explosive atmosphere during operation. Failure of the pressurisation leads to an alarm operating or the disconnection of the components having ignition capability.
The equipment is designed according to EN 50016 and is suitable for gas groups I and II, categories 2G and M2. Pressurised control rooms are not covered by this standard, as they have their own specific standard. Typical products are electric motors, control cabinets and gas analysers.

There are three types of pressurisation:

- *Static pressurisation*
- *Pressurisation with continuous flow of protective gas*
- *Pressurisation with leakage compensation*

Static pressurisation involves the charging of the equipment with protective gas in a non-hazardous area and maintained only by the sealing of the enclosure. There is no protective gas supply in the hazardous area. When the overpressure drops below a set value, an alarm is raised or the equipment is switched off. The apparatus can only be recharged in the non-hazardous area.
Pressurisation with continuous flow of protective gas involves an initial purge cycle followed by a continuous flow of protective gas through the enclosure while maintaining a positive pressure. The system can be used where cooling is required or dilution of an internal gas release.
Pressurisation with leakage compensation involves an initial high purge with protective gas through the enclosure, after which the outlet aperture is sealed and the protective gas supply is maintained to compensate for leakage from the enclosure. The minimum number of air changes before energisation is usually 5. Pressurised air should be drawn from a gas-free area and never from zone 0 or 1. If it is not feasible to duct air from purged equipment into a safe area, a spark and flame arrestor may be required in the outlet air duct.

ZONE WHERE EXHAUST DUCT IS PLACED	APPARATUS	
	Ignition-capable sparks or particles in normal operation	No ignition-capable sparks or particles in normal operation
Zone 2	Required	Not required
Zone 1	Required*	Required*

* If the temperature of the enclosed apparatus constitutes a fire hazard upon failure of pressurisation, a suitable device shall be fitted to prevent the rapid entry of the surrounding atmosphere into the pressurised enclosure.

Alarm requirements – no internal release of flammable gas:

AREA CLASSIFICATION	CONTAINS APPARATUS NOT SUITABLE FOR ZONE 2	CONTAINS APPARATUS SUITABLE FOR ZONE 2
Zone 2	Alarm 1)	No action
Zone 1	Alarm & switch-off 2)	Alarm 1)

1) Immediate corrective action required
2) If automatic switch-off is a more dangerous condition, other precautions should be taken

4.3.2.5 Zone 0 apparatus

EN 50284 specifies the 'Special requirements for the construction, testing and marking of electrical apparatus of equipment group II, category 1G'. As category 1 is mounted in a zone 0 environment, the apparatus requires a very high level of safety. The standard supplements the requirements of EN 50014, EN 50020 and EN 50028.
The standard also applies to apparatus mounted across the boundary between hazardous and less hazardous areas where category 1 and category 2 equipment would normally be installed.
It also includes requirements for apparatus installed outside the hazardous area but electrically connected to apparatus of category 1 inside the hazardous area (e.g. associated apparatus).
To prevent ignition hazards by the electrical circuits of the apparatus, the very high level of safety required can be obtained by:

- *Single apparatus, which remains safe with two faults occurring independently from each other*
- *Two independent means of protection. In the event that one protection fails, an independent second one is still available*

Individual concepts suitable for category 1 are:

- *Apparatus complying with the requirements of EN 50020, type 'ia'*
- *Apparatus protected by encapsulation in accordance with EN 50028 and supplemented by the requirements of this standard*

Two independent types of protection
Electrical apparatus shall meet the requirements of two of the standards in the series EN 50015 to EN 50020 (ib), plus EN 50028. The combined types of protection must depend on different protection principles, which can be checked individually. Both types of protection will be assessed under the assumption of the most arduous fault of the other type of protection.
There the combined protection concept relies on an enclosure, two enclosures should be used. If only one enclosure is used, both the enclosure and the cable entries have to withstand an impact test of 20 J.
Examples:

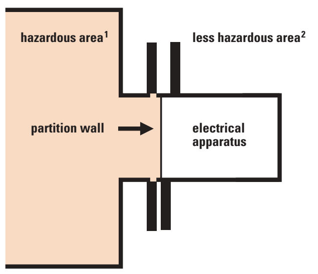
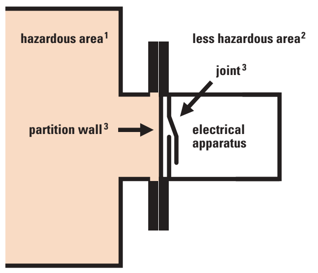
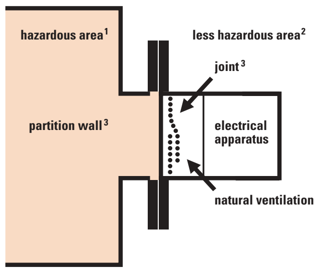
- *Torchlight with Ex d and Ex e housing and Ex ib circuit*

- *Electric motor complying both with EN 50018, flameproof Ex d, EN 50019, increased safety Ex e*
- *Measuring transducer with intrinsically safe circuit type 'ib' and flameproof enclosure Ex d*
- *Pressurised apparatus Ex p with increased safety enclosure Ex e.*

Apparatus mounted across the boundary wall

Where apparatus are mounted across the boundary but are not intrinsically safe type 'ia', they must contain a mechanical separation element inside the apparatus and comply with a means of protection.
The table below illustrates the possible combinations of separation elements and types of protection.

SEPARATION ELEMENTS

<table>
<tr><td rowspan="3">TYPE OF CONSTRUCTION</td><td colspan="3">REQUIREMENTS DEPENDING ON THE THICKNESS t OF THE PARTINION WALL</td></tr>
<tr><td colspan="3">(i) $t \geq 3$ mm no additional requirements</td></tr>
<tr><td>(ii) 3 mm $> t \geq 1$ mm</td><td>(iii) 1 mm $> t \geq 0.2$ mm (X-marking required)</td><td>(iv) $t < 0.2$ mm (X-marking required)</td></tr>
<tr><td>PARTITION WALL

</td><td>standardised type of protection and no ignitable sparks in service (e.g. no open switch contacts)</td><td>type of protection "Intrinsic safety" category "ib"</td><td>not permissible</td></tr>
<tr><td>PARTITION WALL + JOINT

</td><td colspan="2">standardised type of protection</td><td>standardised type of protection and no ignitable sparks in service (e.g. no open switch contacts)</td></tr>
<tr><td>PARTITION WALL + VENTILATION

</td><td>standardised type of protection</td><td colspan="2">standardised type of protection and flameproof joint (dashed)</td></tr>
</table>

1 Requiring category 1 equipment.
2 Requiring category 2 equipment or less.
3 Flameproof joint and partition walls are exchangeable in sequence of order.

Apparatus for use in zone 0 must be built in such a way that ignition sources due to impact and friction are excluded. Ignition hazards due to dangerous electrostatic charges should also be avoided.

Marking

The equipment must be marked according to EN 50014 for equipment group II, category 1, and the respective product standards. Special marking is required for some of the concepts covered in this standard.

• Intrinsic safety		
- Intrinsically safe apparatus	Ex II 1 G	EExiaIICT4
- Associated apparatus	Ex II (1) G	(EExia)IIC
• Special encapsulation	Ex II 1 G	EExma
		U_i= I_i= P_i=
• Two methods of protection	Ex II 1 G	EExdIICT4/EExmeIIT4
• Apparatus across boundary, e.g. sensors	Ex II 1/2 G	EExd[ia]IICT4

4.3.2.6 Zone 2 apparatus

Apparatus for zone 2 are designed to comply with category 3 G equipment according to ATEX 95. They have a normal level of safety and are suitable for normal operation. Apparatus complying with category 0 and 1 can also be used in zone 2.
The requirements for category 3 can be met by using the harmonised standard EN 50021, type of protection 'n'. Other technical standards, e.g. national standards, could be used as long as the Essential Health and Safety Requirements in ATEX 95 are complied with. Category 3 equipment does not have to be tested by a notified body such as BASEEFA, PTB, KEMA, etc. but the manufacturer must be able to provide evidence that the product is safe.
Control boxes may house components with individual EC type examination certificates, but no overall certification. The manufacturer must establish the maximum surface temperature and provide the necessary documentation.
The Ex n standard makes a distinction between apparatus that does not produce arcs, sparks or hot surface 'non-sparking apparatus', an apparatus that produces arcs, sparks or hot surface in normal operation 'sparking apparatus'.

Non-sparking apparatus
The risk of the occurrence of arcs, sparks or hot surfaces during normal operation has been minimised by constructional means. The equipment is marked with 'nA'. Examples of apparatus are motors, luminaries, junction boxes and control boxes.
Fuse terminals are considered to be non-sparking, provided they are not opened under load. Fuses must be non-rewirable. When mounted in an enclosure and built to protection type EEx nA II the manufacturer must ensure the internal or external surface temperature is within the T classification.

Sparking apparatus
In this case, arcs, sparks or hot surfaces do occur during normal operation. The following protection concepts are allowed:
Apparatus with protected contacts 'nC'
These include enclosed-break devices, non-incendive components; hermetically sealed devices and sealed or encapsulated devices.
Energy-limited apparatus and circuits 'nL'
Essentially an intrinsically safe system that is safe with no faults and no unity factor of safety on the ignition curves. The requirements for design and documentation are very similar to intrinsic safety.
Restricted-breathing enclosures 'nR'
These enclosures meet at least IP54 and an internal pressure of 3 mbar takes at least 80 seconds to drop to 1.5 mbar. The type of protection may be applied to enclosures containing sparking contacts but with a limitation in dissipated power such that the average air temperature inside the enclosure does not exceed the external ambient temperature by more than 10 K. When applied to enclosures without sparking contacts, the only limitation is the outside temperature. Restricted-breathing enclosures, without the provision for carrying out checks after installation, must be typ-tested by the manufacturer with the cable glands in place.
Simplified pressurisation 'nP'
This concept is based on an enclosure with at least IP54 (could be restricted-breathing enclosure) that only requires a minimal airflow to cover leakage losses. Simplified pressurisation is currently not covered by EN 50021, but the technical requirements will be based on IEC 60079-2, type of protection 'pz'.

Cable entry devices
Glands must be constructed and mounted such that they maintain the type of protection of the apparatus. Standard industrial glands to EN 50262 can be fitted. Of course, certified cable glands can also be used.

4.3.2.7 Powder filling 'q'

Protection is provided by immersing the ignition-capable parts in a fine powder, usually quartz. The arc is quenched before it can ignite the surrounding gas. Current is limited to a safe level.
The equipment is designed according to EN 50017, and is suitable for gas groups II, categories 2G.

4.3.2.8 Oil immersion 'o'

Protection is provided by immersing the apparatus in oil so that an explosive atmosphere cannot be ignited by the arcs and sparks generated under the oil.
The equipment is designed according to EN 50015, and is suitable for gas groups II, categories 2G.

4.3.2.9 Encapsulation 'm'

Protection is provided by encapsulating any hot or sparking components with a material that prevents the ingress of explosive gas and cools any heat produced by the components.
The equipment is designed according to EN 50028, and is suitable for gas groups II, categories 2G.

4.4 Installation

The standard for 'Electrical installations in hazardous areas' is EN 60079-14. In the UK, the standard replaces BS 5345. All new installations should comply with the European standard, but old installations can still use BS 5345. Nevertheless, electrical installations in hazardous areas shall also comply with the appropriate requirements for installations in non-hazardous areas.

4.4.1 Selection of electrical apparatus

In order to select the appropriate apparatus for an explosive atmosphere, the following information is required:

- *Classification of hazardous areas*
- *Temperature class or ignition temperature of the gas or vapour involved*
- *Gas or vapour classification in relation to the group or subgroup (applicable for protection 'd', 'i' and certain apparatus with protection 'n')*
- *External influences and ambient temperature*

The table below shows the relationship between the gas/vapour subdivision and the apparatus subgroup:

GAS/VAPOUR SUBDIVISION	APPARATUS SUBGROUP
IIA	IIA, IIB, IIC
IIB	IIB, IIC
IIC	IIC

4.4.2 Protection against dangerous incendive sparking

In order to avoid the formation of sparks liable to ignite the explosive atmosphere, any contact with bare live parts other than intrinsically safe parts must be prevented. Usually, IP54 is specified as a minimum degree of protection. Where intrinsically safe and non-intrinsically safe circuits are together in an enclosure, the non-intrinsically safe circuits may be protected with an IP30 cover.
The basic principles on which safety depends are the limitation of earth-fault currents (magnitude and/or duration) in frameworks or enclosures, and the prevention of elevated potentials on equipotential bonding conductors. For electrical supply systems other than intrinsically safe circuits for use in zones 1 and 2 up to 1000 V a.c./1500 V d.c. the following applies:

TN system
If a type TN power system is used, it must be the type TN-S (with separate neutral N and protective conductor PE) in the hazardous area, i.e. the neutral and the protective conductor must not be connected together, or combined in a single conductor, in the hazardous area. At any point of transition from TN-C to TN-S, the protective conductor must be connected to the equipotential bonding system in the non-hazardous area.

TT systems
If a TT system is used in zone 1, it has to be protected by a residual current device.

IT systems
If an IT system is used, an insulation-monitoring device must be provided to indicate the first earth fault.

Equipotential bonding
Potential equalisation is required for installations in hazardous areas. For TN, TT and IT systems, all exposed and extraneous conductive parts must be connected to the equipotential bonding system. It is also advisable to connect metal constructions, metal conduits and metal cable sheaths to the system. Connections must be permanent and secure against self-loosening. Exposed conductive parts need not be separately connected to the equipotential bonding system if they are firmly secured to and in metallic contact with structural parts or piping which are connected to the equipotential bonding system. Metallic enclosures of intrinsically safe apparatus do not have to be connected to the equipotential bonding system unless required by the apparatus documentation.

Static electricity
The standard EN 50014 specifies the basic requirements, and the product standards EN 50284 (zone 0) and EN 50021 list the requirements to be met by electrical equipment. Unlike earlier provisions, these standards specify the surface resistances and the maximum admissible sizes of plastics surfaces for zone 2.

Lightning protection
Because no internationally harmonised standards exist for lightning protection, national standards have to be applied. In any case, steps must be taken to reduce the effects of lightning to a safe level.

4.4.3 Electrical protection

The electrical equipment and the wiring must be protected against overload and the harmful effects of short circuits and earth faults. Special protective measures are required in the case of rotating electrical machinery. The overload protective devices to be used are:

- *A current-dependent, time lag device for all three phases, set at no more than the machine's rated current. The device must trip within 2 hours at 1.2 times the set current but must not trip within 2 hours at 1.05 times the set current.*
- *Embedded temperature sensors providing direct temperature monitoring of the machine.*

In no case should the automatic switch-off result in an increased safety risk. Where it might, alarming is an acceptable alternative to automatic disconnection if the alarm leads to immediate remedial action.

4.4.4 Wiring systems

Cable systems must be installed such that they are protected against mechanical damage and corrosion or chemical influences. The effects of heat should also be avoided.
Ducts, pipes and trenches are designed such that gases cannot collect in them.
Where circuits cross the hazardous area, the wiring system must comply with the relevant zone. Openings in walls or ceilings for cables and conduits must be adequately sealed.
Cable runs in hazardous areas should be uninterrupted. Where connections are made, the correct type of protection must be used, e.g. Ex e junction box.
Unused cores should be terminated in appropriate terminals. They should be bonded to earth at one point, preferably in the safe area.
Multi-stranded and, in particular, fine stranded conductors must be protected against separation of the strands by means of ferrules, lugs or the type of terminal, e.g. all Weidmüller terminal types. When using ferrules, the correct crimping tool should be used.
In general, only one conductor per terminal clamp is permitted. Some types of terminals are able to accommodate more than one conductor, e.g. slot type and Weidmüller's W-series. Alternatively, two wires in one ferrule are also regarded as one conductor.
Where aluminium is used as the conductor material, the cross-sectional area must be at least 16 mm^2, with the exception of intrinsically safe circuits.
Overhead lines should be terminated in the non-hazardous area and the service continued into the hazardous area with cable or conduit. Suitable surge protection should be fitted at or near this terminal point.
Cables for fixed wiring must have flame propagation characteristics.
Conduit systems must be fitted with sealing fittings:

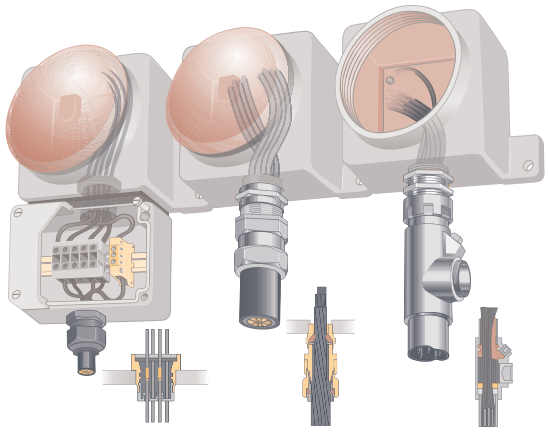
- *Where it enters or leaves a hazardous area*
- *Within 450 mm of all enclosures containing a source of ignition in normal operation*
- *At any enclosure containing taps, splices, joints or terminations where the conduit diameter is more than 50 mm*

The total cross-sectional area of the cables, including insulation, must not be more than 40% of the cross-sectional area of the conduit.
To meet the degree of protection of an enclosure, it may be necessary to seal between the conduit and the enclosure or between the conductors and the conduit.
Unused cable entries should be fitted with stopping plugs appropriate for the type of protection. Except for intrinsic safety, they should only be removed with the aid of a tool.

