The basics of explosion protection

STAHL

Automation
Automation
Automation
Automation

Switching/Distribution
Switching/Distribution
Switching/Distribution
Switching/Distribution

Installation
Installation
Installation
Installation

Operating/Monitoring
Operating/Monitoring
Operating/Monitoring
Operating/Monitoring

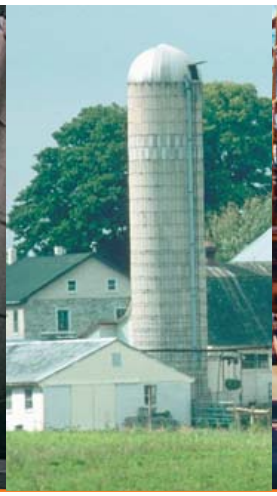
Lighting
Lighting
Lighting
Lighting

Signalling
Signalling
Signalling
Signalling

STAHL

preface

It is a fact that gases, vapours and mists escape during the production, processing, transportation and storage of flammable substances in the chemical and petrochemical industries, as well as in the production of mineral oil and natural gas, in mining and in many other sectors. During many processes, especially in food industries, combustible dusts are also created. These flammable gases, vapours, mists, and dusts form an explosive atmosphere with the oxygen in the air. If this atmosphere is ignited, explosions take place, which can result in severe harm to human life and property. To avoid the danger of explosions, protective specifications in the form of laws, regulations, and standards have been developed in most countries, which are aimed at ensuring that a high level of safety is observed. Due to the growing international economic link, extensive progress has been made in harmonizing regulations for explosion protection. The conditions for a complete harmonization were created in the European Union by the 94/9/EC and 99/92/EC Directives. However, there is still much to be done in this area world-wide. The aim of this brochure is to provide both experts and interested laymen with an overview of the field of explosion protection, in conjunction with electrical apparatus and installations. It does not replace the study of the relevant statutory regulations and applicable standards.
In mining, miners underground have always lived under the threat of firedamp explosions. Herein lies the origins of explosion protection, which has been consistently developed in industrialized countries, and which now provides a high level of safety.


contents

1	Preface	2
2	The Basic Physic Principles and Definitions of Explosion Protection	6
3	Statutory Regulations and Standards	9
3.1	Introduction	9
3.2	European Directives	9
3.2.1	The Directive 94/9/EC (ATEX 95)	9
3.2.2	The Directive 99/92/EC (ATEX 137)	13
3.3	Standards	14
4	Technical Principles	16
4.1	Zone Classification	16
4.2	Minimum Ignition Energy and Explosion Group	16
4.3	Minimum Ignition Temperature and Temperature Classes	18
4.4	Types of Protection	19
4.4.1	Application and Combination of Types of Protection “d” and “e”	24
4.4.2	Applications of Type of Protection “Intrinsic Safety”	25
4.4.3	Applications of Type of Protection “c”	27
5	Installation and Operation of Electrical Equipment in Hazardous Locations	28
5.1	Duties of Installer, Manufacturer and Operator	28
5.2	Classification of Zones and Selection of Apparatus	28
5.3	Methods of Installation	29
5.4	Maintenance	30

6	Explosion Protection in North America		31
	6.1	Introduction	31
	6.2	Classification of Hazardous Locations	31
	6.3	Regulations for Installation	32
	6.4	Constructional Requirements	32
	6.5	Degrees of Protection provided by Enclosures	32
	6.6	Certification and Marking	33
7	Appendix		34
	7.1	Comparison of IEC Publications and European Standards (EN)	34
	7.2	Safety Ratings of Flammable Gases and Vapours	36
	7.3	Classification of Hazardous Locations in North America	37
	7.4	Constructional Requirements for Explosion Protected Electrical Equipment	38
	7.5	Degrees of Protection according to IEC 60 529 – IPXX	40
	7.6	Degrees of Protection according to NEMA Standards	41
8	Literature		42
9	Adresses		44

2. the basic physic principles and definitions

2. The Basic Physic Principles and Definitions of Explosion Protection

An explosion is the sudden chemical reaction of a flammable substance with oxygen with the simultaneous release of high energy. Flammable substances may be present in the form of gases, vapours, mists or dusts. Explosion can only occur, when three factors come together (fig. 1):

1. Flammable material (in ignitable quantities)
2. Oxygen (in the air)
3. Ignition source

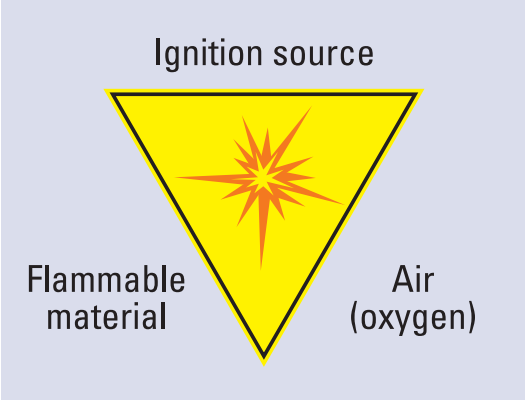


Fig. 1: **An explosion can only occur, when these three factors come together**

Certain characteristic properties of these materials are required for safety considerations. The flash point of a flammable liquid is the minimum temperature at which a liquid gives off vapour in sufficient concentration to form an ignitable mixture with air near the surface of the liquid (at normal air pressure). If the flash point of a flammable liquid is well above the maximum temperatures that arise, an explosive atmosphere can not be formed. The flash point of a mixture of various liquids may be lower than that of the individual components. In addition to the boiling point, the flash point of a liquid serves to classify liquids as highly flammable, easily flammable, and flammable liquids in the Council Directive 98/24/EC "risks related to chemical agents".

To form an explosive atmosphere, the flammable substance must be present in a certain concentration (fig. 2).

If the concentration is too high (rich mixture) or too low (lean mixture), no explosion occurs. Instead, there is just a steady-state combustion reaction or none at all. It is only in the range between the lower and upper explosion limit that the mixture reacts explosively when ignited. The explosion limits depend on the ambient pressure and the proportion of oxygen in the air (table 2).

Table 1: **Classification of flammable liquids**

Designation of the flammable liquid	at flash point and boiling point °C
Highly flammable	Flash point < 0 °C and boiling point < 35 °C
Easily flammable	Flash point < 0 °C and boiling point > 35 °C or 0 °C < flash point < 21 °C
Flammable	21 °C < flash point < 55 °C

Depending on the speed of combustion, we speak of deflagration, explosion or detonation. An atmosphere is described as hazardous or explosive if there is danger to human life or property by an explosion. An explosive atmosphere of even just a few litres can be dangerous in an enclosed space.

Ignition source

Ignition of an explosive atmosphere can be caused by various sources:

> hot surfaces
> flames and hot gases
> mechanically generated sparks
> electrical installations
> equalizing currents, cathodic corrosion protection
> static electricity
> lightning
> electromagnetic waves (high-frequency)
> optical radiation
> ionising radiation
> ultrasonics
> adiabatic compression and shock waves
> exothermal reactions

Table 2: **Explosion Limits of selected Gases and Vapours**

Substance designation	Lower explosion limit [Vol. %]	Upper explosion limit [Vol. %]
Acetylene	2,3	100 (self-decomposing!)
Ethylene	2,4	32,6
Gasoline	~ 0,6	~ 8
Benzol	1,2	8
Heating oil/diesel	~ 0,6	~6,5
Methane	4,4	17
Propane	1,7	10,8
Carbon disulphide	0,6	60,0
Hydrogen	4,0	77,0

Extract from the table "Sicherheitstechnische Kenngrößen, Band 1: Brennbare Flüssigkeiten und Gase" (Safety characteristics, vol. 1: flammable liquids and gases) by E. Brandes and W. Möller as well as by T. Redeker and G. Schön – (6th addendum)