4.4.5 Additional requirements for flameproof enclosures 'd'

Flameproof joints must be protected against corrosion. The use of gaskets is only permitted when specified in the documentation. Non-setting grease or anti-corrosive agents can be applied. Non-hardening grease-bearing textile tape may also be employed outside of the joint, but only in conjunction with gases allocated to group IIA. The tape should be restricted to one layer surrounding all parts of the joints with a short overlap.
There are three cable entry systems:

- *Direct entry*
- *Indirect entry via, e.g. Ex e enclosure*
- *Conduit*



For direct entry, the cable gland selection must be made according to appendix.

To maintain the integrity of the type of protection, glands and conduits should have at least 5 threads of engagement. Clearance holes are not allowed in flameproof enclosures. When mineral-insulated cable is selected (with or without plastic outer covering), the cable gland assembly and 'sealing pot' must be EEx'd' certified and installed strictly in accordance with the manufacturer's instruction. This type of cable is often used for fire and gas protection systems due to its high resistance to temperature and integrity during a fire. Conduit systems must be of the type:

- *Screwed heavy gauge, solid-drawn or seam-welded*
- *Flexible conduit of metal or composite material construction*

Motors supplied at varying frequency and voltage require either:

- *Means for direct temperature control by embedded temperature sensors specified in the motor documentation. The action of the protective device will be to disconnect the motor. In this case, the motor and converter combination does not have to be tested together.*
- *The motor has been type-tested for this duty as a unit in association with the converter specified in the descriptive documents.*

4.4.6 Additional requirements for increased safety 'e'

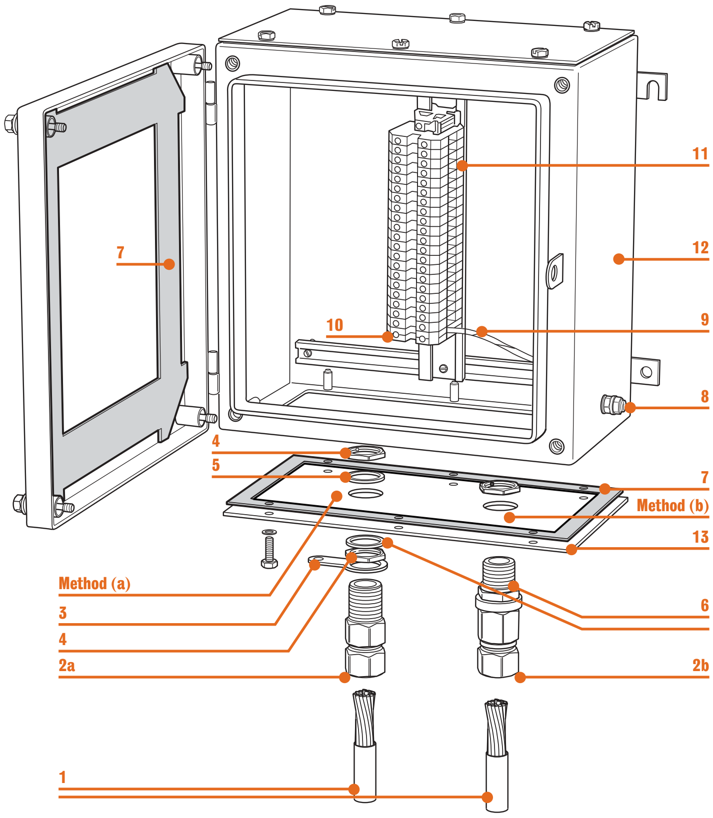
Cable entry devices must maintain at least IP54. Threaded entries in enclosures with a wall thickness of at least 6 mm do not require a sealing washer to maintain the minimum IP rating. However, in practice enclosures are normally IP65 or IP66. Therefore, a sealing washer is recommended.
The various methods of entry for metallic enclosures and for thick wall plastic enclosures are detailed in the next figure. When cast alloy enclosures are selected, special care is necessary to avoid the danger from bimetallic corrosion with dissimilar metals. This is particularly prevalent with alloy enclosures fitted with brass cable glands. The options to overcome this problem are, nickel plated brass, stainless steel, plastic or glands made from a compatible alloy. Plastic enclosures do not present the same earth and bonding problems in Germany and other Continental European countries as they do in the UK. When armoured cables are used the armour must be effectively bonded to the main earth connection on the enclosure. There are commonly two methods used to achieve the necessary earthing requirements as shown in thw following figure i.e. either an internal metal cruciform plate, or alternatively a thick brass plate which is normally supplied with a threaded entry. Due to the overall wall thickness of many non-metallic enclosures, plus the need for sealing and possibly an anti vibration washer, it is often necessary to use a cable gland with an extra long cable gland entry thread (e.g. 20 mm).
Concern has been expressed by various certification bodies regarding the potential danger of self-loosening of cable glands, due to thermal effects in non-metallic enclosures. EN 50019 includes a new test requirement for plastic enclosures that tests the thermal stability of the enclosure material. If the material passes the test, the earth continuity should be secure even without the serrated washer. If it fails the test, the only way to securely maintain the earth continuity is by sandwiching the brass plate between two lock nuts.

STEEL TB TYPE EEX'E' CERTIFIED TERMINAL BOX (CABLE ENTRY GUIDANCE)

1	Cable must be compatible to the selected cable gland
2a	Standard EEx'e' or 'd' IP66 cable gland
2b	Deluge Proof EEx'e' 'd' IP66 cable gland
3	Earth ring tag
4	Locknut
5	Anti vibration serated washer
6	Ingress sealing washer
7	Ingress sealing gasket
8	Internal/External main earth connection
9	Earth bonding conductor (green/yellow)
10	Terminal mounting - rail earth continuity Terminal type EK (green/yellow)
11	EEx'e' component certified rail mounted terminals
12	EEx'e' component certified enclosure
13	Gland plate (2, 3 or 4)

METHOD

a	Clearance cable entry hole
b	Tapped cable entry hole

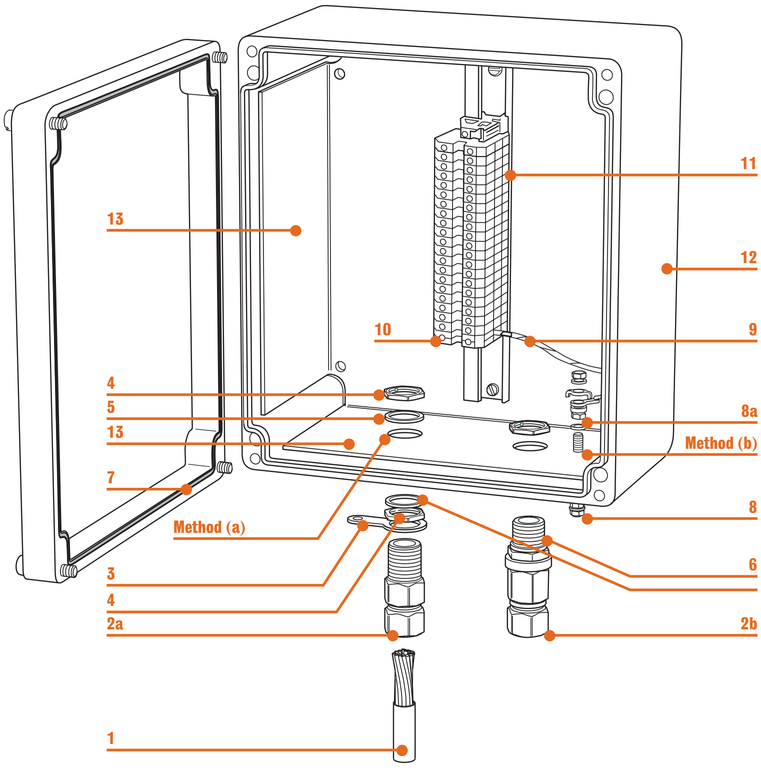


'POK Ex' TYPE CERTIFIED BOX CABLE ENTRY GUIDANCE
(WITH INTERNAL CRUCIFORM EARTH CONTINUITY PLATE)

1	Cable must be compatible to the cable gland
2a	EEx'e' or 'd' cable gland
2b	EEx'e' or 'd' cable gland (deluge proof version)
3	Earth ring tag
4	Locknut
5	Anti vibration serated washer
6	Ingress sealing washer
7	Ingress sealing gasket
8	Optional internal/external main earth connection
8a	Earth continuity connection assembly arrangement
9	Earth bonding conductor (green/yellow)
10	Terminal mounting - rail earth continuity terminal type EK (green/yellow)
11	EEx'e' component certified rail mounted terminals
12	EEx'e' component certified enclosure
13	Internal cruciform earth continuity plate (brass)

METHOD

a	Clearance cable entry hole
b	Tapped cable entry hole



Motors supplied at varying frequency and voltage by a converter must be type-tested for this duty as a unit in association with the converter specified with the descriptive documents.

4.5 Inspection and maintenance

4.5.1 General requirements

Electrical installations in hazardous areas have features specifically designed to make them suitable for use in such atmospheres. ATEX 137 stipulates that it is the operator's responsibility to maintain the integrity of those special features. The operator must ensure that electrical equipment is:

- *Installed and operated correctly*
- *Monitored on a regular basis*
- *Maintained with due regard to safety*

The main standard for the inspection and maintenance requirements is EN 60079-17/IEC 60079-17: Electrical apparatus for explosive gas atmospheres, 'Inspection and maintenance of electrical installations in hazardous areas (other than mines)'. Depending on the country and industry, e.g. offshore or petrol stations, additional national standards might have to be complied with.

4.5.1.1 Documentation

Up-to-date information on the following items must be made available:

- *Site drawings outlining the zone classification*
- *List and location of the apparatus*
- *Apparatus group and temperature class*
- *Special conditions for safe use of electrical apparatus with certificate numbers, which have the suffix 'X'. The 'instructions' of ATEX certified equipment must have all relevant information listed*
- *Descriptive system document for the intrinsically safe system*
- *Spares list*

4.5.1.2 Qualification of personnel

The inspection and maintenance of installations should only be carried out by experienced personnel whose training has included instruction on the various types of protection and installation practices, the relevant rules and regulations, and on the general principles of area classification. Appropriate continuing training should be undertaken on a regular basis.

4.5.1.3 Permit-to-work

A permit-to-work system is a formal written system used to control certain types of work that are potentially hazardous. A permit-to-work is a document which specifies the work to be done and the precautions to be taken. Permits-to-work form an essential part of safe systems of work for many inspection and maintenance activities. They allow work to start only after safe procedures have been defined, and they provide a clear record that all foreseeable hazards have been considered.
A permit is needed when inspection or maintenance work can only be carried out if normal safeguards are dropped, or when new hazards are introduced by the work. Examples are entry into vessels, hot work and pipeline breaking. The precise format of a work permit will vary from site to site.

4.5.2 Inspections

4.5.2.1 General

Before a plant is brought into service for the first time, it must be given an initial inspection. This work can be done by the operator or an outside company (third party).
To ensure that the installation is maintained in a satisfactory condition, it is necessary to carry out either:

- *Regular periodic inspections, or*
- *Continuous supervision by skilled personnel*

and, where necessary, maintenance must be carried out.

4.5.2.2 Types of inspection

a. *Initial inspections are used to check that the selected type of protection and its installation are appropriate. Example checklists are shown in tables 1, 2 and 3 (see Appendix VII).*
b. *Periodic inspections are carried out on a routine basis. They may be visual or close (see tables 1, 2 and 3 in Appendix VII) but could lead to a further detailed inspection.*
The type of equipment, manufacturer's guidance, deterioration of the apparatus, zone of use, and the result of previous inspections determine the grade and the interval between periodic inspections.
The interval between periodic inspections should not exceed three years without seeking expert advice or the use of extensive inspection data.
Movable electrical apparatus are particularly prone to damage or misuse and therefore the interval between inspections should be set accordingly.
c. *Sample inspections can be visual, close or detailed. The size and composition of all samples depends on the purpose of the inspection.*
d. *Continuous supervision is based on the frequent attendance, inspection, service, care and maintenance of the electrical installation by skilled personnel who have experience in the specific installation and its environment, in order to maintain the explosion protection features of the installation in satisfactory condition.*
Where the installation falls outside the capability of continuous supervision, it will be subject to periodic inspection.

4.5.2.3 Grades of inspection

a. *Visual inspections identify, without the use of ladders or hand tools, those defects which are apparent to the eye, e.g. missing bolts*
b. *Close inspections include those aspects covered by visual inspections and, in addition, identify those defects, which are only apparent by the use of access equipment and tools, e.g. loose bolts. Close inspections do not normally require the enclosure to be opened or the equipment to be de-energised.*
c. *Detailed inspections include those aspects covered by close inspections and, in addition, identify those defects, which are only apparent by opening the equipment and/or using tools and test equipment, e.g. loose terminals. Detailed inspections are carried out on completion of the installation, when it has been handed over by the installation contractor, and prior to the equipment being put into service.*

4.5.3 Regular periodic inspections

To set an appropriate inspection interval accurately is not easy, but it should be fixed taking into account the expected deterioration of the equipment. Major factors effecting the deterioration of apparatus include: susceptibility to corrosion, exposure to chemicals or solvents, likelihood of accumulation of dust or dirt, likelihood of water ingress, exposure to excessive ambient temperatures, risk of mechanical damage, exposure to undue vibration, training and experience of personnel, likelihood of unauthorised modifications or adjustments, likelihood of inappropriate maintenance, e.g. not in accordance with manufacturer's recommendation. Once intervals have been set, the installation can be subjected to interim sample inspections to support or modify the proposed intervals or inspection grades.
Where inspection grades and intervals have been established for similar apparatus, plants and environments, this experience can be used to determine the inspection strategy.

4.5.4 Continuous supervsion by skilled personnel

The objective of continuous supervision is to enable the early detection of arising faults and their subsequent repair. It makes use of existing personnel who are in attendance at the installation in the course of their normal work, e.g. erection work, modifications, inspections, maintenance work, checking for faults, cleaning, control operations, functional tests and measurements. Therefore, it may be possible to dispense with the regular periodic inspection and utilise the more frequent presence of the skilled personnel to ensure the ongoing integrity of the apparatus.
A technical person with executive function will be responsible for each installation and its skilled personnel. He will assess the viability of the concept and define the scope of equipment to be considered under continuous supervision. He will also determine the frequency and grade of inspection as well as the content of reporting to enable meaningful analysis of apparatus performance.

4.5.5 Maintenance

Appropriate remedial measures might have to be taken following an inspection report. Care must be taken, to maintain the integrity of the type of protection provided for the apparatus; this may require consultation with the manufacturer. When necessary, the area of work shall be confirmed gas-free prior to commencement of work.
Maintenance requires more detailed knowledge than when the equipment is first installed. Defect parts should only be replaced by manufacturers' authorised replacement parts, and modifications that might invalidate the certificate or other documents should not be made.
For equipment that is manufactured and certified according to ATEX 95, the maintenance requirements, including the need for special tools, can be found in the operating instructions supplied with each piece of equipment.
Some maintenance tasks are listed below:
Flameproof flanges should not be broken without justification. When reassembling flameproof enclosures, all joints shall be thoroughly cleaned and lightly smeared with a non-setting grease to prevent corrosion and to assist weatherproofing. Only non-metallic scrapers and non-corrosive cleaning fluids should be used to clean flanges. A wrap of non-hardening tape may also be used in conjunction with gases allocated to group IIA.
The gasket on increased safety enclosures should be checked for damages and replaced if necessary. Terminals might have to be tightened. Any discoloration could indicate a rise in temperature and the development of a potential hazard. Cable glands and stopping plugs should be checked for tightness.
When replacing lamps in luminaries, the correct rating and type should be used, otherwise excessive temperatures may result.
If it is necessary to withdraw the equipment for maintenance purposes, the exposed conductors must be correctly terminated in an appropriate enclosure, e.g. EEx 'e', or isolated from all sources of supply and either insulated or earthed.