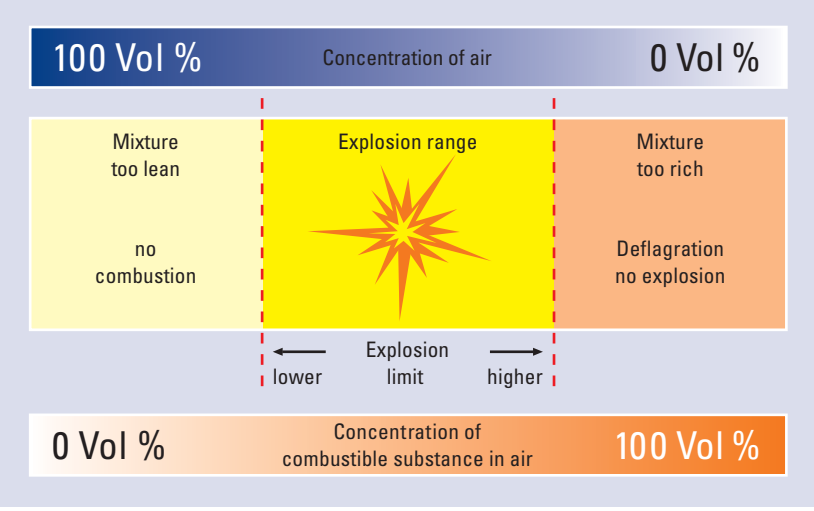


Fig. 2: **Explosion limits**

2. the basic physic principles and definitions

Preventing explosive atmospheres (Primary Explosion Protection)

The term primary explosion protection refers to all precautions, which prevent a hazardous explosive atmosphere from being created. This can be achieved by:

- avoiding flammable substances (replacement technologies)
- inerting (addition of nitrogen, carbon dioxide etc.)
- limitation of the concentration by means of natural or technical ventilation

Avoiding ignition of explosive atmospheres

If the danger of explosion cannot be completely or only partly avoided by measures of preventing the formation of an hazardous explosive atmosphere, then measures must be taken that avoid the ignition of the explosive atmosphere.

The required safety level of these measures depends on the possible danger potential in the installation location. The hazardous areas are therefore divided into zones, according to the probability of an explosive atmosphere being formed (see Section 3.2.2).

In the USA and other countries, hazardous locations are classified into Classes and Divisions (see Section 6.2). For locations classified in this way, requirements must be met concerning the apparatus, which are approved for use in these locations. In addition, it is also necessary to prove that these requirements have been met.

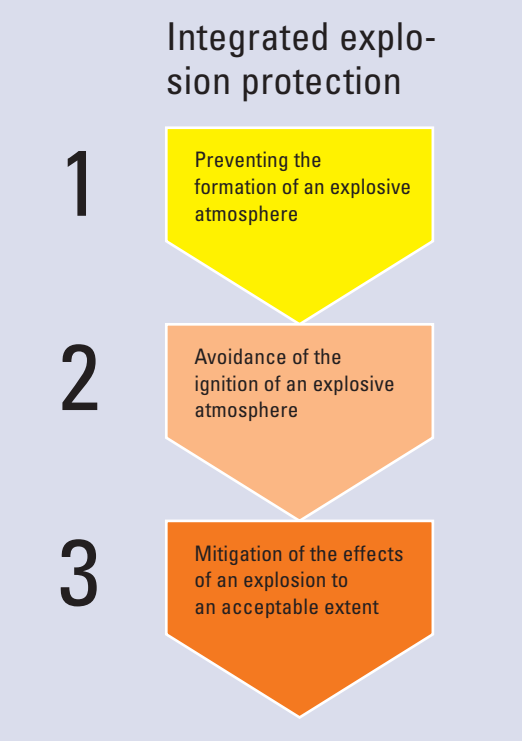
Mitigation of the explosion effects (Constructive Explosion Protection)

If hazardous explosive atmospheres cannot be safely avoided and their ignition cannot be excluded, then measures must be taken which limit the effect of explosions to a safe degree, e.g. by means of:

- explosion pressure resistant construction
- explosion relief devices
- explosion suppression by means of extinguishers

The principle of integrated explosion protection requires following explosion protection measures in a certain sequence.

Fig. 3: **Basic principles of explosion protection**



3. statutory regulations and standards

3. Statutory Regulations

3.1 Introduction

Areas in which there is a risk of explosion that may harm people or the environment are subject to legal or comparable rules in most countries of the world. While these rules were initially issued at the national level, they have since been replaced over the last years by regional European Directives and Standards, and in the field of standardization they have partially been replaced by international regulations.

3.2 European Directives

Already in 1976, the Council of the European Community established the prerequisite of free trade of explosion protected electrical equipment within the European Union by ratifying the "Directive on the harmonization of the laws of the member states concerning electrical equipment for use in potentially explosive atmospheres (76/117/EEC)". This directive has since been adapted to the state of the art by means of execution and adaptation directives on electrical equipment.

Complete harmonization and extension to all types of equipment was achieved with the new Directive 94/9/EC in 1994. The Directive 99/92/EC, which regulates operation in hazardous areas and defines safety measures for the concerned personnel, was issued in 1999.

3.2.1 The Directive 94/9/EC (ATEX 95)

The EC Directive 94/9/EC "on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres" was issued in 1994 to further standardize explosion protection and make corresponding adjustments in line with a new directive approach. It specifies the requirements for explosion protected equipment and protective systems by prescribing essential health and safety requirements. It guarantees free trade within the European Community, as agreed in Article 95 (former 100 a) of the Treaty established between the European Community member states. This is also where the term generally used amongst experts, ATEX 95 or 100 a, comes from. This term is the abbreviation of the French designation for explosive atmosphere "atmosphères explosibles".

The directive had to be implemented into national law without any changes/exceptions. E.g. it was adopted into british law by means of The Equipment and Protective Systems for Use in Potentially Explosive Atmospheres Regulations (EPS) and into German law by means of the "Explosionsschutzverordnung (ExVO)" (Regulation of Explosion Protection) as the 11th Regulation of the "Geräte- und Produktsicherheitsgesetz (GPSG)" (Equipment and Product Safety Law).

The directive applies to all industrial potentially explosive areas including mining, and also covers dust explosion protection. The scope covers all electrical and non-electrical equipment, and protective systems.

This directive is intended for the manufacturer or the importer, and defines design, certification, production and quality assurance, marking, operating instructions, and declaration of conformity for the explosion protected equipment to be placed on the market.

3. statutory regulations and standards

Definitions

> "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" is the definition for 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 separately and 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.

> An "explosive atmosphere" is a mixture with air, under atmospheric condition, 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.

> A "potentially explosive atmosphere" is an atmosphere which could become explosive due to local and operational conditions.

Scope

The directive applies to equipment and protective systems for use in potentially explosive atmospheres.

Safety devices intended for use outside potentially explosive atmospheres but required for or contributing to the safe functioning of equipment with respect to the risk of explosion are also covered by the scope of this Directive. The Directive does not include a reference to mandatory standards, whereas it specifies the essential health and safety requirements to be maintained, and which are mandatory for design and construction. Protection against other hazards (e.g. electric shock) that could be caused by this equipment, is also required as well.

Equipment categories

The manufacturer of equipment that includes their own potential ignition sources, and therefore can cause an explosion, have to ensure that the equipment undergoes an ignition hazard assessment procedure, and takes measures according to the essential safety requirements to exclude the risk of ignition. In the directive, Group II apparatus are divided into three categories with various levels of safety (for mines Group I has two categories). The required protective measures suit the required level of safety (tables 3 and 4).

Table 3: **Categories of Group I: Surface and Underground Mining Systems in case of Dangerous Firedamp/Dust**

Category M1	Category M2
Very high degree of safety	High degree of safety
Safe even when two faults occur independently	Switch-off in case of the presence of explosive atmosphere

Table 4: **Categories of Group II: Other Explosive Areas**

Category 1	Category 2	Category 3
Very high degree of safety	High degree of safety	Normal degree of safety
Safe even when two faults occur independently	Safe even when a fault occurs	Safe during normal operation

Certification

Equipment for use in hazardous areas has to undergo the conformity assessment procedure defined in the directive prior to being placed on the market. Category 1 and M1 equipment must undergo an EC type examination carried out by a Notified Body. The same applies to electrical equipment and I.C.-engines of Category 2 and M2. For non-electrical equipment of this category, as well as for those of Category 3, the manufacturer is authorized to assess and document conformity with the requirements of the directive.

The certificates from a Notified Body are recognized throughout the European Community.

Marking

In addition to the usual data such as the name of the manufacturer, type, serial number, and electrical ratings, any data relating to explosion protection must be contained in the marking (see table 5, marking according to the 94/9/EC Directive and the standards EN 60079 ff and EN 61241 ff).

The CE marking of the equipment confirms that it is designed and manufactured in compliance with all applicable EC Directives. For example, an explosion protected luminaire marked with the CE conformity mark must comply with both the ATEX Directive as well as the “EMC Directive”.

Operating instructions

The operating instructions of the manufacturer must clearly define the intended use of the equipment by the operator. The minimum requirements for the operating instruction are amongst others:
Information on safe

- putting into service
- use
- assembling and dismantling
- maintenance (servicing and emergency repair)
- installation
- adjustment

If necessary, special conditions for safe use have to be specified and should include notes on possible misuse that may occur as experience has shown.

Manufacturer’s Declaration of Conformity

Equipment and systems can be placed on the market, only if marked with the CE mark and complete with operating instructions and the manufacturer’s declaration of conformity. The CE conformity marking and the written declaration of conformity confirm that the product complies with all requirements and assessment procedures specified in the EC Directives.

3. statutory regulations and standards

Table 5: **Marking of electrical equipment**	
Marking defined by directives and standards	
Manufacturer's name or designation	STAHL
Type designation (e.g.)	6000/562
Address	D-74638 Waldenburg
Explosion protection marking	EEx de IIC T6
Marking according to CENELEC	EEx oder Ex (starting from 12/2004)
Types of protection	d, e, ib, [ib], …[1]
Explosion groups for gases	IIA, IIB oder IIC
Temperature class or in case of dust the max. surface temperature of apparatus	T1–T6
Marking according to Directive 94/9/EC	II 2 G D
EU distinguishing mark	Ex
Equipment group	I, II
Equipment category	1, 2 oder 3
G: Gases, vapours or mists; D: dusts	G, D
Testing authority, number of certificate	PTB 97 ATEX 2031[2]
CE mark, number of the auditing and supervising authority	CE 0102
Electrical ratings	V, A, W, Hz
Ambient temperature, if other than –20 °C…+40 °C	Ta ≤ +50 °C

[1] ib for intrinsically safe apparatus, [ib] for associated apparatus
[2] With an … X if reference special conditions for use etc. With a … U for Ex components

3.2.2 The Directive 99/92/EC

In addition to the 94/9/EC Directive, which regulates how explosion protected equipment and protective systems are placed on the market and the design, construction and quality requirements to be met by them, the 99/92/EC Directive stating "Minimum requirements for improving the health and safety protection of worker potentially at risk from explosive atmospheres" refers to the operation of potentially explosive installations, and is therefore intended for the employer. This directive contains only minimum requirements. When implementing it into national law, the single states can adopt further regulations. This was done when implementing it into British law by "The Dangerous Substances and Explosive Atmospheres Regulations (DSEAR)" and into German law by the "Betriebssicherheitsverordnung (BetrSichV)", the German regulation on Industrial Safety and Health Protection, which in addition to this directive, takes into consideration further European directives on safety on work. Comparable regulations are found in other European countries.

According to the 99/92/EC Directive, it is the duty of the employer to verify where there is a risk of explosion, classify the hazardous areas into zones accordingly, and document all measures taken to protect the personnel in the explosion protection document.

Assessment of explosion risks

When assessing the risks of explosion, the following factors are to be taken into account:

- the likelihood that explosive atmospheres will occur and their persistence
- the likelihood that ignition sources, including electrostatic discharges, will be present and become active and effective
- the installations, substances used, processes, and their possible interactions
- the scale of the anticipated effects

Zone Classification

The employer has to classify the areas in which explosive atmospheres may be present into zones, and to ensure that the minimum organisational and technical requirements of the Directive are observed.

Zone 0

A place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is present continuously or for long periods or frequently.

Zone 1

A place in which an explosive atmosphere consisting of a mixture with air or flammable substances in the form of gas, vapour or mist is likely to occur in normal operation occasionally.

Zone 2

A place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

3. statutory regulations and standards

Zone 20
A place in which an explosive atmosphere in the form of a cloud of combustable dust in air is present continously, or for long periods or frequently.

Zone 21
A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is likely to occur in normal operation occasionally.

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.

Table 6 contains an overview of the zones and allocation of equipment according to the category.

Table 6: **Zones and allocation of equipment according to the category**

	Zone	Duration of the occurrence of an explosive atmosphere	Equipment category
Gases, vapours, mists	0	continuously, for a long period, frequently	1G
	1	occasionally	2G
	2	rarely and for a short period	3G
Dusts	20	continuously, for a long period, frequently	1D
	21	occasionally	2D
	22	rarely and for a short period	3D

Explosion protection document
An explosion protection document has to be generated, which contains at least the following information:
- assessment of the explosion risk
- protective measures taken
- zone classification
- observance of minimum requirements. These are divided into organisational measures (instruction of workers, etc.) and technical measures (explosion protection measures).

3.3 Standards

The European Standards EN 50014 - EN 50020 on electrical equipment were issued in 1978 and replaced the national standards for this equipment valid up until then Europe-wide. In addition to the standards for electrical equipment published by the CENELEC, standards for non-electrical explosion-protected equipment have since been developed by the CEN.

According to an agreement between the European Committee for Electrotechnical Standardization CENELEC and the International Electrotechnical Commission IEC, the European standards for electrical equipment have been adopted unchanged by the IEC for several years. The European Standard series EN 50014, which defines the requirements on equipment to be used in explosive gas atmospheres, will be gradually replaced by the European Standards series EN 60079.
These standards have been issued as VDE 0170 in Germany.

The requirements on types of protection for areas where combustible dust may occur are specified in the standard series IEC 61241. In Europe, these standards replace the existing series EN 50281.

Since many requirements are identical to the standards for explosive gas atmospheres, both standard series will be summarized in the series IEC or EN 60079 (tables 7 and 8).

Table 7: **Electrical Apparatus for Explosive Gas Atmospheres**

	EN (old)	EN (new)	IEC
General requirements	EN 50 014	EN 60079-0	IEC 60079-0
Flameproof enclosures “d”	EN 50 018	EN 60079-1	IEC 60079-1
Pressurized enclosures “p”	EN 50 016	EN 60079-2	IEC 60079-2
Powder filling “q”	EN 50 017	EN 60079-5	IEC 60079-5
Oil immersion “o”	EN 50 015	EN 60079-6	IEC 60079-6
Increased safety “e"	EN 50 019	EN 60079-7	IEC 60079-7
Intrinsic safety “i”	EN 50 020	EN 60079-11	IEC 60079-11
Type of protection “n”	EN 50 021	EN 60079-15	IEC 60079-15
Encapsulation “m”	EN 50 028	EN 60079-18	IEC 60079-18
Intrinsically safe systems		EN 60079-25	IEC 60079-25
Electrical equipment for Zone 0	EN 50 284	EN 60079-26	IEC 60079-26
Intrinsically safe field bus systems		EN 60079-27	IEC 60079-27
Optical radiation “op”		EN 60079-28	IEC 60079-28

Table 8: **Electrical Apparatus for Use in the Presence of Combustible Dust**

	EN (old)	EN (new)	IEC (new)	IEC (old)
General requirements		EN 61241-0	IEC 61241-0	IEC 61241-1-1
Protected by enclosures “tD”	EN 50281-1-1	EN 61241-1	IEC 61241-1	IEC 61241-1-1
Pressurized enclosures “pD”		EN 61241-2	EN 61241-2	EN 61241-4
Intrinsic safety “iD”		EN 61241-11	IEC 61241-11	EN 61241-5
Encapsulation “mD”		EN 61241-18	IEC 61241-18	

4. technical principles

4. Technical Principles

4.1 Zone Classification

Hazardous areas are classified into zones to facilitate the selection of appropriate electrical apparatus as well as the design of suitable electrical installations. Information and specifications for the classification into zones are included in IEC 60079-10.

The greatest potential risk has to be taken into account when classifying the potentially explosive areas into zones and determining the necessary protective measures.