4.5.6 Repair

Ideally, repair work on explosion-proof electrical equipment should only be carried out by the manufacturer. This rule can be waived in cases where the repairs are carried out by instructed and specially trained, skilled personnel, and only genuine spare parts are used. IEC 60079-19 gives guidance on the repair and overhaul of certified equipment. It is not permissible for modifications and rework to be carried out that could jeopardise the characteristics essential to explosion protection (type of protection and temperature class). Rewiring of installations is permissible if carried out by trained, skilled personnel. The rewiring work done must be properly logged.
It is forbidden to rework the gap lengths and gap widths of flameproof enclosures by machining, or to apply paint or other coatings to the respective joints. Such modifications could impair the integrity of the enclosure and cause an uncontrolled explosion.
When ATEX 95 and ATEX 137 came into force on 1 July 2003, a number of issues present themselves regarding spare parts.
Spare parts that are not equipment, protective systems, components or devices, as defined in ATEX 95, are not subject to the directive. Therefore, if the spare part does not require certification today, it will not require ATEX certification when placed on the market after 30 July 2003, provided the spare part is identical to the one it replaces, e.g. manufacturers of non-electrical equipment can continue to supply spare parts for existing equipment without the need to re-certify. Spare parts that are equipment, protective systems, components or devices according to article 1 of ATEX 95 will have to comply with the directive when placed on the market after 1 July 2003, e.g. if a lighting fitting contains a component-certified ballast today, a ballast manufactured and supplied after 30 June 2003 will have to comply with ATEX 95, or component-certified terminals supplied as spare parts after 30 June 2003 will have to comply with ATEX 95. When the manufacturer of the original spare part offers a new, different one in its place (due to technical progress, obsolescence, etc.) and it is used for the repair, ATEX 95 does not apply to the repaired product (as long as no substantial modifications have taken place).
Spare parts which were placed on the market before 30 June 2003 and were 'ready for use' at the time can still be used after 30 June 2003. 'Ready for use' means the ability to be incorporated or installed without a change to the performance or safety characteristics as originally intended by the manufacturer. Whether a product is 'ready for use' will have to be assessed on a case-by-case basis, but basically it means that qualifying stock at distributors and end-users can be used after 30 June 2003. Examples of products 'ready for use' are pre-assembled junction boxes, barriers, solenoid valves, etc. Equipment which requires assembly before it can be sold is not 'ready for use'.

SECTION 5
COMBUSTIBLE DUSTS

5.1 Definitions and dust characteristics

5.1.1 General

Installations in which combustible dust is handled, produced or stored should be designed, operated and maintained so that any releases of combustible dust, and consequently the extent of classified areas, are kept to a minimum. In situations where explosive dust/air mixtures are possible, the following steps should be taken:

- *Eliminate the likelihood of an explosive dust/air mixture and combustible dust layers; or*
- *Eliminate the likelihood of any ignition source*

If this cannot be done, measures should be taken to avoid that either or both exist at the same time. If it is not possible to eliminate the probability of an explosive dust/air mixture and a source of ignition at the same time, explosion protective systems should be considered to halt an incipient explosion immediately or to mitigate the effects, e.g. dust explosion venting systems.
However, in order to avoid unnecessary and costly plant down time, measures would still be put in place to minimise the possibility of an ignition occurring.
The concept for area classification is similar to that used for flammable gases and vapours. However, combustible dusts, unlike flammable gases and vapours, will not necessarily be removed by ventilation or dilution after release has stopped. Very dilute and therefore non-explosive dust clouds could, in time, form thick dust layers.
Dust layers present three risks:

1. *A primary explosion within a building may raise dust layers into clouds, and cause secondary explosions more damaging than the primary event. Dust layers should always be controlled to reduce this risk.*
2. *Dust layers may be ignited by the heat flux from equipment on which the layer rests. The risk is of fire, rather than explosion, and this may be a slow process.*
3. *A dust layer may be raised into a cloud, ignite on a hot surface and cause an explosion. In practice, dust cloud ignition temperatures are often much higher than layer ignition temperatures.*

The likelihood of a layer causing a fire can be controlled by the correct selection of equipment and effective housekeeping.

5.1.2 Directives and standards relevant to dust

The standards supporting the two directives ATEX 95, which is aimed at manufacturers, and ATEX 137, which is aimed at users, are listed in the table on the right.
Until the ATEX directives had been developed, dust areas in the UK had been classified in zones Y and Z based on standards BS 6467 and BS 7535. Germany has used a different classification system, zones 10 and 11. Current equipment standards and installation practices are allowed until 30 June 2003, after which only ATEX-certified equipment may be placed on the market and put into service.

NUMBER OF CURRENT IEC STANDARD	PROPOSED NEW IEC NUMBER	CENELEC STANDARD	SUBJECT
61241-1-1	61241-0		General requirements
	61241-1	50281-1-1	Protection by enclosures 'tD'
61241-1-2	61241-14	50281-1-2	Selection and installation
61241-2-1	61241-20-1	50281-2-1	Test method – MIT
61241-2-2	61241-20-2		Test method – electrical resistivity
61241-2-3	61241-20-3		Test method – MIE
61241-3	61241-10	pr50281-3	Area classification
61241-4	61241-2	61241-4	Pressurisation 'pD'
	61241-11		Intrinsic safety 'iD'
	61241-18		Encapsulation 'mD'
	61241-17	50281-1-2	Inspection & maintenance
	61241-19		Repair & overhaul

5.1.3 Dust definitions

5.1.3.1 Dust

Small solid particles in the atmosphere which settle out under their own weight, but which may remain suspended in the air for some time.

5.1.3.2 Combustible dust

Dust that can burn or glow in the air and form explosive mixtures with air at atmospheric pressure and normal temperature.

5.1.3.3 Conductive dust

Dust with an electrical resistivity equal to or less than 10^3 Ωm.

5.1.3.4 Explosive dust atmosphere

Mixture with air, under atmospheric conditions, of flammable substances in the form of dust, or fibres in which, after ignition, combustion spreads throughout the unconsumed mixture.

5.1.4 Dust characteristics

As part of the explosion risk assessment when dealing with dust, as required under ATEX 137, three basic questions should be answered.

1. *Is it flammable?*
2. *How easily can it be ignited?*
3. *How violent will the explosion be?*

Some dusts will glow when in contact with a heat source but extinguish immediately when removed, others will burn fiercely and sustain a fire, which could ignite a dust cloud. If the combustibility of a product is required at a high ambient temperature, the sample should be tested at the anticipated high temperature, e.g. drying temperature. Sometimes there can be a big difference in the combustion behaviour.
The ease of ignition is addressed by the measurement of the minimum ignition temperature of a dust layer and dust cloud, and the minimum ignition energy.

The minimum ignition temperature of a dust layer is the lowest temperature of a heated, free-standing surface which is capable of igniting a 5 mm thick dust layer. Combustible dusts, when deposited in heaps or layers, may, under certain circumstances, develop internal combustion and high temperatures. Mostly, this occurs when the dust deposit or layer rests on a heated surface, which supplies the heat needed to trigger self-ignition in the dust. Such surfaces can be overheated bearings, heaters in workrooms, light bulbs, walls in dryers, etc. If disturbed and dispersed by an air blast or a mechanical action, the burning dust can easily initiate a dust explosion if brought into contact with a combustible dust cloud. Sometimes the dust in the deposit that has not yet burnt forms the dust cloud.

The minimum ignition temperature of a dust cloud is the lowest temperature of a heated impact plate at which the dust blown into the oven ignites or decomposes, producing flames or an explosion in less than or equal to 5 seconds. Hot surfaces capable of igniting dust clouds exist in a number of situations in industry, such as in furnaces, burners and dryers, or by overheated bearings. The minimum ignition temperature is not a true constant for a given dust cloud, but depends on the geometry of the hot surface and the dynamics of the cloud. If the dust cloud is kept at a high temperature for a long period of time, e.g. in a fluidised bed, ignition can occur at temperatures below the experimentally determined minimum ignition temperature.
The minimum ignition energy (MIE) of a dust cloud is the lowest energy value of a high-voltage capacitor discharge required to ignite the most ignitable dust/air mixture at atmospheric pressure and room temperature. Powders show quite a broad spectrum of ignition sensitivity, and the vast majority need a very energetic ignition source. On plants where powders and solvents are handled, the risk assessment will normally be centred on the solvent characteristics. The following table shows some explosive parameters of dust.

MATERIAL	T_{CLOUD} (°C)	T_{LAYER} (°C)	IGNITION ENERGY (mJ)
FLOUR	380	300	>30
WOOD FLOUR	410	200	>100
ALUMINIUM	560	270	>5
SULPHUR	240	250	10

The explosion violence is determined by the explosion pressure characteristics. The maximum explosion pressure, the maximum rate of pressure rise and the lower explosion limit are determined in a standard test apparatus with a content of 20 litres.
The maximum rate of pressure rise (dp/dt) max. measured in the 20 litre-sphere is used to obtain the K_{St}-value. **The maximum explosion pressure** and the **K_{St}-value** describe the explosion behaviour of a combustible dust in a closed system. The following tables give the St classification of dust explosions and some examples of K_{St}-values.

05 COMBUSTIBLE DUSTS

CLASS	K_{St} (bar m/s)	CHARACTERISTICS
St0	0	No explosion
St1	0-200	Weak/moderate explosion
St2	200-300	Strong explosion
St3	>300	Very strong explosion

MATERIAL	K_{St}
Coal dust	60-97
Grain	98-112
Epoxy resin	53-168
Flour	80-192
Organic pigment	28-344
Aluminium	16-1900

Most process equipment is normally far too weak to withstand the pressures exerted even by only partly developed, confined dust explosions. Consequently, a primary objective of fighting an explosion after it has been initiated is to prevent the build-up of destructive overpressures. Explosion-protective systems such as venting, suppression and isolation can be used.

The explosion limits describe the range of dust concentrations in the air within which an explosion is possible. Generally, only the lower explosion limit is determined.

Other factors affecting dust flammability are particle size, moisture content, solvent content and temperature. Having obtained the relevant information regarding the process, plant and material characteristics, the next step is to locate the flammable atmospheres and identify any potential sources of ignition.

5.2 Area classification

5.2.1 Definitions of zones

The concept of zones for dusts is based on the classification of areas where combustible dust may be present, either as a layer or a cloud of combustible dust, mixed with air. The area where there is a possibility of combustible dust being present is divided into 3 zones (ATEX 137) dependent on the probability of a release and the presence of the dust. Some references to previous zones Y and Z or 10 and 11 are likely to be found in documentation for some time.

5.2.1.1 Zone 20

Definition of zone 20

A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is present continuously for long periods or frequently.

Examples of typical zone 20 locations
- *Inside hoppers, silos, etc.*
- *Inside cyclones and filters*
- *Inside dust transportation systems, except some parts of belt and chain conveyors*
- *Inside blenders, mills, dryers, bagging equipment, etc.*
- *Outside the containment, where bad housekeeping allows layers of dust of uncontrollable thickness to be formed*

5.2.1.2 Zone 21

Definition of zone 21

A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is likely to occur occasionally in normal operation.

Examples of typical zone 21 locations
- *Areas outside dust containment and in the immediate vicinity of access doors subject to frequent removal or opening for operation purposes when internal explosive dust/air mixtures are present*
- *Areas outside dust containment in the proximity of filling and emptying points, feed belts, sampling points, truck dump stations, belt dump-over points, etc., where no measures are employed to prevent the formation of explosive dust/air mixtures*
- *Areas outside dust containment where dust accumulates and where, due to process operations, the dust layer is likely to be disturbed and form explosive dust/air mixtures*
- *Areas inside dust containment where explosive dust clouds are likely to occur (but neither continuously, nor for long periods, nor frequently), e.g. silos (if filled and/or emptied only occasionally) and the dirty side of filters if long self-cleaning intervals occur*

5.2.1.3 Zone 22

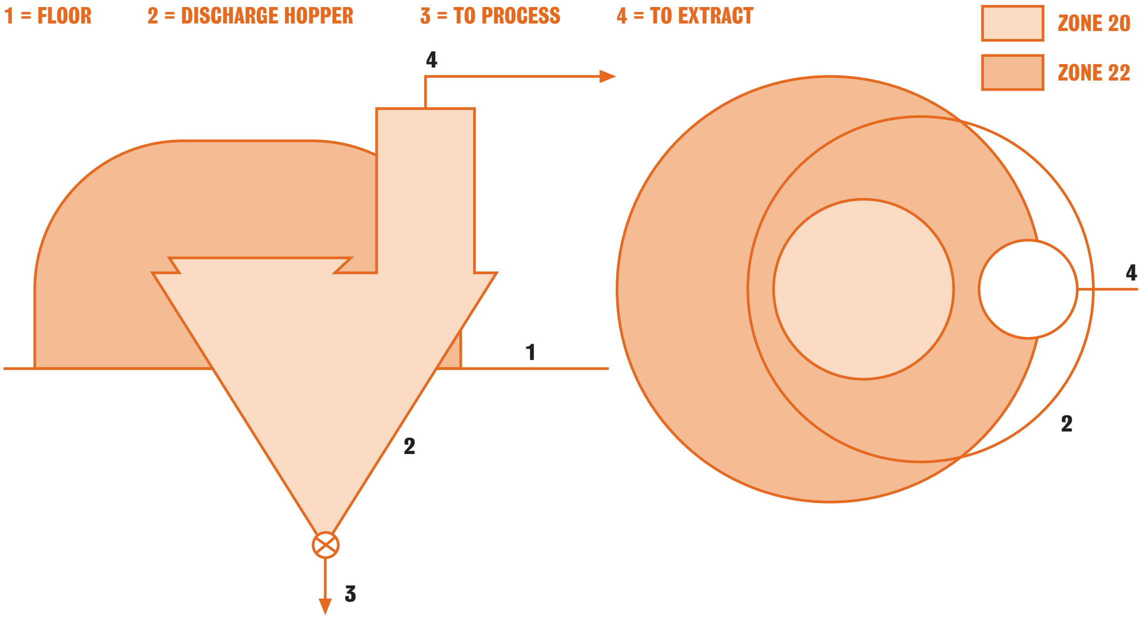
Definition of zone 22

A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

Examples of typical zone 22 locations

- *Outlets from bag filter vents, because in the event of a malfunction there can be emission of explosive dust/air mixtures*
- *Locations near equipment that has to be opened at infrequent intervals or equipment that, from experience, can easily form leaks where, due to pressure above atmospheric, dust will be blown out: pneumatic equipment, flexible connections that can become damaged, etc.*
- *Storage of bags containing dusty products. Failure of bags can occur during handling, causing dust leakage*
- *Areas that are normally classified as zone 21 can fall under zone 22 when measures are employed to prevent the formation of explosive dust/air mixtures. Such measures include exhaust ventilation. The measures should be used in the vicinity of (bag) filling and emptying points, feed belts, sampling points, truck dump stations, belt dump-over points, etc.*
- *Areas where controllable dust layers are formed that are likely to be raised into explosive dust/air mixtures. Only if the layer is removed by cleaning before hazardous dust/air mixtures can be formed, is the area designated non-classified*

5.2.1.4 Zone identification



5.2.2 Grades of release, extent of zones, housekeeping

5.2.2.1 Grades of release

The conditions in which process equipment, process steps or other actions that can be expected in plants can form explosive dust/air mixtures or create combustible dust layers need to be identified. It is necessary to consider separately the inside and outside of a dust containment.
Inside a dust containment area, dust is not released to the atmosphere but as part of the process continuous dust clouds may be formed. These may exist continuously or may be expected to continue for long periods or for short periods, which occur frequently depending on the process cycle.
Outside the dust containment, many factors can influence the area classification. Where higher than atmospheric pressures are used within the dust containment, dust can easily be blown out of leaking equipment. In the case of negative pressure within the dust containment, the likelihood of formation of dusty areas outside the equipment is very low. Dust particle size, moisture content and, where applicable, transport velocity, dust extraction rate and fall height can influence release rate potential.
There are 3 grades of release:

- *Continuous presence of dust cloud: examples are the insides of process equipment such as silos, blenders and mills in which dust is introduced or formed*
- *Primary grade of release: examples are the close vicinity around an open bag filling or emptying point*
- *Secondary grade of release: examples are manholes that need to be opened occasionally and only during a very short period, or a dusts handling plant where deposits of dust are present*

Based on the likelihood of the formation of potentially explosive dust/air mixtures, the areas can be designated according to the table on the right:

DESIGNATION OF ZONES DEPENDING ON PRESENCE OF COMBUSTIBLE DUST

PRESENCE OF COMBUSTIBLE DUST	RESULTING ZONE CLASSIFICATION
Continuous presence of dust cloud	20
Primary grade of release	21
Secondary grade of release	22

5.2.2.2 Extent of zones

The extent of a zone for explosive dust atmospheres is defined as the distance in any direction from the edge of a source of dust release to the point where the hazard associated with that zone is considered to no longer exist. Consideration should be given to the fact that fine dust can be carried upwards from a source of release by air movement within a building. The extent of an area formed by a source of release also depends upon several dust parameters such as dust amounts, flow rate, particle size, product moisture content, etc. In case of areas outside buildings (open air) the boundary of the zone can be reduced because of weather effects such as wind, rain, etc.