If there is no expert (skilled person) available in the company to verify the risk of explosion and to determine the necessary measures, it is recommended that a competent authority be turned to.

The equipment used in the defined hazardous zone must meet the requirements of the relevant assigned category (see section 3.2.1).

4.2 Minimum Ignition Energy and Explosion Group

The minimum ignition energy is the minimum energy just sufficient to ignite the most ignitable mixture. This characteristic has to be considered when selecting the apparatus. The measured value of the minimum ignition energy is indicated for dusts. Gases are divided into explosion groups.

Explosion groups

Apparatus are divided into two groups:

- **Group I:**
  Electrical apparatus for mines endangered by firedamp
- **Group II:**
  Electrical apparatus for other places liable to be endangered by explosive atmospheres

In the case of electrical apparatus in Group I (mining), it is assumed that the only flammable gas that can occur is methane, but combined with coal dust. Other flammable gases, which can also occur in these areas, must be further classified as shown in Group II.

Electrical apparatus of Group II used in explosive gas atmospheres are further classified into explosion groups.

Classification criteria are the Maximum Experimental Safe Gap (MESG) and the "Minimum Ignition Current (MIC)". The MESG and MIC are determined for the various gases and vapour according to a stipulated testing arrangement. The maximum experimental safe gap is the gap of the test apparatus with a width of flameproof joint of 25 mm at which an internal ignition of an explosive mixture is not propagated to the exterior (IEC 60079-1-1). The minimum ignition current relates to the minimum ignition current for laboratory methane.

An overview of the maximum experimental safe gaps and minimum ignition currents for the various explosion groups is shown in table 9.

The dangerousness of the gases increases from explosion group IIA to IIC. The requirements for the electrical apparatus increase accordingly to these explosion groups. For this reason, the marking of the electrical apparatus must show to which explosion group it belongs. Electrical apparatus approved for IIC may also be used for all other explosion groups.

Table 9: **Explosion Groups**

Explosion group	Maximum experimental safe gap	Minimum ignition current ratio*
IIA	> 0,9	> 0,8
IIB	0,5 – 0,9	0,45 – 0,8
IIC	< 0,5	< 0,45

*rel. to methane = 1

4. technical principles

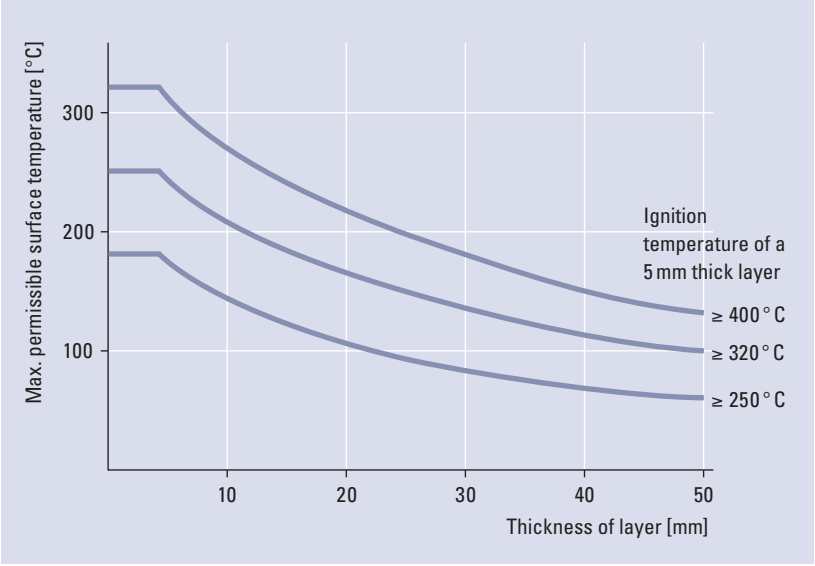
4.3 Ignition Temperature and Temperature classes

The ignition temperature of a flammable gas, vapour, or combustible dust is the lowest temperature of a heated surface at which the gas/air or vapour/air mixture ignites. It represents virtually the lowest temperature at which a hot surface can ignite a respective explosive atmosphere.

Flammable gases and vapours are classified into temperature classes according to their inflammability. The maximum surface temperature of electrical apparatus should always be lower than the ignition temperature of the gas/air or vapour/air mixture in which it is used. Of course, equipment classified in a higher temperature class (e.g. T5) may also be used for applications in which a lower temperature class is required (e.g. T2 or T3).
In North America there is a system incorporating further classification according to temperature subclasses.

Combustible dusts are not divided into temperature classes. The minimum ignition temperature of the dust cloud has to be compared with the max. surface temperature of the apparatus. In doing so, a safety factor has to be considered. The max. surface temperature of the apparatus must not exceed 2/3 of the minimum ignition temperature of the dust cloud. Since dust can also deposit on apparatus, the minimum ignition temperature of the dust layer must also be taken into account. This temperature is the lowest temperature of a hot surface on which a dust layer of 5 mm can be ignited. The max. surface temperature of the apparatus has to be adjusted using a safety factor of 75 K. The thicker the layer, the higher the heat insulation. For this reason, the dust layer is already ignitable at low temperatures, which is why a reduced surface temperature is admitted on the apparatus. It is determined according to the scheme (fig. 4) (EN 61241-14). If the layer is thicker than 50 mm, the ignition temperature has to be determined by laboratory tests. This applies also to layers thicker than 5 mm when the ignition temperature at 5 mm is lower than 250 °C. Laboratory testing is also necessary when the apparatus are completely covered with combustible dust.

Fig. 4: **Determination of the max. Surface Temperature of Dust Layers of 5 mm to 50 mm**



4.4 Types of Protection

Only explosion protected equipment may be used in areas in which an explosive atmosphere may still be expected despite the implementation of prevention measures. Electrical, explosion protected equipment can have various types of protection according to the construction regulations of the standards series EN 60079, former EN 50014 and following. If electrical equipment shall be used in areas with combustible dust, the standards series EN 61241 is applicable. The type of protection employed by the manufacturer depends mainly on the kind and function of the apparatus. Various safety levels exist for some types of protection. These correspond to the equipment categories as defined in the 94/9/EC Directive. The Ex ia version relative to intrinsic safety can be classified as category 1. It can be installed in Zone 0. The Ex ib version corresponds to category 2 which suits Zone 1. From a safety point of view, all standardized types of protection should be seen as being equal.

The tables 10–13 give an overview of the standardized types of protection, and describes the basic principle, as well as the usual applications.

4. technical principles

Table 10: **Types of Protection for Electrical Apparatus in Explosive Gas Atmosphere, Part 1**

Type of protection in accordance with IEC, EN, UL, FM and NFPA	Representation (diagram)	Basic principle	Main application
Increased safety "e" EN 60079-7 UL 60079-7 IEC 60079-7 FM 3600		Additional measures are applied to increase the level of safety, thus preventing the possibility of excessive temperatures and the occurance of sparks or electric arcs within the enclosure or on exposed parts of electrical apparatus, where such ignition sources would not occur in normal service.	Terminal and connection boxes, control boxes for installing Ex-components (which have a different type of protection), squirrel-cage motors, light fittings
Flameproof enclosure "d" EN 60079-1 UL 60079-1 IEC 60079-1 FM 3600		Parts which can ignite a potentially explosive atmosphere are surrounded by an enclosure which withstands the pressure of an explosive mixture exploding inside the enclosure, and prevents the transmission of the explosion to the atmosphere surrounding the enclosure.	Switchgear and control gear and display units, control systems, motors, transformers, heating equipment, light fittings
Pressurized enclosure "p" EN 60079-2 NFPA 496 IEC 60079-2 FM 3620		The formation of a potentially explosive atmosphere inside a casing is prevented by maintaining a positive internal pressure of protective gas in relation to the surrounding atmosphere and, where necessary, by supplying the inside of the casing with a constant flow of protective gas acting to dilute any combustible mixtures.	Switchgear and control cabinets, analysers, large motors px = use in Zone 1, 2 py = use in Zone 1, 2 pz = use in Zone 2
Intrinsic Safety "i" EN 60079-11 UL 60079-11 IEC 60079-11 FM 3610		Apparatus used in a potentially explosive area contain intrinsically safe electric circuits only. An electric circuit is intrinsically safe if no sparks or thermal effects produced under specified test conditions (which include normal operation and specific fault conditions) is not capable of causing ignition of a given explosive atmosphere.	Measurement and control technology, communication technology, sensors, actuators ia = use in Zone 0, 1, 2 ib = use in Zone 1, 2 [Ex ib] = associated apparatus – installation in safe area
EN 60079-25 IEC 60079-25		Intrinsic Safety evaluation for defined systems (equipment and cables)	Intrinsically safe systems
EN 60079-27 IEC 60079-27	FISCO Ex ia IIC T4 FNICO Ex ia IIC T4	Definition of the physical and electrical limit values of the intrinsically safe bus string	Fieldbus intrinsically safe concept (FISCO) for Zone 1 Fieldbus Nonincendive Concept (FNICO) for Zone 2