5.2.2.3 Housekeeping

Inside a dust containment where powders are handled or processed, layers of dust of uncontrolled thickness often cannot be prevented because they are an integral part of the process.
Theoretically, the thickness of dust layers outside equipment can be limited. The limitation is by housekeeping, and during the consideration of sources of release it is essential to agree the nature of the housekeeping arrangements for the plant. The frequency of cleaning alone is not enough to determine whether a layer contains sufficient dust to control these risks. The rate of deposition of the dust has an effect; for example, a secondary grade of release with a high deposition rate may create a dangerous layer much more quickly than a primary grade with a lower deposition rate. The effect of cleaning is therefore more important than frequency.
Three levels of housekeeping can be described:

- *Good: dust layers are kept to negligible thickness, or are non-existent, irrespective of the grade of release. In this case, the risk of the occurrence of explosive dust clouds from layers and the risk of fire due to layers has been removed.*
- *Fair: dust layers are not negligible but are short-lived (less than 1 shift). Depending on the thermal stability of the dust and the surface temperature of the equipment, the dust may be removed before any fire can start.*
- *Poor: dust layers are not negligible and persist for more than 1 shift. The fire risk may be significant.*

When a planned level of housekeeping is not maintained, additional fire and explosion risks are created. Some equipment may no longer be suitable.

5.3 Dust explosion protection measures

Combustible dusts and fibres can be ignited by several electrical or mechanical ignition sources such as:

- *Hot surfaces*
- *Arcing or sparking in switches, contacts, brushes, etc.*
- *Electrostatic discharge*
- *Thermite sparks*
- *Mechanical sparking or friction*

In order to avoid effective ignition sources or mitigate their effect, a number of explosion protection measures can be applied.

5.3.1 Protective sytems

To halt an incipient explosion or to mitigate the effects of an explosion, the following protective systems can be considered:

5.3.1.1 Explosion-restistent (containment)

An explosion-resistant design ensures that the explosion is contained inside the vessel. This also means that connecting and isolating equipment have to meet the same requirements.
Two types of design exist:
Explosion pressure-resistant vessels or apparatus are able to withstand the expected pressure of the explosion without permanent deformation.
Explosion pressure shock-resistant vessels or apparatus are able to withstand the expected explosion pressure without destruction, but may be permanently deformed.

5.3.1.2 Venting system

An explosion vent is a relief device that ruptures at a predetermined pressure to allow the fireball and explosive pressure to vent into a safe area. The vents fit into the walls of a process volume and are available in a variety of sizes, configurations and materials to ensure fast, reliable operation in an explosion situation. Typically, vents are installed in conjunction with an isolation system.

5.3.1.3 Suppression system

In a matter of milliseconds, an explosion suppression system detects the build-up of pressure in an explosion, and discharges an explosion suppressant into the enclosed space before destructive pressures are created.
Chemically, by interfering with the explosion's reaction, and
thermally, by removing heat from the deflagration's flame front and thereby lowering its temperature below that needed to support combustion.
The explosion suppressant also creates a barrier between the combustible particles, to prevent the further transfer of heat.

5.3.1.4 Isolation system

Isolation systems are designed to detect incipient explosions and react instantly to keep the deflagration from spreading to unprotected areas or interconnected equipment.
The chemical type isolation method discharges an explosion suppressant into the pipeline to suppress the fireball and prevent it from reaching other plant areas or equipment.
The mechanical type isolation method produces the same results by triggering the release of a high-speed valve that forms a mechanical barrier in the pipeline.

5.3.2 Protection by enclosures – 'tD'

The harmonised standard EN 50281-1-1, which defines the concept, does not currently use the type designation 'tD'. In due course, the equivalent IEC standard, which uses this marking, will replace this standard. 'Protection by enclosures' is based on limiting the maximum surface temperature of the enclosure and restricting the ingress of dust by using dust-tight or dust-protected enclosures. The equipment inside the enclosure can be sparking or at a higher temperature than the surface temperature. Only when gas and dust are present at the same time will the type of enclosure and/or content be restricted. The term 'enclosure' is used for boxes, motor housings, luminaries, etc.

The degrees of dust protection are defined as:
Dust-tight enclosure: an enclosure which prevents the ingress of all observable dust particles. (IP6X)
Dust-protected enclosure: an enclosure in which the ingress of dust is not totally prevented, but dust does not enter in sufficient quantities to interfere with the safe operation of the equipment. Dust shall not accumulate in a position within the enclosure where it is liable to cause an ignition hazard (IP5X). The table in Appendix III gives details of the IP code.

In accordance with ATEX 95, the enclosures are used in the following zones:

ZONE 20	ZONE 21, ZONE 22 WITH CONDUCTIVE DUST	ZONE 22
IP6X	IP6X	IP5X
II 1 D	II 2 D	II 3 D

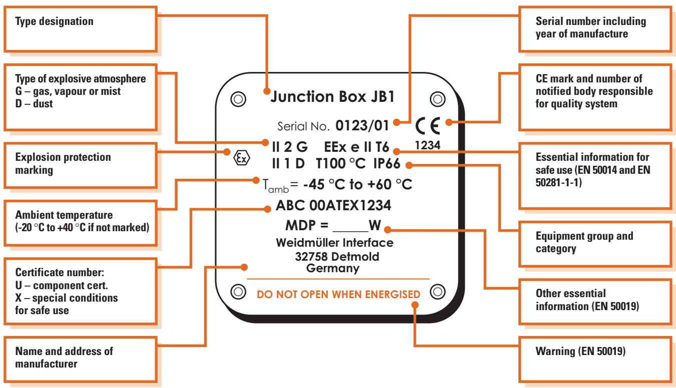
The requirement for category 1D and 2D enclosure and gasket materials is basically the same as for increased safety enclosures. However, the demands on non-metallic materials with regard to static electricity are more onerous. Propagating brush discharges have to be avoided, and this can be achieved by using plastic material with one or more of the following characteristics:

- *Insulation resistance* $\leq 10^9\ \Omega$
- *Breakdown voltage* $\leq$ *4 kV*
- *Thickness* $\geq$ *8 mm of the external insulation on metal parts*

A warning label 'Only clean with a damp cloth' is not allowed. Enclosures suitable for 3D are basically the same as for EEx n. **Cable entries** conform to the requirements of EN 50014. It should be noted that in the case of dust explosion protection for category 1D and 2D equipment, IP6X is required and for category 3D equipment, IP5X.

Marking in accordance with ATEX 95 should include

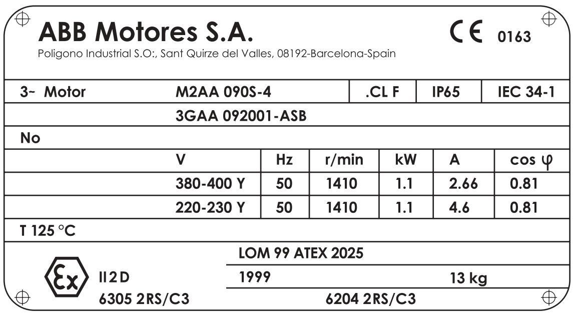
- *Manufacturer's name and address (logo)*
- *Type identification*
- *Serial number (if required)*
- *Year of manufacture*
- *Ex*
- *Equipment group II*
- *'D' for dust*
- *Category 1, 2 or 3*
- *Certificate number (if required)*
- *Maximum surface temperature*
- *IP rating*
- *Relevant electrical information*
- *CE mark*



05 COMBUSTIBLE DUSTS

The label is an example of the marking for a junction box. The assembly has been certified for gas as well as for dust atmospheres. However, when used in an environment where gas and dust is present at the same time, additional precautions should be taken before use, i.e. minimum IP rating for EEx e is IP54, but for zone 21 in a dust atmosphere, IP6X is required. Therefore, the minimum IP rating is IP64.

This label on the right is an example of the marking for a motor. This motor can be installed in zone 21 and has a maximum surface temperature of 125 °C and an IP rating of IP65.



5.3.3 Protection by pressurisation – 'pD'

The concept is basically the same as for gas. Special attention is placed on the presence of dust when opening and closing the enclosure. The temperature classification of the unit is determined by the higher of the following temperatures:

- *The maximum external surface temperature of the enclosures*
- *The maximum surface temperature of internal parts that are protected and remain energised when the supply of protective gas for pressurisation is removed or fails*

5.3.4 Protection by encapsulation – 'mD'

With this type of protection, a piece of electrical equipment that generates sparks or heats up excessively can be encapsulated in a casting compound (thermosets or thermoplastics with or without fillers) so that it is shielded from an external explosive dust atmosphere. Encapsulation guarantees isolation from an explosive atmosphere under all operating and installation conditions.
A standard is currently being drafted.

5.3.5 Protection by intrinsic safety – 'iD'

The concept is basically the same as for gas atmospheres. For apparatus installed in dust containment, barriers of the type 'ia' must be used.
A standard is currently being drafted.

5.3.6 Other protection concepts

Current practice in combustible dust applications uses equipment certified for use in gas atmospheres. This is allowed until 30 June 2003, after which only ATEX-certified equipment may be installed.
The zones of use are listed in the table on the right:

PROTECTION TYPE		ZONES OF USE
FLAMEPROOF ENCLOSURE	EEx d	21 & 22
INCREASED SAFETY	EEx e	21 & 22
REDUCED RISK	EEx n	22
INTRINSIC SAFETY	EEx i	ia: 20, 21, 22 ib: 21, 22
PRESSURISATION	EEx p	21 & 22
ENCAPSULATION	EEX m	21 & 22
OIL IMMERSION	EEx o	21 & 22
POWDER FILLING	EEx q	21 & 22

Additional precautions have to be taken when using such equipment in a dust atmosphere. Flameproof equipment would have to be purchased specifically for dust atmospheres, as the normal IP rating might not be sufficient. Cabling can follow conventional practice for flameproof equipment, but if flammable gas is not an issue, EEx e cable glands with IP65 will be suitable. EEx e or EEx n apparatus should be purchased with the appropriate ingress protection. Intrinsically safe barriers certified for flammable gases can be used in dust atmospheres. When used in dust containment, barriers of the type 'ia' and certified for gas group IIC should be used.
In accordance with ATEX 95, apparatus with two independent methods of protection can also be used in zone 20. Example: tD-certified enclosure, IP6X with 'iD' circuit or 'pD' apparatus with 'tD'-certified enclosure.

5.3.7 Selection of apparatus

When selecting apparatus for use in dust atmospheres, the following information should be available:

- Zones equipment will be used in
- Characteristics of the dust present, such as:
  - Ignition temperature of 5 mm dust layer
  - Ignition temperature of the dust cloud

The equipment category suitable for the zones is selected in accordance with the table below:

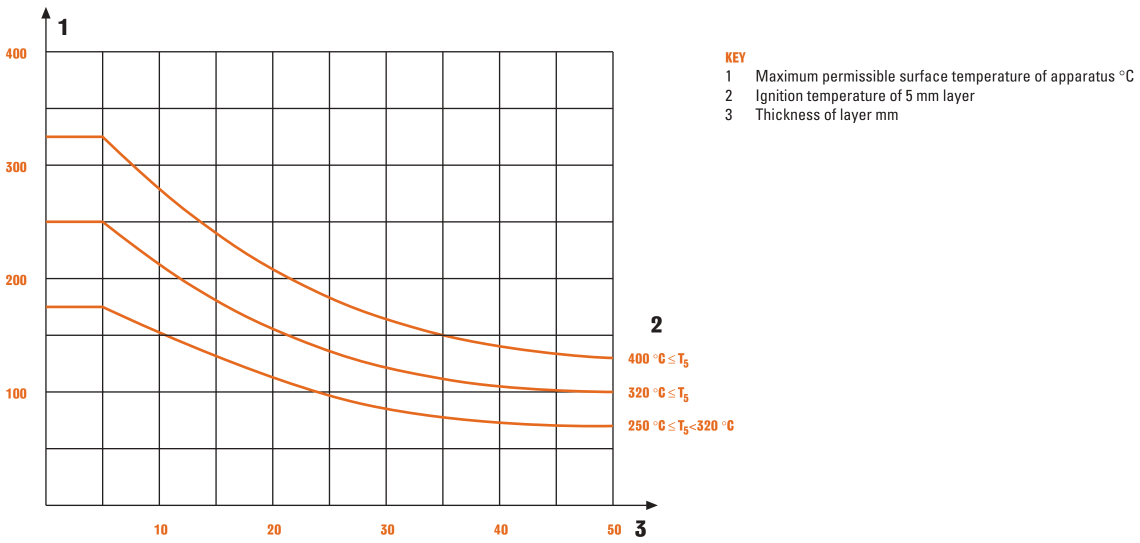
TYPE OF DUST	ZONE 20	ZONE 21	ZONE 22
CONDUCTIVE	Cat. 1D Excessive and uncontrollable dust layers. Test under simulated working conditions.	Cat. 1D or cat. 2D	Cat. 1D or cat. 2D
NON CONDUCTIVE	Cat. 1D Excessive and uncontrollable dust layers. Test under simulated working conditions.	Cat. 1D or cat.2D	Cat. 1D or cat. 2D or cat. 3D

The maximum surface temperature for apparatus operating in any zone is calculated by deducting a safety margin from the minimum ignition temperatures of a dust cloud and a dust layer up to 5 mm thick.

1. Maximum permissible surface temperature in case of dust clouds
$T_{max.} = 2/3\ T_{cloud}$
(T_{cloud} is the ignition temperature of a cloud of dust)
2. Maximum permissible surface temperature in case of dust layer (max. 5 mm)
$T_{max.} = T_{5\,mm} - 75\ K$
(T5 mm is the ignition temperature of a 5 mm dust layer)
Example: milk powder, skimmed spray dried
$T_{5\,mm} = 340\ °C$ and $T_{cloud} = 540\ °C$
$T_{max.}(1) = 2/3 \times 540\ °C = 360\ °C$
$T_{max.}(2) = 340\ °C - 75\ K = 265\ °C$

According to this, the maximum surface temperature of the apparatus must not exceed 265 °C. Where it is possible that dust layers between 5 mm and 50 mm are formed on top of the apparatus, the maximum permissible surface temperature must be reduced in accordance with the graph in the following figure.

REDUCTION IN MAXIMUM PERMISSIBLE SURFACE TEMPERATURE FOR INCREASING DEPTH OF DUST LAYERS



In our example, the ignition temperature of the 5 mm layer is between 320 °C and 400 °C, therefore the middle curve (320 °C) should be used. For a layer, say 20 mm thick, the maximum surface temperature derived from the figure above is: $T_{max.} = 160\ °C$
Where it cannot be avoided that a dust layer in excess of 50 mm is formed on top of the apparatus, around the sides, or where the apparatus is totally submerged in the dust (typical zone 20 application), a much lower surface temperature may be required. This should be investigated under simulated working conditions.
The special requirements for zone 20 can be met by a system of power limitation, with or without temperature control. Power engineering apparatus, e.g. motors, luminaries, plugs and sockets, shall, wherever practicable, be placed outside zone 20 areas or, if used at all, be submitted for special testing.

5.4 Installations

The installation requirements are similar to those in areas free of combustible dust. Installations in dust atmospheres shall be designed and apparatus installed with a view to providing ease of access for cleaning.

5.4.1 Types of cables

All common types of cable can be used if they are drawn into screwed, solid-drawn or seam-welded conduits. It is also possible to use cables that are inherently protected against mechanical damage and are impervious to dust, e.g.