Table 11: **Types of Protection for Electrical Apparatus in Explosive Gas Atmosphere, Part 2**

Type of protection in accordance with IEC, EN, UL, FM und NFPA	Representation (diagram)	Basic principle	Main application
Oil immersion "o" EN 60079-6 UL 60079-6 IEC 60079-6 FM 3600		Electrical apparatus or parts of electrical apparatus are immersed in a protective fluid (such as oil), such that a potentially explosive atmosphere existing over the surface or outside of the apparatus cannot be ignited.	Transformers, starting resistors
Powder filling "q" EN 60079-5 UL 60079-5 IEC 60079-5 FM 3600		Filling the casing of an electrical apparatus with a fine granular packing material has the effect of making it impossible for an electric arc created in the casing under certain operating conditions to ignite a potentially explosive atmosphere surrounding the casing. Ignition must not result either from flames or from raised temperature on the surface of the casing.	Sensors, display units, electronic ballast, transmitter
Encapsulation "m" EN 60079-18 UL 60079-18 IEC 60079-18 FM 3600		Parts that are capable of igniting an explosive atmosphere by either sparking or heating are enclosed in a compound in such a way as to avoid ignition of an explosive atmosphere.	Switchgear with small breaking capacity, control and signalling units, display units, sensors ma = use in Zone 0, 1, 2 mb = use in Zone 1, 2
Type of protection "n_" EN 60079-15 UL 60079-15 IEC 60079-15 FM 3600		Electrical apparatus cannot ignite a explosive atmosphere surrounding them (in normal operation and under defined abnormal operating conditions).	All electrical equipment for Zone 2 nA = non-sparking apparatus nC = sparking apparatus in which contacts are protected conveniently nL = energy-limited apparatus nR = purged/pressurized apparatus nZ = purged pressurized apparatus, n
Optical radiation "op_" EN 60079-28 IEC 60079-28		Appropriate measures prevent ignition of an explosive atmosphere by optical radiation.	Optical fibre There are three different methods: Ex op is = intrinsically safe optical radiation Ex op pr = protected optical radiation Ex op sh = blocking optical radiation

Table 12: **Electrical Apparatus for Use in the Presence of Combustible Dust**

Type of protection in accordance with IEC or EN	Repre-sentation (diagram)	Basic principle	Main application
Protected by enclosures “tD” EN 61241-1 IEC 61241-1		Thanks to the tightness, dust cannot ingress the appa-ratus at all or its quantity is limited to a safe degree. For this reason, ignitable apparatus can be mounted into the enclosure. The surface temperature of the enclosure must not ignite the surrounding atmosphere.	Switchgear and control gear, control, connection, and terminal boxes, motors, light fittings td A21 = according to method A for Zone 21 td B21 = according to method B for Zone 21
Pressurized enclosure “pD” EN 61241-4 IEC 61241-4		The formation of a potentially explosive atmosphere inside a casing is prevented by maintaining a positive internal pressure of protective gas in relation to the surrounding atmosphere and, where necessary, by sup-plying the inside of the casing with a constant flow of protective gas which acts to dilute any combustible mixtures.	Switchgear and control cabinets, motors
Intrinsic Safety “iD” EN 61241-11 IEC 61241-11		Apparatus used in a potentially explosive area contain intrinsically safe electric circuits only. An electric circuit is intrinsically safe if no sparks or thermal effects produced under specified test conditions (which include normal operation and specific fault conditions) is not capable of causing ignition of a given explosive atmo-sphere.	Measurement and control technology, com-munication technology, sensors, actuators iaD = use in Zone 20, 21, 22 ibD = use in Zone 21, 22 [Ex ibD] = associated electrical apparatus – installation in safe area
Encapsulation “mD” EN 61241-18 IEC 61241-18		Parts that are capable of igniting an explosive atmo-sphere by either sparking or heating are enclosed in a compound in such a way as to avoid ignition of a dust layer or cloud.	Switchgear with small capacity, control and signalling units, display units, sensors maD = use in Zone 20, 21, 22 mbD = use in Zone 21, 22

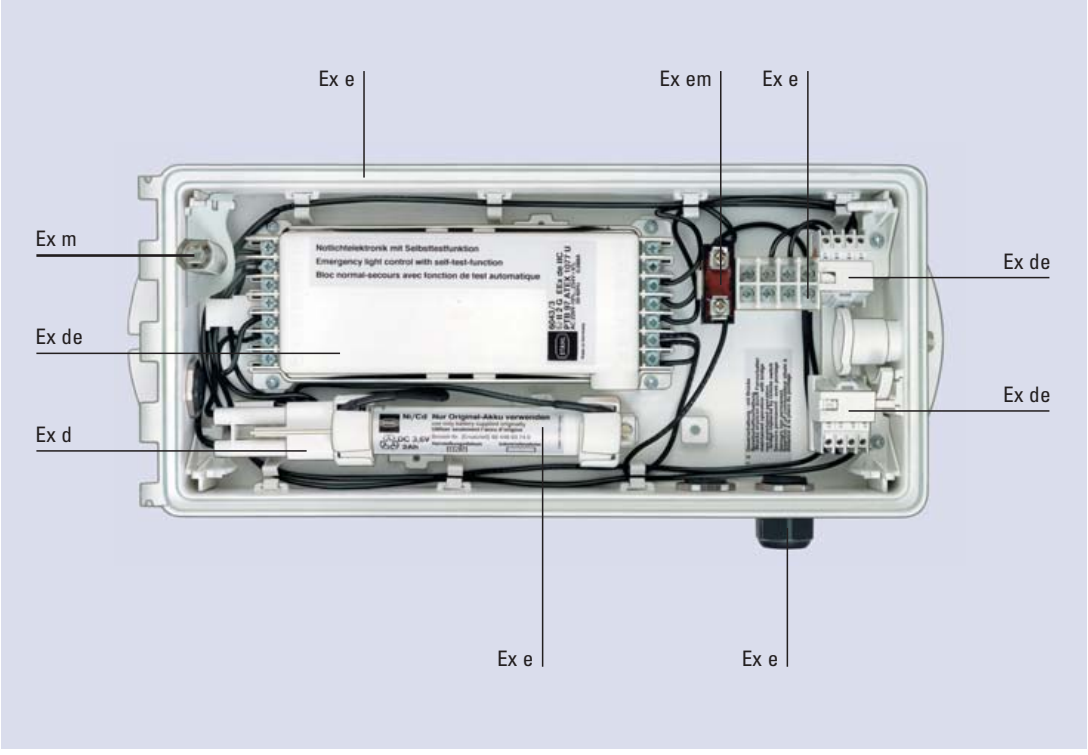
Table 13: **Types of Protection for Non-electrical Apparatus in Explosive Gas Atmosphere and used in the Presence of Combustible Dust**

Type of protection in accordance with IEC or EN	Repre-sentation (diagram)	Basic principle	Main application
Constructional safety “c” EN 13463-5		Proven technical principles are applied to equipment types which do not have any ignition source under normal operating conditions, so that the risk of mechanical failure which cause ignitable temperatures and sparks is reduced to a minimum degree.	Couplings, pumps, gearing, chain drives, belt conveyors
Flameproof enclosure “d” EN 13463-3		Parts which can ignite a potentially explosive atmo-sphere are surrounded by an enclosure which with-stands the pressure of an explosive mixture exploding inside the enclosure, and prevents the transmission of the explosion to the atmosphere surrounding the enclosure.	Brakes, couplings
Pressurized enclosure “p” EN 13463-7		The formation of a potentially explosive atmosphere in-side a casing is prevented by maintaining a positive internal pressure of protective gas in relation to the surrounding atmosphere and, where necessary, by sup-plying the inside of the casing with a constant flow of protective gas acting to dilute any combustible mixtures.	Pumps
Ignition source monitoring “b” EN 13463-6		Sensors are integrated in the equipment to detect hazardous conditions to come, and to take steps against them before potential ignition sources become effective. The measures can be initiated automatically by means of a direct connection between the sensors and the ignition protection system or manually by issuing a warning message intended for the operator of the equipment.	Pumps, belt conveyors
Liquid immersion “k” EN 13463-8		Ignition sources are rendered inactive by immersion in a protective liquid or by constant moistening using a liquid film.	Submerged pumps, gears, liquid immersion
Restricted breathing “fr” EN 13463-2		The effective sealing of the enclosure can reduce penetration of explosive atmosphere to an extent that no potentially explosive atmosphere can form in it. Pressure differences between the interior and the exterior atmo-sphere have to be taken into account. Application is limited to equipment category 3.	Equipment exclusively for Zone 2 or Zone 22

4.4.1 Application and Combination of Types of Protection "d" and "e"

The most important type of protection for switchgear is "Flameproof Enclosures", usually in conjunction with "Increased Safety". Switchgear does produce sources of ignition in normal use and therefore "Increased Safety" alone is not applicable as type of protection for switchgear, since "Increased Safety" is based on the principle to avoid sources of ignition by additional measures. However, "Increased Safety", in conjunction with "Flameproof Enclosures", cut a fine figure for switchgear and control gear. Modern, explosion protected luminaires also use a combination of several types of protection to achieve the best results with regard to safety, function, and economy (fig. 5).

Fig. 5: **Combination of Types of Protection Emergency Light Fitting C-Lux 6108**



4.4.2 Applications of Type of Protection "Intrinsic Safety"

The type of protection "Intrinsic Safety" is based on the principle of energy limitation within an electric circuit. The energy from a power circuit capable of causing an explosive atmosphere to ignite is thus limited to such an extent that the surrounding explosive atmosphere cannot ignite as a result of sparks or inadmissible surface heating of the electrical components.

The type of protection "Intrinsic Safety" is particularly used in measurement and control technology, as no high currents, voltage and power are required here.

Terms and Definitions

Intrinsically safe electrical circuit

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

Intrinsically safe apparatus

Electrical apparatus in which all circuits are intrinsically safe.

Associated apparatus

Electrical apparatus which contains circuits, some of which are intrinsically safe and some are not, and which is constructed such that the non-intrinsically safe circuits cannot negatively adversely affect the intrinsically safe circuits (table 14).

Minimum ignition energy

The minimum ignition energy of a gas/air and vapour/air mixture is the smallest level of electrical energy which occurs while a capacitor is discharging, and which may still be sufficient to ignite the most ignitable mixture of a gas or vapour and air at atmospheric pressure and 20 °C.

An essential aspect of the type of protection "Intrinsic Safety" is reliability with regard to the observance of voltage and current limit values, even if determined faults may occur. Intrinsically safe apparatus and intrinsically safe components from related equipment are classified in different levels of protection "ia", "ib" or "ic" with regard to infallibility. The level of protection "ia" is a prerequisite for category 1 equipment and suitable for use in Zone 0, the level of protection "ib" for category 2 equipment and suitable for use in Zone 1. The new level of protection "ic" for category 3 is suitable for use in Zone 2.

Table 14: **Difference between Intrinsically Safe and Associated Apparatus**

Intrinsically safe apparatus	Associated apparatus	
These contain intrinsically safe circuits only	These contain both intrinsically safe and non-intrinsically safe electric circuits	
EEx ib IIC T6	[EEx ib] IIC T6	EEx de [ib] IIC T6
All necessary information such as category, explosion group and temperature class is provided.	The square brackets indicate that the associated electrical apparatus contains an intrinsically safe electric circuit that may be introduced into Zone 1, gas groups IIA, IIB and IIC.	
The apparatus may be used in Zone 1.	The apparatus has to be installed outside of the potentially explosive area.	Thanks to being integrated in a flameproof enclosure ("d"), the apparatus may be used in Zone 1.

Fig. 6: **Electric Isolators IS pac**

Isolation of Intrinsically Safe Circuits from Non-intrinsically Safe Circuits

An important measure for intrinsically safe circuits is the safe isolation of all intrinsically safe circuits from non intrinsically safe circuits (fig. 6). Safe electrical isolation is always required, with the exception of safety barriers.

Electric isolation is generally recommanded for Zone 0. Zener diodes, used for limiting voltage, as well as other semiconductor components are considered to be fallible and must therefore be safeguarded by means of redundant components. Wire wound or sheet resistors for current limitation are considered to be infallible components (they have high resistivity in the event of a fault). Therefore one single component is sufficient.

Normal safety

Safety is required under normal operation.
The failure of the zener diode is not taken into account. (level of protection “ic”: one single zener diode).

Table 15: **Levels of protection of intrinsically safe electrical circuits**

Level of protection “ia”	Level of protection “ib”	Level of protection “ic”
Electrical apparatus of level of protection ”ia” shall not be capable of causing ignition in normal operation and when one fault occurs or when a combination of any two faults occurs.	Electrical apparatus of level of protection ”ib” shall not be capable of causing ignition in normal operation or when one fault occurs.	Electrical apparatus of level of protection “ic” shall not be capable of causing ignition in normal operation.
Safety factor 1.5: During normal operation and in case of one fault	Safety factor 1.5: During normal operation and in case of one fault	Safety factor 1.0: During normal operation
Safety factor 1.0: Two independent faults	Safety factor 1.0: In case of one fault, if the electrical apparatus does not have unprotected switching contacts in those components, which may be exposed to an explosive atmosphere, and when the fault is monitored.	

Single fault safety

In the event of the failure of one zener diode, a second zener diode must take its function (level of protection "ib": one redundant zener diode).

Double fault safety

In the event of a failure of two zener diodes, a third zener diode must take their function (level of protection "ia": two redundant zener diodes, table 15).

4.4.3 Applications of Type of Protection "c"

Non-electrical apparatus are often realised with the type of protection "Constructional safety". The risk of failure, which may cause ignition sources in an apparatus, is reduced to a low level by means of constructional measures for this type of protection. To do so, e.g., hot surfaces, mechanically generated sparks, and electrostatic discharges are examined. The measures depend mainly on the equipment type and may vary significantly. Here, the examined material combination, dimensioning, tolerances, and lubricants of moving parts play a role. Even servicing intervals and monitoring of the service life may be of vital importance.
The manufacturer defines the intended use in the operating instructions. By doing so, ambient and operating conditions as well as the admitted operating parameters are specified. The operator has to observe the operating instructions.

5. installation and operation of electrical equipment

5. Installation and Operation of Electrical Equipment in Hazardous Areas

5.1 Duties of Installer, Manufacturer and Employer

Safety in potentially explosive areas can only be guaranteed by a close and effective working relationship amongst all parties involved (fig. 7). The employer is responsible for the safety of his installations. It is his duty to verify where there is a risk of explosion and then divide areas into Zones accordingly. He must ensure that the installation is installed in accordance with regulations and is inspected before initial use. The installation must be kept in a regular and correct state by periodic inspection and maintenance.

The installer must observe the installation requirements, and select and install the electric apparatus correctly for its intended use.

Manufacturers of explosion protected apparatus are responsible for routine testing, certification and documentation and are required to ensure that each device manufactured complies with the approved design.

5.2 Classification of Zones and Selection of Apparatus

The question of possible risks of explosion must be addressed at the early stages new facility planning. When classifying potentially explosive areas, the influence of natural or technical ventilation must be considered in addition to the quantity of flammable substances being released. Furthermore, the explosion safety characteristics must be ascertained for the flammable

Fig. 7: : **Co-operation of all parties involved**

substances being used (see Appendix 7.2). Only then can a decision be reached on the classification of potentially explosive areas into Zones and the selection of suitable apparatus.
IEC 60 079-14 (EN 60079-14) applies to the installation of electrical apparatus in explosive gas atmospheres Group II. IEC 61241-14 (EN 61241-14) applies to all areas with combustible dust.