- *Thermoplastic or elastomer-insulated, screened or armoured cable with a PVC, PCP, or similar sheath overall*
- *Cables enclosed in a seamless aluminium sheath with or without armour*
- *Mineral insulated cables with metal sheath*
  Note: Cables may need to be derated to limit surface temperature
- *Cables externally provided with protection or where there is no danger of mechanical damage, thermoplastic or elastomer-insulated with a PVC, PCP or similar overall sheath are allowed*

5.4.2 Cable installation

- *Cable runs shall be arranged so that they are not exposed to the friction effects and build-up of electrostatic charge due to the passage of dust.*
- *Cable runs shall be arranged as far as possible so that they collect the minimum amount of dust and are accessible for cleaning. Wherever possible, cables that are not associated with the hazardous areas shall not pass through.*
- *Where layers of dust are liable to form on cables and impair the free circulation of air, consideration shall be given to reduce the current-carrying capacity of the cables, especially if low ignition temperature dust is present.*
- *When cables pass through a floor, partition or a ceiling that forms a dust barrier, the hole that is provided shall be made good to prevent the passage or collection of combustible dust.*
- *When a metal conduit is used, care should be taken to ensure that no damage might occur to the connecting points, that they are dustproof, that the dust proofing of connected equipment is maintained, and that they are included in the potential equalisation.*

5.4.3 Cable entry devices

The requirements for the entries in category 1D and 2D dust explosion protection equipment are basically the same as for increased safety. The only difference is the IP rating, IP6X for zone 20 and zone 21.

5.5 Inspection and maintenance

5.5.1 Inspection

Inspection criteria are still undergoing extensive revision. The procedures are similar to those for gas atmospheres but special consideration should be given to:

- *Presence of accumulations of dust on the outside of apparatus is to be noted and recorded. Excessive dust layers will cause apparatus to overhead, which may lead to premature failure*
- *Presence of any dust within the equipment and enclosures when carrying out detailed inspections. Note and record presence of dust*

The inspection table in appendix VIII represents current views, but may be subject to future amendments. The inspection grades used are the same as for gas atmospheres.

5.5.2 Maintenance

Maintenance procedures follow those for gas atmospheres very closely.
The principle requirement is to ensure that no excessive accumulations of dust remain on the electrical equipment or are able to cause friction in mechanical equipment.
Where significant dust layers are allowed to settle and remain for a long period of time, this could lead to serious deterioration of the equipment or could become a combustible atmosphere when disturbed.

5.5.3 Repair

Repair procedures follow those for gas atmospheres.

SECTION 6
EXPLOSION PROTECTION IN NORTH AMERICA

6.1 Regulations in North America

The principles of our 'hazard triangle' equally apply to gas, vapour and dust atmospheres in North America. The American system of explosion protection for electrical equipment and installations differs quite a bit from the European type. However, the introduction of zones as an alternative to divisions sees an introduction of IEC practices. The North American HazLoc installation codes (National Electrical Code for the US and the Canadian Electrical Code for Canada) can be viewed as the starting point from which all subsequent aspects of the North American HazLoc system are derived. These codes include details on equipment construction, performance and installation requirements, and area classification requirements.
For the US, the National Electrical Code (NEC) includes the following six articles regarding hazardous locations:

Article 500 – General Class I, II, & III Division requirements
Article 501 – Specific Class I, Division requirements
Article 502 – Specific Class II, Division requirements
Article 503 – Specific Class III, Division requirements
Article 504 – Specific Class I, II, & III I.S. Division requirements
Article 505 – General and Specific Class I, Zone requirements

For Canada, the Canadian Electrical Code (CEC) includes the following rules, along with an appendix, regarding hazardous locations:

Rule 18-000 – General Class I, Zone and Class II & III, Division requirements
Rule 18-090 – Specific Class I, Zone 0 requirements
Rule 18-100 – Specific Class I, Zone 1 & 2 requirements
Rule 18-200 – Specific Class II, Division requirements
Rule 18-300 – Specific Class III, Division requirements
Appendix J – General and Specific Class I, Division requirements

For both installation codes, more specific instructions exist for certain occupancies such as commercial garages, service stations, spraying applications and aircraft hangers.

6.2 Hazardous (classified) locations

6.2.1 Classification of locations

Locations are classified depending on the properties of flammable vapours, liquids, gases, combustible dusts or fibres that may be present, and the likelihood that a flammable or combustible concentration or quantity is present.

Class I location:
A location in which flammable gases or vapours are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures.
Class I, division 1 location:
A location in which:
Ignitable concentrations of flammable gases or vapours can exist under normal operating conditions;
Ignitable concentrations of such gases or vapours may exist frequently because of repair or maintenance operations or because of leakage;
Breakdown or faulty operation of equipment or processes might release ignitable concentrations of flammable gases

or vapours, and might also cause simultaneous failure of electrical equipment that could act as a source of ignition.
Class I, division 2 location:
A location in which:
Volatile flammable liquids or flammable gases are handled, processed, or used, but in which the liquids, vapours, or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems, or in case of abnormal operation of equipment;
Ignitable concentrations of gases or vapours are normally prevented by positive mechanical ventilation and might become hazardous through failure or abnormal operation of the ventilating equipment;
Ignitable concentrations of gases or vapours might occasionally migrate to a class I, division 1 unless such migration is prevented by adequate positive-pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided.

Class II location:
A location that is hazardous because of the presence of combustible dust.
Class II, division 1 location:
A location in which:
Combustible dust is in the air under normal operating conditions in quantities sufficient to produce explosive or ignitable mixtures;
Mechanical failure or abnormal operation of machinery or equipment might cause such explosive or ignitable mixtures to be produced and might also provide a source of ignition through simultaneous failure of electrical equipment, operation of protection devices, or from other causes;
Combustible dusts of an electrically conductive nature may be present in hazardous quantities.
Class II, division 2 location:
A location in which combustible dust is not normally in the air in quantities sufficient to produce explosive or ignitable mixtures and dust accumulations are normally insufficient to interfere with the normal operation of electrical equipment or other apparatus, however combustible dust may be in suspension in the air as a result of infrequent malfunctioning of handling or processing equipment and combustible dust accumulations on, in, or in the vicinity of the electrical equipment may be sufficient to interfere with the safe dissipation of heat from electrical equipment or may be ignitable by abnormal operation or failure of electrical equipment.

Class III location:
A location that is hazardous because of the presence of easily ignitable fibres or flyings but in which such fibres or flyings are not likely to be in suspension in the air in quantities sufficient to produce ignitable mixtures.
Class III, division 1 location:
A location in which easily ignitable fibres or materials producing combustible flyings, are handled, manufactured, or used.
Class III, division 2 location:
A location in which easily ignitable fibres are stored or handled (except in the process of manufacture).

6.2.2 Material groups

NEC 500

CLASS I	CLASS II	CLASS III
D (Propane)	E (Metal dust)	– (Fibres)
C (Ethylene)	F (Coal dust)	
B (Hydrogen)	G (Grain dust)	
A (Acetylene)		

The different material groups are shown in the table below. It is immediately obvious that the groups are totally different from the European system. Class III does not have material groups.

6.2.3 Temperature classification

MAXIMUM SURFACE TEMPERATURE	NEC 500
450 °C (842 °F)	T1
300 °C (572 °F)	T2
280 °C (536 °F)	T2A
260 °C (500 °F)	T2B
230 °C (446 °F)	T2C
215 °C (419 °F)	T2D
200 °C (392 °F)	T3
180 °C (356 °F)	T3A
165 °C (329 °F)	T3B
160 °C (320 °F)	T3C
135 °C (275 °F)	T4
120 °C (248 °F)	T4A
100 °C (212 °F)	T5
85 °C (185 °F)	T6

Class I equipment must not have any exposed surfaces that operate at a temperature in excess of the ignition temperature of the specific gas or vapour. The T codes are given in the table on the left.

Group II equipment must not have an external surface temperature higher than that specified in the following table.

CLASS II GROUP	EQUIPMENT NOT SUBJECT TO OVERLOADING	EQUIPMENT THAT MAY BE OVERLOADED	
		NORMAL OPERATION	ABNORMAL OPERATION
E	200 °C	200 °C	200 °C
F	200 °C	150 °C	200 °C
G	165 °C	120 °C	165 °C

The maximum surface temperature for class III must not be higher than 165 °C for equipment that is not subject to overloading, and 120 °C for equipment that may be overloaded.

6.2.4 Protection techniques

Suitability of identified equipment is determined by any of the following:

- *Equipment listing or labelling*
- *Evidence of equipment evaluation from a qualified testing laboratory or inspection agency concerned with product evaluation*
- *Evidence acceptable to the authority having jurisdiction, such as a manufacturer's self-evaluation or the owner's engineering judgement*

	CLASS I	CLASS II	CLASS III
DIVISION 1	Explosion-proof Intrinsic safety Purged/pressurised (Type X or Y)	Dust-ignition proof Intrinsic safety Purged/pressurised	Dust tight Intrinsic safety Hermetically sealed Purged/pressurised
DIVISION 2	Hermetically sealed Non-incendive circuits Non-incendive components Non-incendive equipment Non-sparking devices Oil immersion Purged/pressurised (Type Z) Any class I, division 1 method Any class I, zone 0, 1 or 2 method	Dust tight Hermetically sealed Non-incendive circuits Non-incendive components Non-incendive equipment Non-sparking devices Any class II, division 1 method	Non-incendive circuits Non-incendive components Non-incendive equipment Non-sparking devices Any class III, division 1 method

Equipment in general-purpose enclosures can be installed in division 2 locations provided the equipment does not constitute a source of ignition under normal operating conditions. Typically, UL-listed rail-mounted terminals fitted in a type 4X enclosure can be installed in a division 2 location.
The following table shows the conversion from the US type to the European IP code. The table cannot be used to convert into IP type because the American requirements are very different.

CONVERSION OF US 'TYPE' INTO 'IP' CODE DESIGNATIONS

TYPE NUMBER	IP DESIGNATION
1	IP10
2	IP11
3	IP54
3R	IP14
3S	IP54
4 and 4X	IP56
5	IP52
6 and 6P	IP67
12 and 12K	IP52
13	IP54

6.2.5 Marking

The equipment must be marked to show the class, group, and operating temperature or temperature class referenced to a 40 °C ambient temperature. Electrical equipment suitable for ambient temperatures exceeding 40 °C must be marked with both the ambient temperature and the operating temperature or temperature class at that ambient temperature. Equipment of the non-heat-producing type, such as junction boxes, conduits and fittings, is not required to have the operating temperature or temperature class marked. The coding is identical for the USA and Canada.

CLASS I, DIVISION 1, GROUPS A&B T4

MEANS	
CLASS I	Flammable gas or vapour
DIVISION 1	Area classification (explosive atmosphere can exist under normal operating conditions)
GROUPS A & B	A: acetylene, B: hydrogen
T4	Temperature code

6.3 Class I, zone 0, 1 and 2 locations

6.3.1 Classification of locations

Locations are classified depending on the properties of flammable vapours, liquids, or gases that may be present, and the likelihood that a flammable or combustible concentration or quantity is present.

Zone 0:
A class I, zone 0 location is a location in which:
1. Ignitable concentrations of flammable gases or vapours are continuously present.
2. Ignitable concentrations of flammable gases or vapours are present for long periods of time.

Zone 1:
A class I, zone 1 location is a location in which:
1. Ignitable concentrations of flammable gases or vapours are likely to exist under normal operating conditions.
2. Ignitable concentrations of flammable gases or vapours may exist frequently because of repair or maintenance operations, or because of leakage.
3. Equipment is operated or processes are carried out in such a way that equipment breakdown or faulty operations could result in the release of ignitable concentrations of flammable gases or vapours, and also cause simultaneous failure of electrical equipment in a mode to cause the electrical equipment to become a source of ignition.
4. Ignitable concentrations of vapours could be communicated to an adjacent class I, zone 0 location, unless communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided.

Zone 2:
A class I, zone 2 location is a location in which:

1. Ignitable concentrations of flammable gases or vapours are not likely to occur in normal operation and, if they do occur, will exist only for a short period.
2. Volatile flammable liquids, flammable gases, or flammable vapours are handled, processed, or used, but the liquids, gases, or vapours are normally confined within closed containers or closed systems from which they can escape only as a result of accidental rupture or breakdown of the containers or system, or as the result of abnormal operation of the equipment with which the liquids or gases are handled, processed, or used.
3. Ignitable concentrations of flammable gases or vapours are normally prevented by positive mechanical ventilation, but may become hazardous as the result of failure or abnormal operation of the ventilation equipment.
4. Ignitable concentrations of flammable gases or vapours could be communicated to an adjacent class I, zone 1 location, unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided.

6.3.2 Material groups

CENELEC/IECNEC 505
IIA (Propane)
IIB (Ethylene)
IIC (Acetylene & Hydrogen)

Material groups (gas groups) are identical to the European ones.

6.3.3 Temperature classification

MAXIMUM SURFACE TEMPERATURE	CENELEC/IECNEC 505 (GROUP II)
450 °C (842 °F)	T1
300 °C (572 °F)	T2
200 °C (392 °F)	T3
135 °C (275 °F)	T4
100 °C (212 °F)	T5
85 °C (185 °F)	T6

The temperature range is identical to the one in Europe.

6.3.4 Protection techniques

Suitability of identified equipment is determined by any of the following:

- *Equipment listing or labelling*
- *Evidence of equipment evaluation from a qualified testing laboratory or inspection agency concerned with product evaluation*
- *Evidence acceptable to the authority having jurisdiction, such as a manufacturer's self-evaluation or the owner's engineering judgement*

NEC 505

ZONE 0	ZONE 1	ZONE 2
Intrinsic safety 'ia'	Encapsulated, 'm'	Hermetically sealed, 'nC'
Class I, division 1 intrinsic safety	Flameproof, 'd'	Non-incendive, 'nC'
	Increased safety, 'e'	Non-sparking, 'nA'
	Intrinsic safety, 'ib'	Restricted breathing, 'nR'
	Oil immersed, 'o'	Sealed device, 'nC'
	Powder-filled, 'q'	Any class I, zone 0 or 1 method
	Purged/pressurised, 'p'	Any class I, division 1 or 2 method
	Any class I, zone 0 method	
	Any class I, division 1 method	

6.3.5 Marking

The marking requirements are very similar to the marking prior to the ATEX directive coming into force. There are two types of equipment, i.e. zone equipment and division equipment.
The zone equipment has been approved according to the IEC concept. The division equipment is equipment identified for class I, division 1 or class I, division 2 and in addition of its original marking, it can also be marked with zone information.

6.3.5.1 Markings for division-based zone certification

CLASS I, DIVISION 1, GROUP IIB + H2, T6

MEANS	
CLASS I	Flammable gas or vapour
ZONE 1	Area classification (explosive atmosphere is likely to exist under normal operating conditions)
GROUP IIB + H2	Hydrogen
T6	Temperature class

The coding is identical for the USA and Canada.
Not all division 1 equipment is suitable for zone 0, therefore it is necessary to pay special attention when marking division-based equipment for use in zone-classified areas.

Intrinsically safe products suitable for class I, division 1 locations:

1. Intrinsically safe products that comply with UL class I, division 1, group D requirements may also be marked class I, zone 0, group IIA
2. Intrinsically safe products that comply with UL class I, division 1, group C requirements may also be marked class I, zone 0, group IIB
3. Intrinsically safe products that comply with UL class I, division 1, group B requirements may also be marked class I, zone 0, group IIB plus hydrogen (or '+ H2')
4. Intrinsically safe products that comply with both UL class I, division 1, group A and UL class I, division 1, group B requirements may also be marked class I, zone 0, group IIC

Any products suitable for class I, division 1 locations:

1. Products that comply with UL class I, division 1, group D requirements may also be marked class I, zone 1, group IIA
2. Products that comply with UL class I, division 1, group C requirements may also be marked class I, zone 1, group IIB
3. Products that comply with UL class I, division 1, group B requirements may also be marked class I, zone 1, group IIB plus hydrogen (or '+ H2')
4. Products that comply with both UL class I, division 1, group A and UL class I, division 1, group B requirements may also be marked class I, zone 1, group IIC

Any products suitable for class I, division 2 locations:

1. Products that comply with UL class I, division 2, group D requirements may also be marked class I, zone 2, group IIA
2. Products that comply with UL class I, division 2, group C requirements may also be marked class I, zone 2, group IIB
3. Products that comply with UL class I, division 2, group B requirements may also be marked class I, zone 2, group IIB plus hydrogen (or '+ H2')
4. Products that comply with both UL class I, division 2, group A and UL class I, division 2, group B requirements may also be marked class I, zone 2, group IIC

6.3.6 Markings for IEC-based zone certification

The marking between the USA and Canada is different. The Canadian marking is identical to the IEC marking.

USA: CLASS I, ZONE 0, AEX IA IIC T4

MEANS	
CLASS I	Flammable gas or vapour
ZONE 0	Area classification (explosive atmosphere always present)
AEx	Approved to US standards
ia	Protection method (intrinsic safety)
IIC	Gas group (Acetylene & Hydrogen)
T4	Temperature class

CANADA: EX IA IIC T4

MEANS	
EX	Approved to Canadian standards
ia	Protection method (intrinsic safety)
IIC	Gas group (Acetylene & Hydrogen)
T4	Temperature class

SECTION 7
APPENDICES

I. Definitions and abbreviations
II. EC Declaration of Conformity
III. Ingress and impact protection for enclosures
IV. Defined arrangement method – terminal content
V. Gland selection
VI. Generic permit-to-work
VII. Inspection schedules for gas atmospheres
VII.1 Ex'd', Ex'e' and Ex'n'
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IX. UL/NEMA type designations for enclosures
X. Explosion protection methods according to NEC
XI. Harmonised standards for ATEX 95
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XIII. Certifications

APPENDIX I

Definitions and abbreviations

ACB	Accepted certification bodies
Assembly	A combination of two or more pieces of equipment, together with components if necessary, and placed on the market and/or put into service as a single functional unit
Associated apparatus	Electrical apparatus which contains both intrinsically safe and non-intrinsically safe circuits, and is constructed so that the non-intrinsically safe circuits cannot adversely affect the intrinsically safe circuits
ATEX	ATmosphères EXplosibles
ATEX 137	Directive 1999/92/EC – Minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres
ATEX 95	Directive 94/9/EC – Equipment and protective systems for use in potentially explosive atmospheres
ATR	Assessment and test report
Attestation of conformity for components	Declaration by the manufacturer that the components conform with the provisions of Directive 94/9/EC and include details on how to be incorporated into equipment or protective systems
BASEEFA	British Approval Service for Electrical Equipment in Flammable Atmospheres – UK notified body
CAD	Chemical Agents Directive 98/24/EC – Protection of the health and safety of workers from risks related to chemical agents at work
CEC	Canadian Electrical Code
CEN	European committee for standardisation (non-electrical)
CENELEC	European committee for electrotechnical standardisation
Clearance	Shortest distance in air between two conductive parts
Combustible dust	Dust that can burn or glow in air and form explosive mixtures with air at atmospheric pressure and normal temperature
Components	Any item essential to the safe functioning of equipment and protective systems but with no autonomous function
Conductive dust	Dust with electrical resistivity equal to or less than $10^3\ \Omega m$
Creepage distance	Shortest distance along the surface of an insulating medium between two conductive parts
DSEAR	Dangerous substances and explosive atmospheres regulations
Dust-protected	Enclosure in which the ingress of dust is not totally prevented but dust does not enter in sufficient quantities to interfere with the safe operation of the equipment; dust must not accumulate in a position within the enclosure where it is liable to cause an ignition hazard
Dust-ignition-proof	Enclosed in a manner that will exclude dusts and will not permit arcs, sparks or heat otherwise generated inside of the enclosure to cause ignition of exterior layers or clouds of a specified dust on or in the vicinity of the enclosure
Dust-tight	Constructed so that dust particles will not enter the enclosure
EC	European Community
EC Declaration of Conformity	Declaration by the manufacturer that the equipment complies with the EHSRs of Directive 94/9/EC and any other relevant directives that apply
EHSR	Essential Health and Safety Requirements
Equipment	Machines, apparatus, fixed or mobile devices, control components and instrumentation thereof, and detection or prevention systems which, separately or jointly, are intended for the generation, transfer, storage, measurement, control and conversion of energy for the processing of material, and which are capable of causing an explosion through their own potential sources of ignition
EU	European Union
ExNB	Ex notified bodies
Explosion-proof apparatus (US)	Apparatus enclosed in a case that is capable of withstanding an explosion of a specified gas or vapour that may occur within it, and of preventing the ignition of a specified gas or vapour surrounding the enclosure by sparks, flashes, or explosion of the gas or vapour within, and that operates at such an external temperature that a surrounding flammable atmosphere will not be ignited thereby
ExTL	Ex testing laboratory
FISCO	Fieldbus Intrinsically Safe COncept
Flameproof (EU)	A type of protection in which the parts which can ignite an explosive atmosphere are placed in an enclosure which can withstand the pressure developed during an internal explosion

	of an explosive mixture, and which prevents the transmission of the explosion to the explosive atmosphere surrounding the enclosure
Flashpoint	The lowest liquid temperature at which a liquid gives off vapours in a quantity such as to be capable of forming an ignitable vapour/air mixture
Harmonised standards	Standards developed specifically to allow a presumption of conformity with the EHSR of ATEX 95
Hermetically sealed component	A component that is sealed against entrance of an external atmosphere and in which the seal is made by fusion, such as soldering, brazing, welding, or the fusion of glass to metal
Increased safety	A type of protection in which additional measures are applied to give increased security against the possibility of excessive temperatures and the occurrence of arcs and sparks inside and on external parts of electrical apparatus which do not produce arcs or sparks in normal service
Installation	A combination of two or more pieces of equipment, which were already placed on the market independently by one or more manufacturers
Intrinsically safe apparatus	Apparatus in which all the circuits are intrinsically safe
Intrinsically safe circuit	A circuit in which any spark or thermal effect produced is not capable of causing ignition of a mixture of flammable or combustible material in air under prescribed test conditions
IP	Ingress protection
KEMA	Dutch notified body
LEL	Lower explosion limit
MESG	Maximum experimental safety gap
MIC	Minimum ignition current
NEC	National electrical code
Non-incendive circuit	A circuit in which any arc or thermal effect produced under intended operating conditions of the equipment is not capable, under the test conditions specified, of igniting the specified flammable gas- or vapour- air mixture
Non-incendive component	A component having contacts for making or breaking an incendive circuit and the contacting mechanism shall be constructed so that the component is incapable of igniting the specified flammable gas- or air-air mixture. The housing of a nonincendive component is not intended to exclude the flammable atmosphere or contain an explosion
Non-incendive field circuit	A circuit that enters or leaves the equipment enclosure and that under intended operating conditions is not capable, under the test conditions specified, of igniting the specified flammable gas- or air-air mixture or combustible dust
Non-sparking apparatus	Apparatus that has no normally arcing parts or thermal effects capable of ignition. Normal use excludes the removal or insertion of components with the circuit energised
Pressurisation	The process of supplying an enclosure with a protective gas with or without continuous flow at sufficient pressure to prevent the entrance of a flammable gas or vapour, a combustible dust, or an ignitable fibre
Protective systems	Design units which are intended to halt incipient explosions immediately, and/or to limit the effective range of explosion flames and explosion pressures. Protective systems may be integrated into equipment or separately placed on the market for use as autonomous systems
PTB	German notified body
Purging	The process of supplying an enclosure with a protective gas at a sufficient flow and positive pressure to reduce the concentration of any flammable gas or vapour initially present to an acceptable level
Relative density of a gas/vapour	The density of a gas or a vapour relative to the density of air at the same pressure and at the same temperature (air is equal to 1.0)
Sealed device	A device that is constructed so that it cannot be opened, has no external operating mechanisms, and is sealed to restrict entry of an external atmosphere without relying on gaskets. The device may contain arcing parts or internal hot surfaces
Simple apparatus	An electrical component or combination of components of simple construction with well -defined electrical parameters, which is compatible with the intrinsic safety of the circuit in which it is used
"U" symbol	The symbol used as a suffix to a certificate reference to denote special conditions for safe use
UEL	Upper explosion limit
"X" symbol	The symbol used as a suffix to a certificate reference to denote special conditions for safe use

APPENDIX II

EC Declaration of Conformity

Weidmüller

EC Manufacturer's Declaration
Annex to Declaration of 07.2002

Document-No./ Month/Year	S E 18 July 2002
Manufacturer:	Weidmüller Interface GmbH & Co.
Address:	32758 Detmold Postfach 30 30

We declare on our sole responsibility that the products specified in the enclosure to which this declaration refers, conform with the mentioned harmonized international and/or national standads and specifications.

So far as the designated products are intended for installation in a machine, this declaration is considered a manufacturer's declaration in accordance with Article 4, paragraph 2 of EC Directive 89 / 392 / EEC

Place, Date:	Detmold, 05.07.2002
Legally binding signature	
Position in company:	

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Weidmüller

EC Manufacturer's Declaration
Annex to Declaration of 07.2002

Annex to the Manufacturer's Declaration: **Document-No.:** **S E 18**
Month. Year **07.2002**

List of completely or partially applied standards or specifications (as far as applies):

		Standards and specifications	
Product Group	harmonised	national [1]	international [1]
Enclosures	EN 50298 EN 60529	DIN VDE 0660-511 DIN-VDE 0470-1	 IEC 60529
Cable Glands	EN 50262	DIN-VDE 0619	
Profibus-PA Fieldbus-Integrater	EN 50170		IEC 6158-2
not standardized socket connectors	EN 61984	DIN EN 61984/VDE 0627 DIN IEC 60512	IEC 61984 IEC 60512
Plug Connectors with high density rectangular type	EN 175301 EN 61984	DIN EN 175301 DIN EN 61984/VDE 0627 DIN IEC 60512	 IEC 61984 IEC 60512
Types of connection:			
- Screw connection	 EN 60999 =	DIN 57609/VDE 0609 DIN EN 60999 =	 IEC 999
- Screwless-type clamping units	 EN 60999 =	DIN 57607/VDE 0607 DIN EN 60999 =	 IEC 999
- Snap-on connection		DIN 46249	IEC 760
- Crimped connection	EN 60352-2 =	DIN EN 60352-2 =	IEC 352-2
- Solder connection	HD 323.2.2.20 S3 =	DIN IEC 68-2-20 =	IEC 68-2-20
- Clip connection DIN 41611 Teil 4			
- Wire wrap connection	EN 60352-1	DIN EN 60352-1 =	IEC 352-1
- Press-In connection	EN 60352-5	DIN EN 60352-5 =	IEC 352-5
- Insulation displacement connection	EN 60352-4	DIN EN 60352-4 =	IEC 352-4

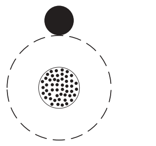
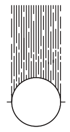
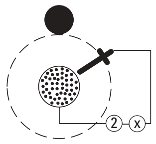
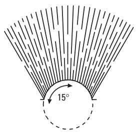
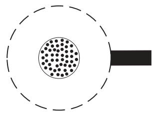
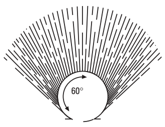
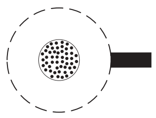
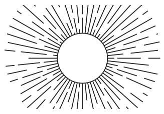
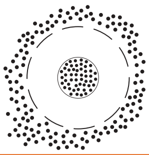
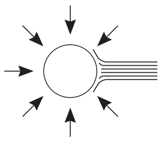
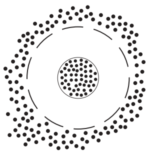
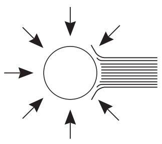
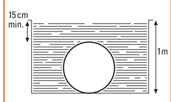
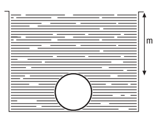
While applying accessory material the manufacturing instructions are to be considered, if necessary.
if there is no date of issue of the standards quoted above each valid issue shall prevail.

[1] Only for the low voltage directive 73 / 23 / EC

APPENDIX III

Ingress and impact protection for enclosures

INGRESS AND IMPACT PROTECTION FOR ENCLOSURES – EN 60529 (IP) AND EN 50102 (K)

1ST NUMBER			2ND NUMBER			3RD NUMBER			
IP	PROTECTION AGAINST SOLID BODIES		IP	PROTECTION AGAINST LIQUIDS		K	IMPACT PROTECTION		
0		No protection	0		No protection	0			No protection
1		Protected against solid bodies larger than 50 mm (e.g.:accidental contact with the hand)	1		Protected against vertical water drops falling (condensation)	1	200 g	7.5 cm	Impact energy 0.150 J
2		Protected against solid bodies larger than 12 mm (e.g.: hand fingers)	2		Protected against drops of water falling up to 15° from the vertical	2	200 g	10 cm	Impact energy 0.200 J
3		Protected against solid bodies larger than 2.5 mm (e.g.: tools, and small wires, etc.)	3		Protected against drops of water falling up to 60° from the vertical	3	200 g	17.5 cm	Impact energy 0.350 J
4		Protected against solid bodies larger than 1 mm (e.g.: fine tools, wires, etc.)	4		Protected against water projected from all directions	4	200 g	25 cm	Impact energy 0.500 J
5		Protected against dust (no harmful deposit)	5		Protected against jets of water from all directions	5	200 g	35 cm	Impact energy 0.700 J
6		Completely protected against dust	6		Protected against jets of water of similar force to heavy sea waves	6	500 g	20 cm	Impact energy 1.00 J
			7		Protected against effects of immersion	7	500 g	40 cm	Impact energy 2.00 J
			8		Protected against the continuors effects of inmersion under pressure	8	1.7 Kg	29.5 cm	Impact energy 5.00 J
						9	5 Kg	20 cm	Impact energy 10.00 J
						10	5 Kg	40 cm	Impact energy 20.00 J

APPENDIX IV

Terminal content using the 'Defined arrangement method'

NEXT 303020

CURRENT (A)	CONDUCTOR SIZE (H Sq, mm)							
0	1.5	2.5	4	6	10	16	25	35
8	105							
10	51							
12		77						
14		46						
16		34	131					
18			52					
20			38					
23				57				
25				41				
32					71			
35					40			
45						69		
50						33		
58								
63							55	
68								
75								
80								62

The 'defined arrangement method' specifies a set of values comprising, for each terminal size, the permissible number of terminals, the conductor size and the maximum current. If more than one combination is possible, the information is presented in a table. The amount of heat loss depends on the volume of the enclosure. Therefore, each table is unique for a specific enclosure size. Our example is a Weidmüller enclosure NexT 30/30/20 (H300xW300xD200).

NEXT 303020

CURRENT (A)	CONDUCTOR SIZE (H Sq, mm)							
0	1.5	2.5	4	6	10	16	25	35
8	105							
10	51							
12		77						
14		46						
16		34	131					
18			52					
20			38					
23				57				
25				41				
32					71			
35					40			
45						69		
50						33		
58								
63							55	
68								
75								
80								62

For our first application, we select a conductor size of 2.5 mm^2 @ 12 Amps. According to our table, the permissible number of terminals is 77.

This number is not necessarily the physical number of terminals that can be fitted in the enclosure. For the smaller cross-sections, the power dissipation depends on the cable size, as the resistance of a quality terminal is negligible. Therefore, the number in the table is in fact the number of cable pairs that can be terminated in the enclosure, and is not dependent on the size of terminal that is selected.

TYPE	ROWS	TERMINALS
SAK 2.5	2	23
SAK 4	2	21
WDU 2.5	2	27
WDU 4	2	23

Note: Maximum terminal content for guidance only.

The actual physical terminal content of our NexT 30/30/20 enclosure depends on the terminal size that is selected for the application. We take the Weidmüller SAK and WDU types, mounted on vertical rails, as an example.

If you select the SAK 2.5, you can fit 46 terminals in the enclosure or, if you select a WDU 2.5, you can fit 54 terminals. Both are lower than the permissible number of 77 because of physical constraints. If you select a larger terminal such as the SAK 4, you can fit even less terminals in the enclosure, i.e. 42.

For our second application, we select the same conductor size but the current rating is 16 Amps. According to our table, the permissible number of terminals is 34.
Using the same terminals types as before, the maximum physical terminal content is higher than the permissible number of terminals in the table. This is not allowed.
Therefore, the maximum number of terminals that can be fitted in the NexT 30/30/20 is 34.
Even if you use a larger terminal size, i.e. WDU 4 or SAK 4, you are only allowed 31 terminals because the conductor size of 2.5 mm^2 is the limiting factor.

NEXT 303020

CURRENT (A)	CONDUCTOR SIZE (H Sq, mm)							
0	1.5	2.5	4	6	10	16	25	35
8	105							
10	51							
12		77						
14		46						
16		34	131					
18			52					
20			38					
23				57				
25				41				
32					71			
35					40			
45						69		
50						33		
58								
63							55	
68								
75								
80								62

However, if you increase the conductor size to 4 mm^2 @ 16 Amps, this would increase the permissible number of terminals to 131. The physical constraints would again limit the maximum number of terminals that can be fitted in the enclosure.

NEXT 303020

CURRENT (A)	CONDUCTOR SIZE (H Sq, mm)							
0	1.5	2.5	4	6	10	16	25	35
8	105							
10	51							
12		77						
14		46						
16		34	131					
18			52					
20			38					
23				57				
25				41				
32					71			
35					40			
45						69		
50						33		
58								
63							55	
68								
75								
80								62

Different sizes of terminals can be mixed together by utilising the tabular values proportionally.
The loading of the different terminal types is calculated by taking the number of installed terminals/conductor pairs divided by the corresponding permissible number of terminals in the table. The sum of the individual loads must always be less than 100%. If the total load is more than 100%, reduce the number of terminals or select a larger enclosure.