Equipment shall only be used within the ambient temperature range stipulated in its marking.

If the marking does not contain any information, the standard range of between –20 °C and +40 °C does apply.

Electrical apparatus with the types of protection "d" and "i" must correspond to an explosion group IIA, IIB or IIC. Electrical apparatus must be selected and installed such that it is protected against external influences which may adversely affect the explosion protection measures.

5.3 Methods of Installation

Essentially, three systems are used for electrical installations in hazardous areas:

> 1. Cable system with indirect entry
> 2. Cable system with direct entry
> 3. Conduit system

The technical design of the electrical apparatus used with the individual types of installation is accordingly different.

Only the conduit system or mineral insulated cables (MI) are permitted in the USA for all applications in Class 1, Division 1 in accordance with NEC 501-4, whereby the mineral insulated cables are mainly used as heating lines and fire resistant signal and control lines. Certain types of cable and line are also permitted in Division 2. A comparison of the various systems is shown below.

Cable systems

Cable systems are mainly used in Europe. For this, high-quality cables are laid uncovered. It is only in areas in which mechanical damage could be expected that they are laid in conduits that are open at both ends.

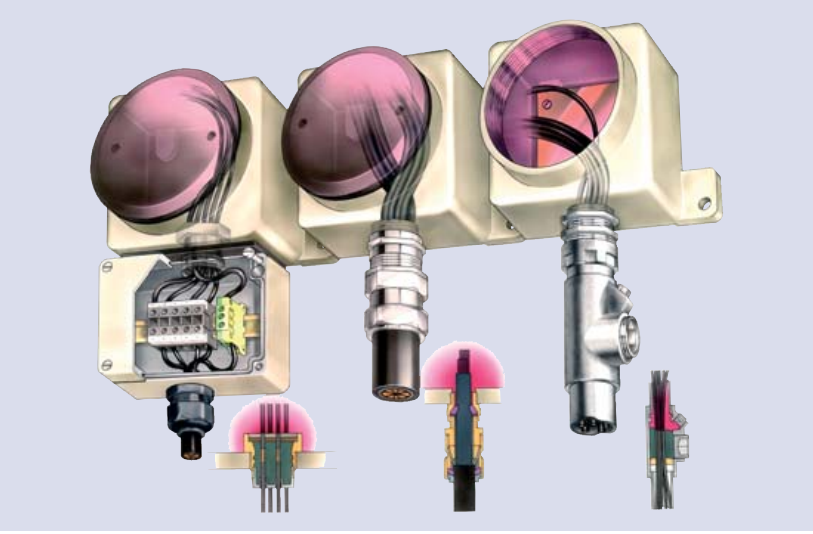
In the case of **indirect** entry, the cables and lines are conducted via cable glands into a connection chamber in the type of protection "Increased Safety" and connected to the terminals also provided in "Increased Safety". From here, the individual wires are conducted via flameproof bushings into the flameproof enclosure.

The cable bushings are installed by the manufacturer, with the result that, by contrast with direct entry, a routine test of the factory wired flameproof enclosure can be made.

The installation engineer need only open the connection chamber for the connection, not the flameproof enclosure.

In the case of **direct** entry, the connecting cables are entered directly into the flameproof enclosure. Only cable glands that have been specially certified for this purpose may be used for this type of entry.

Fig. 8: **Methods of Installation worldwide: Left: Cable system with indirect entry; Centre: Cable system with direct entry; Right: Conduit system**



5. installation and operation of electrical equipment

The flexible gasket and the cable sheath must form a flameproof joint through which no flames can penetrate. For this reason, attention must be paid to the appropriate selection of cable gland depending on both the type and structure of cable and installation location. If the flameproof enclosure has to be used in a IIC atmosphere or if a flameproof enclosure with a volume bigger than 2 dm³ has to be applied in Zone 1, the gaskets or cable glands have to be sealed. The flameproof enclosure primarily depends here on the care taken by the electrician when connecting the cables.

Conduit System

In the case of installation using the conduit system, the electrical lines are drawn as single wires into enclosed metal conduits. The conduits are connected to the housings by means of fittings and equipped with a seal at each entrance point. The entire conduit system is flameproof. The aim of the seal is to prevent explosions which may occur inside the housing from transmitting into the conduit. Otherwise, extremely high explosion pressures would be created as a result of pre-compression in long cylindrical tubes. For this reason, it is recommended that seals be installed not just at the entrance points but at specific intervals. Drains must be installed at low points at which condensate can accumulate.

5.4 Maintenance

Periodic maintenance is required to maintain the safety of electrical installations in hazardous areas. Personnel who carry out such maintenance work should work under the guidance of an explosion protection expert and should be informed of the particular hazards involved (skilled person, IEC 60079-17).

Before corrective maintenance, it must be ensured that there is no danger of explosions occurring during this work. Normally, formal written work-permission for this should be acquired from the company management. On completion of the work, a documentation should be kept of what work was carried out, and confirmation given that all relevant regulations have been observed.

A technical person with executive function shall be identified for each installation. He is responsible for the determination of the frequency of inspection, the grade of inspection, the availability of the documentation, the training for the skilled personel, etc.

6. explosion protection in north america

6. Explosion Protection in North America

6.1 Introduction

The basic principles of explosion protection are the same all over the world. However, technologies have developed in North America in the field of explosion protection for electrical equipment and installations which deviate considerably from those of the IEC (International Electrotechnical Commission). The differences from IEC technologies are among others the classification of hazardous locations, the construction of apparatus and the installation of electrical systems.

6.2 Classification of Hazardous Locations

For potentially explosive atmospheres the term "hazardous (classified) locations" is used in North America. These are defined in Articles 500 and 505 of the National Electrical Code (NEC) in the USA and in Section 18 and Annex J of the Canadian Electrical Code (CEC) in Canada. Hazardous locations are locations, where fire or explosion hazards may exist due to flammable gases, vapours or mists (Class I), combustible dusts (Class II), or ignitable fibres or flyings (Class III).

Based on the likelihood or risk that an ignitable concentration of a flammable substance will be present the hazardous locations are traditionally subdivided into Division 1 and Division 2.

In 1996 the IEC classification system was introduced as a parallel system to the existing system for Class I in the USA. This system was implemented by the new Article 505. This now gives the end user the possibility to choose the system that best suits his needs.

The IEC zone classification for Class I was also introduced in Canada (CEC, 1988 edition). All newly built facilities in Canada need to be classified according to this principle.

The traditional North American classification system divides Class I flammable gases, vapours, mists and liquids into Gas Groups A, B, C and D, and Class II combustible dusts into Groups E, F and G.

Group A is the most hazardous gas group in the traditional NEC system whereas Group IIC is the most hazardous group in the IEC system in Article 505 of the NEC.

In Canada both gas grouping systems may be used with the zone classification system.

The maximum surface temperature determination given in the new Article 505 maintains a pure IEC approach of having main temperature classes T1 to T6 with further subdivisions of the temperature classes in the Division system. In the 1998 CEC, this structure T1–T6 with intermediate subdivisions was maintained.

Table 19 in appendix 7.3 provides an overview of the classification of hazardous locations in North America.

6. explosion protection in north america

6.3 Regulations for Installation

The National Electrical Code in the USA and the Canadian Electrical Code in Canada apply to electrical apparatus and installations for hazardous locations. These have the nature of installation regulations for electrical facilities in all locations, and refer to a number of further standards of other institutions that contain specifications for the erection and construction of suitable equipment.

The methods of installation for the zone concept in accordance with the NEC are similar to the traditional Class/Division system. New to the NEC 1996 is the use of listed Metal Clad (MC) cables in addition to rigid conduit and Mineral Insulated cables in Class I, Division 1 or Zone 1.

One significant advantage to the CEC is the increased possibility of using cables. In contrast to the USA, Canada has, for some time now, also permitted the use of special cables similar to the IEC steel-wire armoured cables.