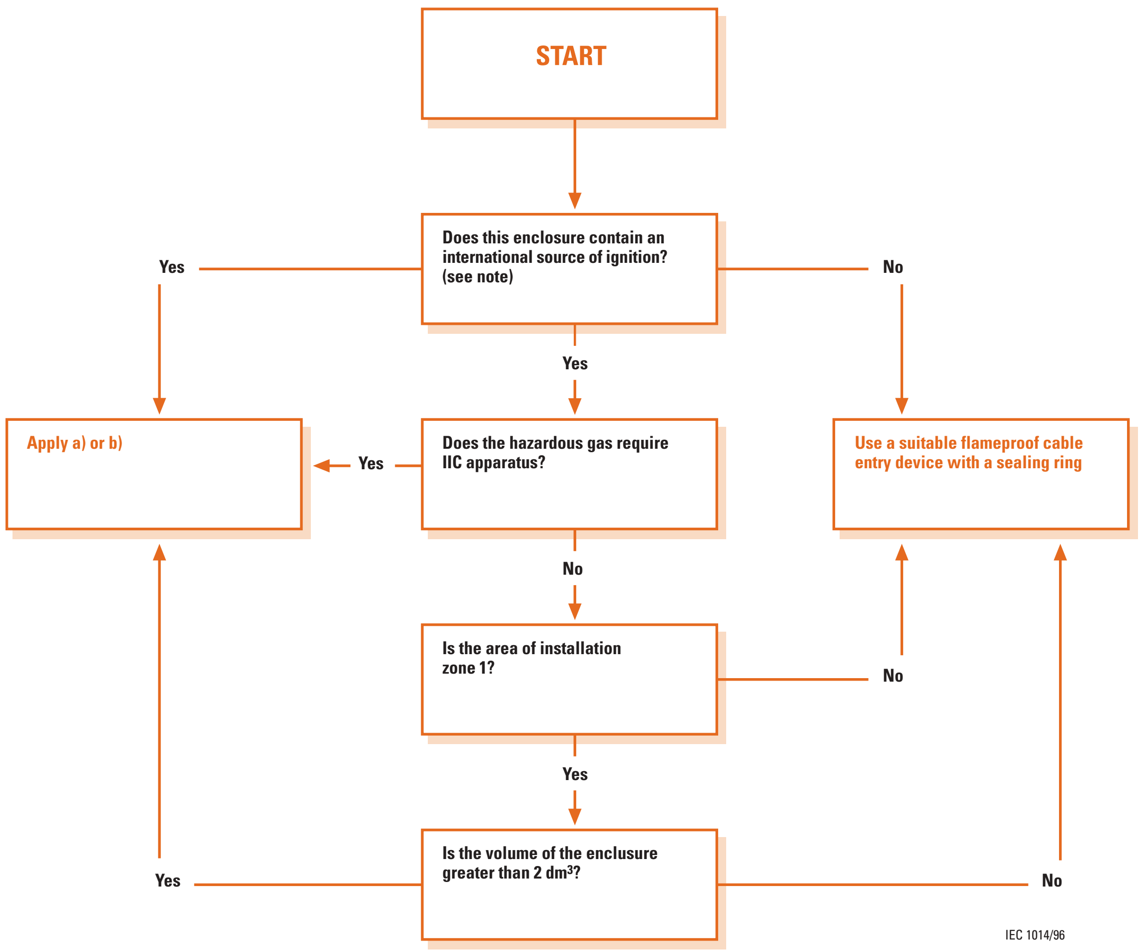
NEXT 303020

CURRENT (A)	CONDUCTOR SIZE (H Sq, mm)							
0	1.5	2.5	4	6	10	16	25	35
8	105							
10	51							
12		77						
14		46						
16		34	131					
18			52					
20			38					
23				57				
25				41				
32					71			
35					40			
45						69		
50						33		
58								
63							55	
68								
75								
80								62

CONDUCTOR SIZE (mm^2)	CURRENT (AMPS)	NUMBER OF TERMINALS	LOAD ≤ 100%
1.5	10	30 (permissible 51)	30/51 = 58.82%
4	20	9 (permissible 38)	9/38 = 23.68%
10	35	6 (permissible 40)	6/40 = 15.00%
			97.50%

APPENDIX V

Gland selection



NOTE

Internal sources of ignition include sparks or equipment temperatures occuring in normal operation witch can cause ignition. An enclosure containing terminals only or an indirect entry enclosure is considered not to constitute an internal source of ignition.

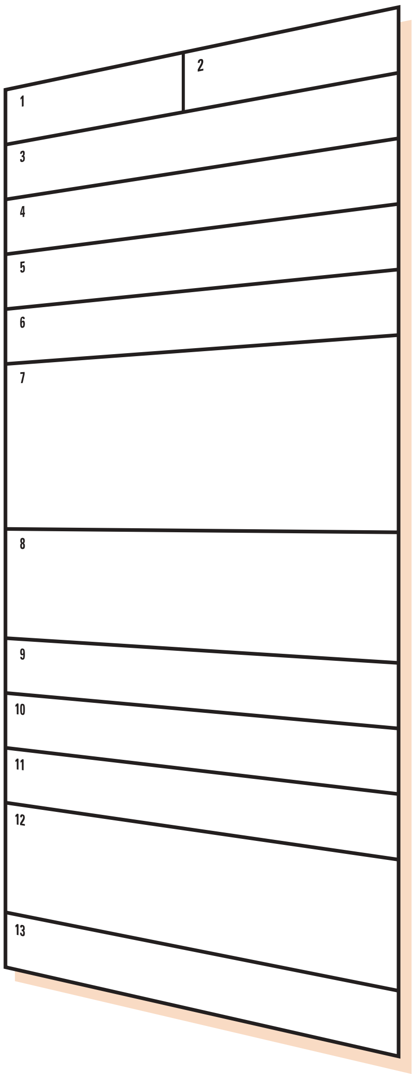
Selection

a) Flameproof sealing device (for example, stopper box or sealing chamber) specified in the apparatus documentation or having component approval and employing cable entry devices appropriate to the cable used. The sealing devices such as stopper boxes or sealing chambers shall incorporate compound or other appropriate seals which permit stopping around individual cores. Sealing devices shall be fitted at the point of entry to the apparatus.

b) Flameproof cable entry devices incorporating compound filled seals around the individual cores or other equivalent sealing arrangements.

APPENDIX VI

Generic permit-to-work



PERMITS SAVE LIVES – GIVE THEM PROPER ATTENTION (Signatures names must be legible)

1	**Permit title**	
2	**Permit number**	Reference to other relevant permits or isolation certificates
3	**Job location**	
4	**Plant identification**	
5	**Description of work to be done and its limitations**	
6	**Hazard identification**	Including residual hazards and hazards introduced by the work
7	**Precautions necessary**	Person(s) who carries out precautions, e.g. isolations, should sign that precautions have been taken
8	**Protective equipment**	
9	**Authorisation**	Signature confirming that isolations have been made and precautions taken, expect where these can only be taken during the work. Date and time duration of permit
10	**Acceptance**	Signature confirming understanding of work to be done, hazards involved and precautions requiered. Also confirming permit information has been explained to all workers involved.
11	**Extension/shift handover procedures**	Signatures confirming checks made that plant remains safe to be worked upon, and new acceptor/workers made fully aware of hazards/precautions. New time expiry given
12	**Hand back**	Signed by acceptor certifying work completed. Signed by issuer certifying work completed and plant ready for testing and recommissioning.
13	**Cancellation**	Certifying work tested and plant satisfactorily recommissioned

APPENDIX VII

Inspection schedules for gas atmospheres

TABLE 1. INSPECTION SCHEDULE FOR EX 'D', EX 'E' AND EX 'N' INSTALLATIONS (Grade of inspection: D = detailed, C = close, V = visual)

CHECK THAT...		EX 'D'			EX 'E'			EX 'N'		
A	**APPARATUS**	**D**	**C**	**V**	**D**	**C**	**V**	**D**	**C**	**V**
1	Apparatus is appropriate to area classification	x	x	x	x	x	x	x	x	x
2	Apparatus group is correct	x	x		x	x		x	x	
3	Apparatus temperature class is correct	x	x		x	x		x	x	
4	Apparatus circuit identification is correct	x			x			x		
5	Apparatus circuit identification is available	x	x	x	x	x	x	x	x	x
6	Enclosure, glasses and glass-to-metal sealing gaskets and/or compounds are satisfactory	x	x	x	x	x	x	x	x	x
7	There are no unauthorised modifications	x			x			x		
8	There are no visible unauthorised modifications		x	x		x	x		x	x
9	Bolts, cable entry devices (direct and indirect) and blanking elements are of the correct type and are complete and tight - Physical check - Visual check	 x	 x	 x	 x	 x	 x	 x	 x	 x
10	Flange faces are clean and undamaged and gaskets, if any, are satisfactory	x								
11	Flange gap dimensions are within maximal values permitted	x	x							
12	Lamp rating, type and position are correct	x			x			x		
13	Electrical connections are tight				x			x		
14	Condition of enclosure gaskets is satisfactory				x			x		
15	Enclosed-break and hermetically sealed devices are undamaged							x		
16	Restricted breathing enclosure is satisfactory							x		
17	Motor fans have sufficient clearance to enclosure and/or covers	x			x			x		
B	**INSTALLATION**									
1	Type of cable is appropriate	x			x			x		
2	There is no obvious damage to cables	x	x	x	x	x	x	x	x	x
3	Sealing of trunking, ducts, pipes and/or conduits is satisfactory	x	x	x	x	x	x	x	x	x
4	Stopper boxes and cable boxes are correctly fitted	x								
5	Integrity of conduit system and interface with mixed system is maintained	x			x			x		
6	Earthing connections, including any supplementary earthing bonding connections are satisfactory (e.g. connections are tight and conductors are of sufficient cross-section) - Physical check - Visual check	 x	 x	 x	 x	 x	 x	 x	 x	 x
7	Fault loop impedance (TN system) or earthing resistance (IT system) is satisfactory	x			x			x		
8	Insulation resistance is satisfactory	x			x			x		
9	Automatic electrical protective devices operate within permitted limits	x			x			x		
10	Automatic electrical protective devices are set correctly (auto-reset not possible in zone 1)	x			x			x		
11	Special conditions of use (if applicable) are complied with	x			x			x		
12	Cables not in use are correctly terminated	x			x			x		
13	Obstructions adjacent to flameproof flanged joints are in accordance with EN 60079-14	x	x	x						
C	**ENVIRONMENT**									
1	Apparatus is adequately protected against corrosion, weather, vibration and other adverse factors	x	x	x	x	x	x	x	x	x
2	No undue accumulation of dust and dirt	x	x	x	x	x	x	x	x	x
3	Electrical insulation is clean and dry				x			x		

NOTES

General: the checks used for apparatus using both types of protection 'e' and 'd' will be a combination of both columns
Items B7 and B8: account should be taken of the possibility of an explosive atmosphere in the vicinity of the apparatus when using electrical test equipment

TABLE 2. INSPECTION SCHEDULE FOR EX 'I' INSTALLATIONS (Grade of inspection: D = detailed, C = close, V = visual)

CHECK THAT...				
A	**APPARATUS**	**D**	**C**	**V**
1	Circuit and/or apparatus documentation is appropriate to area classification	x	x	x
2	Apparatus installed is that specified in the documentation (Fixed apparatus only)	x	x	
3	Circuit and/or apparatus category and group correct	x	x	
4	Apparatus temperature class is correct	x	x	
5	Installation is clearly labelled	x	x	
6	There are no unauthorised modifications	x		
7	There are no visible unauthorised modifications		x	x
8	Safety barrier units, relays and other energy limiting devices are of the approved type, installed in accordance with the certification requirements and securely earthed where required	x	x	x
9	Electrical connections are tight	x		
10	Printed circuit boards are clean and undamaged	x		
B	**INSTALLATION**			
1	Cables are installed in accordance with the documentation	x		
2	Cable screens are earthed in accordance with the documentation	x		
3	There is no obvious damage to cables	x	x	x
4	Sealing of trunking, ducts, pipes and/or conduits is satisfactory	x	x	x
5	Point-to-point connections are all correct	x		
6	Earth continuity is satisfactory (e.g. connections are tight and conductors are of sufficient cross-section)	x		
7	Earth connections maintain the integrity of the type of protection	x	x	x
8	The intrinsically safe circuit is isolated from earth or earthed at one point only (refer to documentation)	x		
9	Separation is maintained between intrinsically safe and non-intrinsically safe circuits in common distribution boxes or relay cubicles	x		
10	As applicable, short-circuit protection of the power supply is in accordance with the documentation	x		
11	Special conditions of use (if applicable) are complied with	x		
12	Cables not in use are correctly terminated	x	x	x
C	**ENVIRONMENT**			
1	Apparatus is adequately protected against corrosion, weather, vibration and other adverse factors	x	x	x
2	No undue accumulation of dust and dirt	x	x	x

TABLE 3. INSPECTION SCHEDULE FOR EX 'P' INSTALLATIONS (PRESSURISATION OR CONTINUOUS DILUTION)
(Grade of inspection: D = detailed, C = close, V = visual)

CHECK THAT...				
A	**APPARATUS**	**D**	**C**	**V**
1	Apparatus is appropriate to area classification	x	x	x
2	Apparatus group is correct	x	x	
3	Apparatus temperature class is correct	x	x	
4	Apparatus circuit identification is correct	x		
5	Apparatus circuit identification is available	x	x	x
6	Enclosure, glasses and glass-to-metal sealing gaskets and/or compounds are satisfactory	x	x	x
7	There are no unauthorised modifications	x		
8	There are no visible unauthorised modifications		x	x
9	Lamp rating, type and position are correct	x		
B	**INSTALLATION**			
1	Type of cable is appropriate	x		
2	There is no obvious damage to cables	x	x	
3	Earthing connections, including any supplementary earthing bonding connections are satisfactory (e.g. connections are tight and conductors are of sufficient cross-section) - Physical check - Visual check	x	x	x
4	Fault loop impedance (TN system) or earthing resistance (IT system) is satisfactory	x		
5	Automatic electrical protective devices operate within permitted limits	x		
6	Automatic electrical protective devices are set correctly	x		
7	Protective gas inlet temperature is below maximum specified	x		
8	Ducts, pipes and enclosures are in good condition	x	x	x
9	Protective gas is substantially free from contaminants	x	x	x
10	Protective gas pressure and/or flow is adequate	x	x	x
11	Pressure and/or flow indicators, alarms and interlocks function correctly	x		
12	Pre-energising purge period is adequate	x		
13	Conditions of spark and particle barriers of ducts for exhausting the gas in hazardous area are satisfactory	x		
14	Special conditions of use (if applicable) are complied with	x		
C	**ENVIRONMENT**			
1	Apparatus is adequately protected against corrosion, weather, vibration and other adverse factors	x	x	x
2	No undue accumulation of dust and dirt	x	x	x

APPENDIX VIII

Inspection schedule for combustible dusts

INSPECTION SCHEDULE (Grade of inspection: D = detailed, C = close, V = visual)

CHECK THAT...				
A	**APPARATUS**	**D**	**C**	**V**
1	Apparatus is appropriate to area classification	x	x	x
2	Apparatus maximum surface temperature class is correct	x	x	
3	Apparatus circuit identification is correct	x		
4	Apparatus circuit identification is available	x	x	x
5	Enclosure, glasses and glass-to-metal sealing gaskets and/or compounds are satisfactory	x	x	x
6	There are no unauthorised modifications	x		
7	There are no visible unauthorised modifications		x	x
8	Bolts, cable entry devices (direct and indirect) and blanking elements are of the correct type and are complete and tight - Physical check - Visual check	x	x	x
9	Lamp rating, type and position are correct	x		
10	Electrical connections are tight	x		
11	Condition of enclosure gaskets is satisfactory	x		
12	Motor fans have sufficient clearance to enclosure and/or covers	x		
B	**INSTALLATION**			
1	The installation is such that the risk of dust accumulations is minimised	x	x	x
2	Type of cable is appropriate	x		
3	There is no obvious damage to cables	x	x	x
4	Sealing of trunking, ducts, pipes and/or conduits is satisfactory	x	x	x
5	Integrity of conduit system and interface with mixed system is maintained	x		
6	Earthing connections, including any supplementary earthing bonding connections are satisfactory (e.g. connections are tight and conductors are of sufficient cross-section) - Physical check - Visual check	x	x	x
7	Fault loop impedance or earthing resistance is satisfactory	x		
8	Insulation resistance is satisfactory	x		
9	Automatic electrical protective devices operate within permitted limits	x		
10	Automatic electrical protective devices are set correctly	x		
11	Special conditions of use (if applicable) are complied with	x		
C	**ENVIRONMENT**			
1	Apparatus is adequately protected against corrosion, weather, vibration and other adverse factors	x	x	x
2	No undue accumulation of dust and dirt	x	x	x

APPENDIX IX

UL/NEMA type designations for enclosures

ENVIRONMENTAL TYPE DESIGNATIONS

ENCLOSURE TYPE DESIGNATION	INTENDED USE AND DESCRIPTION
1	Indoor use primarily to provide a degree of protection against limited amounts of falling dirt.
2	Indoor use primarily to provide a degree of protection against limited amounts of falling water and dirt.
3	Outdoor use primarily to provide a degree of protection against rain, sleet, wind-blown dust and damage from external ice formation.
3R	Outdoor use primarily to provide a degree of protection against rain, sleet, and damage from external ice formation.
3S	Outdoor use primarily to provide a degree of protection against rain, sleet, wind-blown dust and to provide for operation of external mechanisms when ice-laden.
4	Indoor or outdoor use primarily to provide a degree of protection against wind-blown dust and rain, splashing water, hose-directed water and damage from external ice formation.
4X	Indoor or outdoor use primarily to provide a degree of protection against corrosion, wind-blown dust and rain, splashing water, hose-directed water, and damage from external ice formation.
5	Indoor use primarily to provide a degree of protection against settling airborne dust, falling dirt, and dripping non-corrosive liquids.
6	Indoor or outdoor use primarily to provide a degree of protection again hose-directed water, and the entry of water during occasional temporary submersion at a limited depth and damage from external ice formation.
6P	Indoor or outdoor use primarily to provide a degree of protection against hose-directed water, the entry of water during prolonged submersion at a limited depth and damage from external ice formation.
7	Indoor use in locations classified as class I, division 1, groups A, B, C or D hazardous locations as defined in the National Electric Code (NFPA 70) (commonly referred to as explosion-proof).
8	Indoor or outdoor use in locations classified as class I, division 2, groups A, B, C or D hazardous locations as defined in the National Electric Code (NFPA 70) (commonly referred to as oil immersed).
9	Indoor use in locations classified as class II, division 1, groups E, F and G hazardous location as defined in the National Electric Code (NFPA 70) (commonly referred to as dustignition-proof).
10	Intended to meet the applicable requirements of the Mine Safety and Health Administration (MSHA).
12 and 12K	Indoor use primarily to provide a degree of protection against circulating dust, falling dirt, and dripping non-corrosive liquids.
13	Indoor use primarily to provide a degree of protection against dust, spraying of water, oil, and non-corrosive coolant.

The above "types" are usually tested in accordance with:

a) ANSI/UL50, *Enclosures for Electrical Equipment* for types 1, 2, 3, 3R, 3S, 4, 4X, 5, 6, 6P, 12, 12K and 13.

b) ANSI/UL698, *Industrial Control Equipment for Use in Hazardous (Classified) Locations* and other related standards for types 7, 8 and 9.

c) ANSI/NEMA250, *Enclosures for Electrical Equipment (1000 Volts Maximum)* for types 1, 2, 3, 3R, 3S, 4, 4X, 5, 6, 6P, 7, 8, 9, 12, 12K and 13.

APPENDIX X

Explosion protection methods according to NEC

EXPLOSION PROTECTION METHODS

CLASS	AREA	NEC 500	NEC 505
I	Zone 0	–	Intrinsic safety 'ia' Class I, division 1 intrinsic safety
	Zone 1	–	Encapsulated, 'm' Flameproof, 'd' Increased safety, 'e' Intrinsic safety, 'ib' Oil immersed, 'o' Powder filled, 'q' Purged/pressurised, 'p' Any class I, zone 0 method Any class I, division 1 method
	Zone 2	–	Hermetically sealed, 'nC' Non-incendive, 'nC' Non-sparking, 'nA' Restricted breathing, 'nR' Sealed device, 'nC' Any class I, zone 0 or 1 method Any class I, division 1 or 2 method
	Division 1	Explosionproof Intrinsic safety Purged/pressurised (type X or Y)	–
	Division 2	Hermetically sealed Non-incendive circuits Non-incendive components Non-incendive equipment Non-sparking devices Oil immersion Purged/pressurised (type Z) Any class I, division 1 method Any class I, zone 0, 1 or 2 method	–
II	Division 1	Dust-ignition proof Intrinsic safety Purged/pressurised	–
	Division 2	Dust tight Hermetically sealed Non-incendive circuits Non-incendive components Non-incendive equipment Non-sparking devices Any class II, division 1 method	–
III	Division 1	Dust tight Intrinsic safety Hermetically sealed Purged/pressurised	–
	Division 2	Non-incendive circuits Non-incendive components Non-incendive equipment Non-sparking devices Any class III, division 1 method	–

APPENDIX XI

Harmonised standards for ATEX 95

STANDARDS

YEAR	NUMBER	REFERENCE AND TITLE OF THE STANDARD	EUROPEAN STANDARDS BODY
1997	EN 1127-1	Explosive atmospheres – Explosion prevention and protection – Part 1: Basic concepts and methodology	CEN
2001	EN 12874	Flame arresters – Performance requirements, test methods and limits for use	CEN
2001	EN 13012	Petrol filling stations – Construction and performance of automatic nozzles for use on fuel dispensers	CEN
2001	EN 13463-1	Non-electrical equipment for potentially explosive atmospheres – Part 1: Basic methodology and requirements	CEN
2000	EN 1755	Safety of Industrial Trucks – Operation in potentially explosive atmospheres – Use in flammable gas, vapour mist and dust	CEN
2000	EN 1834-1	Reciprocating internal combustion engines – Safety requirements for design and construction of engines for use in potentially explosive atmospheres – Part 1: Group II engines for use in flammable gas and vapour atmospheres	CEN
2000	EN 1834-2	Reciprocating internal combustion engines – Safety requirements for design and construction of engines for use in potentially explosive atmospheres – Part 2: Group I engines for use in underground workings susceptible to firedamp and/or combustible dust	CEN
2000	EN 1834-3	Reciprocating internal combustion engines – Safety requirements for design and construction of engines for use in potentially explosive atmospheres – Part 3: Group II engines for use in flammable dust atmospheres	CEN
1998	EN 50015	Electrical apparatus for potentially explosive atmospheres – Oil immersion 'o'	CENELEC
1998	EN 50017	Electrical apparatus for potentially explosive atmospheres – Powder filling 'q'	CENELEC
2000	EN 50018	Electrical apparatus for potentially explosive atmospheres – Flameproof enclosure 'd'	CENELEC
2000	EN 50019	Electrical apparatus for potentially explosive atmospheres – Increased safety 'e'	CENELEC
1999	EN 50021	Electrical apparatus for potentially explosive atmospheres – Type of protection 'n'	CENELEC
1998	EN 50054	Electrical apparatus for the detection and measurement of combustible gases – General requirements and test methods	CENELEC
1998	EN 50055	Electrical apparatus for the detection and measurement of combustible gases – Performance requirements for Group I apparatus indicating up to 5 % (v/v) methane in air	CENELEC
1998	EN 50056	Electrical apparatus for the detection and measurement of combustible gases – Performance requirements for Group I apparatus indicating up to 100 % (v/v) methane in air	CENELEC
1998	EN 50057	Electrical apparatus for the detection and measurement of combustible gases – Performance requirements for Group II apparatus indicating up to 100 % lower explosive limit	CENELEC
1998	EN 50058	Electrical apparatus for the detection and measurement of combustible gases – Performance requirements for Group II apparatus indicating up to 100 % (v/v) gas	CENELEC
1998	EN 50104	Electrical apparatus for the detection and measurement of oxygen – Performance requirements and test methods	CENELEC
1999	EN 50241-1	Specification for open path apparatus for the detection of combustible or toxic gases and vapours – Part 1: General requirements and test methods	CENELEC
1999	EN 50241-2	Specification for open path apparatus for the detection of combustible or toxic gases and vapours – Part 2: Performance requirements for apparatus for the detection of combustible gases	CENELEC
1998	EN 50281-1-1	Electrical apparatus for use in the presence of combustible dust – Part 1-1: Electrical apparatus protected by enclosures – Construction and testing	CENELEC
1998	EN 50281-1-2	Electrical apparatus for use in the presence of combustible dust – Part 1-2: Electrical apparatus protected by enclosures – Selection, installation and maintenance + Corrigendum 12.1999	CENELEC
1998	EN 50281-2-1	Electrical apparatus for use in the presence of combustible dust – Part 2-1: Test methods – Methods for determining the minimum ignition temperatures of dust	CENELEC
1999	EN 50284	Special requirements for construction, test and marking of electrical apparatus of equipment group II, Category 1G	CENELEC
2000	EN 50303	Group I, Category M1 equipment intended to remain functional in atmospheres endangered by firedamp and/or coal dust	CENELEC

APPENDIX XII

Construction regulations for North America

REGULATIONS

CLASS	AREA	TYPE OF IGNITION PROTECTION	APPLICABLE STANDARDS FOR APPROVAL		
			UL	FM	CSA
I	Zone 0	Intrinsic safety 'ia'	UL 2279, Pt 11	FM 3610	CSA-E-79-11
		Class I, div. 1 intrinsically safe (2 faults)	ANSI/UL 913	FM 3610	CSA 22.2 No.157
I	Zone 1	Encapsulation 'm'	UL 2279, Pt 18	FM 3614 (ISA S12.23.01)	CSA-E-79-18
		Flameproof 'd'	UL 2279, Pt 1	FM 3618 (ISA S12.22.01	CSA-E-79-1
		Increased safety 'e'	UL 2279, Pt 7	FM 3619 (ISA S12.16.01)	CSA-E-79-7
		Intrinsic safety 'ib'	UL 2279, Pt 11	FM 3610	CSA-E-79-11
		Oil immersion 'o'	UL 2279, Pt 6	FM 3621 (ISA S12.26.01)	CSA-E-79-6
		Powder filling 'q'	UL 2279, Pt 5	FM 3622 (ISA S12.25.01)	CSA-E-79-5
		Purged/pressurised 'p'	–	(IEC 79-2)	CSA-E-79-2
		Any class I, zone 0 equipment	–	–	–
		Any class I, div. 1 equipment	–	–	–
I	Zone 2	Non-incendive 'nC'	UL 2279, Pt 15	(ISA S12.12.01, IEC 79-15)	CSA-E-79-15
		Energy limited 'nC'	UL 2279, Pt 15	(ISA S12.12.01, IEC 79-15)	CSA-E-79-15
		Non-sparking devices 'nA'	UL 2279, Pt 15	(ISA S12.12.01, IEC 79-15)	CSA-E-79-15
		Restricted breathing 'nR'	UL 2279, Pt 15	(ISA S12.12.01, IEC 79-15)	CSA-E-79-15
		Hermetically sealed 'nC'	UL 2279, Pt 15	(ISA S12.12.01, IEC 79-15)	CSA-E-79-15
		Sealed devices	UL 2279, Pt 15	(ISA S12.12.01, IEC 79-15)	CSA-E-79-15
		Any class I, zone 0 or 1 equipment	–	–	–
		Any class I, div. 1 or 2 equipment	–	–	–
I	Division 1	Explosionproof	ANSI/UL 1203	FM 3615	CSA 22.2 No.30
		Intrinsically safe (2 faults)	ANSI/UL 913	FM 3610	CSA 22.2 No.157
		Purged/pressurised (type X or Y)	ANSI/NFPA 496	FM 3620	ANSI/NFPA 496
I	Division 2	Non-incendive circuits	UL 1604	FM 3611	CSA 22.2 No.213
		Non-incendive components	UL 1604	FM 3611	CSA 22.2 No.213
		Non-incendive equipment	UL 1604	FM 3611	CSA 22.2 No.213
		Non-sparking devices	UL 1604	FM 3611	CSA 22.2 No.213
		Oil immersion 'o'			
		Purged/pressurised (type Z)	ANSI/NFPA 496	FM 3620	ANSI/NFPA 496
		Hermetically sealed	UL 1604	FM 3611	CSA 22.2 No.213
		Sealed devices	UL 1604	FM 3611	CSA 22.2 No.213
		Any class I, div. 1 equipment	–	–	–
		Any class I, zone 0, 1 or 2 equipment	–	–	–
II	Division 1	Dust-ignition proof	ANSI/UL 1203	FM 3616	CSA 22.2 No.25
		Intrinsically safe	ANSI/UL 913	FM 3610	CSA 22.2 No.157
		Purged/pressurised (type X or Y)	ANSI/NFPA 496	FM 3620	ANSI/NFPA 496
II	Division 2	Dust tight	UL 1604	FM 3611	CSA 22.2 No.157
		Non-incendive circuits	UL 1604	FM 3611	–
		Non-incendive components	UL 1604	FM 3611	–
		Non-incendive equipment	UL 1604	FM 3611	–
		Non-sparking devices	UL 1604	FM 3611	–
		Hermetically sealed	UL 1604	FM 3611	–
		Purged/pressurised (type Z)	ANSI/NFPA 496	FM 3620	–
		Any class II, div. 1 equipment	–	–	–
III	Division 1	Dust tight	UL 1604	FM 3611	CSA 22.2 No.157
		Intrinsically safe	ANSI/UL 913	FM 3610	CSA 22.2 No.157
		Hermetically sealed	UL 1604	FM 3611	–
		Purged/pressurised	ANSI/NFPA 496	FM 3620	–
III	Division 2	Dust tight	UL 1604	FM 3611	CSA 22.2 No.157
		Non-incendive circuits	UL 1604	FM 3611	–
		Non-incendive components	UL 1604	FM 3611	–
		Non-incendive equipment	UL 1604	FM 3611	–
		Non-sparking devices	UL 1604	FM 3611	–
		Any class III, div. 1 equipment	–	–	–

APPENDIX XIII

Certifications

Certificate of Registration

BSI REGISTERED FIRM

This is to certify that

Weidmüller Ltd

Power Station Road, Sheerness
Kent ME12 3AB

hold Certificate No. FM 00673 and operate a quality management system which complies with the requirements of BS EN ISO 9001 1994 for the activities detailed in the scope of registration.

Originally registered 29 April 1986.

EQNet

THE EUROPEAN NETWORK FOR QUALITY SYSTEM ASSESSMENT AND CERTIFICATION

This is to state that

WEIDMULLER, S.A.

C/ NARCIS MONTURIOL, 11
08960 - SANT JUST DESVERN
(Barcelona)

holds the Quality System Certificate

AENOR

ER-007/1/95

for the standard from the

ISO 9000 / EN 29000

series, and the scope as specified therein

TÜV CERT

CERTIFICATE

The TÜV CERT Certification Body of TÜV NORD Zertifizierungs- und Umweltgutachter Gesellschaft mbH certifies in accordance with TÜV CERT procedures that

Weidmüller GmbH & Co.
D - 33102 Paderborn

has established and applies a quality system for

sales and marketing of electromechanical components and services for automation solutions.

An audit was performed, Report No. 935816-03

Proof has been furnished that the requirements according to

DIN EN ISO 9001 : 1994

are fulfilled.

The certificate is valid until October 2002

Certificate Registration No. 09 / 100 / 9535 / 4

Deutsche Akkreditierungsstelle Technik (DATech) e.V.

vertreten im

Deutschen AkkreditierungsRat

Akkreditierung

Akkreditierung ist gültig bis: 18.12.2002

DAR-Registriernummer: DAT-P-008/91-12

Frankfurt/M., 19.12.1997

Lloyd's Register
Quality Assurance

CERTIFICATE OF APPROVAL

This is to certify that the Quality Management System of :

Weidmüller Interface GmbH & Co.
Detmold, Federal Republic of Germany

has been approved by Lloyd's Register Quality Assurance
Limited to the following quality management system standards:

ISO 9001:1994 EN ISO 9001:1994 DIN EN ISO 9001:1994
ANSI/ASQC Q91:1994 AS 3901-1987 GOST 40.9001:1988
IS 14001:1988

The Quality Management System is applicable to :

Design and manufacture of interface solutions of active and passive components and intelligent modules for industrial-, process-, and building automation including terminations, connectors and printed circuit board terminals, electronics, marking systems, tools.

This certificate is valid only in association with the certificate schedule bearing the same number on which the locations applicable to this approval are listed.

Approval Certificate No. 911763

Original Approval : 2nd June 1992

Current Certificate : 2nd September 1996

Certificate Expiry : 30th April 1998

on behalf of LRQA

Weidmüller

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