6.4 Construction and Design Requirements

The regulations of the National Electrical Code and the Canadian Electrical Code stipulate which apparatus and types of protection may be used in different hazardous locations.

Various standards and regulations govern the construction and testing of explosion-protected electrical apparatus and installations in North America. In the USA, these are mainly the standards issued by Underwriters Laboratories Inc. (UL), Factory Mutual Research Corporation (FM) and the International Society for Measurement and Control (ISA). In Canada, those of the Canadian Standards Association (CSA) apply.

The tables in appendix 7.4 provide an overview of the constructional requirements for hazardous locations and methods of protection.

6.5 Degrees of Protection provided by Enclosures

As the standard IEC 60 529 defines the degrees of protection provided by enclosures, as in the USA the degrees of protection are included in the NEMA Publication No. 250 (National Electrical Manufacturing Association). These enclosure types cannot be exactly equated with the IEC enclosure classification designation since NEMA takes additional environmental influences (such as cooling lubricant, cutting coolant, corrosion, icing, hail) into account. The tables 7.5 and 7.6 in the appendix illustrate the types of protection according to both standards.

6.6 Certification and Marking

In the USA and Canada, electrical apparatus and apparatus used in hazardous locations are, as a rule, subject to approval. Exceptions to this are items of electrical apparatus which, due to their design and the peculiar nature of the explosive atmosphere in which they are used, cannot ignite. The responsible authorities shall decide whether such equipment is subject to approval.

Equipment which has been developed and manufactured for use in hazardous locations is tested and approved in the USA and Canada by a notified testing authority. In the USA, this is for example the Underwriters Laboratories or Factory Mutual, and in Canada the Canadian Standards Association.

In addition to data such as manufacturer, type, serial number, and electrical data, any data relating to explosion protection must be shown on the marking of the equipment. The requirements for this are specified in the NEC, the CEC as well as the relevant apparatus regulations of the testing authority.

Class I, II & III, Division 1 and 2

The approved electrical equipment for Class I, Class II and Class III, Division 1 and Division 2 must be marked to show the following information:

1. Class(es), Division(s)
   (optional except for Division 2)
2. Gas/dust group(s)
3. Operating temperature or temperature class
   (optional T5 and T6)

Example: Class I Division 1 Groups C D T4

Class I, Zone 0, 1 and 2

For equipment intended for use in Class I, Zone 0, Zone 1 or Zone 2, a distinction is made between "Division Equipment" and "Zone Equipment".

(1) Division Equipment

Equipment approved for Class I, Division 1 and/or Class I, Division 2 shall be permitted to be marked with the following:

1. Class I, Zone 1 or Class I, Zone 2
2. Gas group(s) IIA, IIB or IIC
3. Temperature class
4. Types of Protection

Example: Class I Zone 1 d,e IIC T4

(2) Zone Equipment

Equipment meeting one or more types of protection described in Article 505 of the NEC or Section 18 of the CEC shall be marked with the following in the order shown:

1. Class (optional in Canada)
2. Zone (optional in Canada)
3. AEx (USA) or Ex or EEx (Canada)
4. Type(s) of protection
5. Equipment group II or applicable gas group(s) IIA, IIB or IIC
6. Temperature class

Example: Class I Zone 0 AEx ia IIC T6

7. appendix

7. Appendix

7.1 Comparison of IEC Publications and European Standards (EN)

Table 16: **Electrical Apparatus for Explosive Gas Atmosphere**

	IEC	EN (new)	EN (old)
General requirements	IEC 60079-0	EN 60079-0	EN 50 014
Flameproof enclosures “d”	IEC 60079-1	EN 60079-1	EN 50 018
Construction and verification test of flameproof enclosures of electrical apparatus	IEC 60079-1-1		
Pressurized enclosures “p”	IEC 60079-2	EN 60079-2	EN 50 016
Method of test for ignition temperature	IEC 60079-4		
Powder filling “q”	IEC 60079-5	EN 60079-5	EN 50 017
Oil-immersion “o”	IEC 60079-6	EN 60079-6	EN 50 015
Increased safety “e”	IEC 60079-7	EN 60079-7	EN 50 019
Classification of hazardous areas	IEC 60079-10	EN 60079-10	
Intrinsic Safety “i”	IEC 60079-11	EN 60079-11	EN 50 020
Classification of mixtures of gases or vapours with air according to their maximum experimental safe gaps and minimum ignition currents	IEC/TR 60079-12		
Construction and use of rooms or buildings protected by pressurization	IEC/TR 60079-13		
Electrical installations in hazardous areas (other than mines)	IEC 60079-14	EN 60079-14	
Type of protection “n”	IEC 60079-15	EN 60079-15	EN 50 021
Artificial ventilation for the protection of analyser(s) houses	IEC/TR 60079-16		
Inspection and maintenance of electrical installations in hazardous areas (other than mines)	IEC 60079-17	EN 60079-17	
Encapsulation “m”	IEC 60079-18	EN 60079-18	EN 50 028
Repair and overhaul for apparatus used in potentially explosive atmospheres (other than mines or explosives)	IEC 60079-19	EN 60079-19	
Data for flammable gases and vapours, relating to the use of electrical apparatus	IEC/TR 60079-20		
Intrinsically safe systems	IEC 60079-25	EN 60079-25	
Electrical Equipment for Zone 0	IEC 60079-26	EN 60079-26	EN 50 284
Fieldbus intrinsically safe concept (FISCO) and Fieldbus nonincendive Concept (FNICO)	IEC 60079-27	EN 60079-27	
Protection of devices and transmission systems which work with optical radiation		EN 60079-28	
Electrical apparatus for the detection and measurement of flammable gases – general requirements and performance requirements		EN 60079-29-1	

Table 17: **Electrical Apparatus for Use in the Presence of Combustible Dust**

	IEC (new)	IEC (old)	EN (new)	EN (old)
General requirements	IEC 61241-0	IEC 61241-1-1	EN 61241-0	EN 50281-1-1
Protected by enclosures “tD”	IEC 61241-1	IEC 61241-1-1	EN 61241-1	EN 50281-1-1
Pressurized enclosures “pD”		IEC 61241-4		EN 61241-4
Classification of potentially explosive dust atmospheres	IEC 61241-10		EN 61241-10	
Intrinsic Safety “iD”	IEC 61241-11	EN 61241-5	EN 61241-11	
Selection and installation	IEC 61241-14		EN 61241-14	
Inspection and maintenance of electrical installations in hazardous areas (other than mines)	IEC 61241-17		EN 61241-17	
Encapsulation “mD”	IEC 61241-18		EN 61241-18	
Test methods: minimum ignition temperature		IEC 61241-2-1		EN 50281-2-1
Test methods: resistivity of dust in layers		IEC 61241-2-2	EN 61241-2-2	
Test methods: minimum ignition energy		IEC 61241-2-3		

Comments on the tables 16 and 17:
IEC/EN 6124 and IEC/EN 60079 standards will be summerized in the series IEC/EN 60079 standards e.g. IEC 61241-1 will be classified as IEC 60079-31.
– some of the standards are in preparation!

7. appendix

7.2 Safety Characteristics of Flammable Gases and Vapours

Table 18: **Safety Ratings: Ignition Temperature, Temperature Class and Explosion Group**

Material	Ignition Temperature °C	Temperature Class	Explosion Group
1,2-Dichloroethane	440	T 2	II A
Acetaldehyde	155	T 4	II A
Acetic acid	485	T 1	II A
Acetic anhydride	330	T 2	II A
Acetone	535	T 1	II A
Acetylene	305	T 2	II C[3]
Ammonium	630	T 1	II A
Benzene	555	T 1	II A
Carbon disulphide	95	T 6	II C[1]
Carbon monoxide	605	T 1	II A
Cyclohexanone	430	T 2	II A
Diethyl ether	175	T 4	II B
Diesel fuels	220	T 3	II A
Ethane	515	T 1	II A
Ethanol	400	T 2	II B
Ethene	440	T 2	II B
Ethyl chloride	510	T 1	II A
Ethyl ethanoate	470	T 1	II A
Ethyl glycol	235	T 3	II B
Ethylene oxide	435 (self-decomposing)	T 2	II B
Fuel oil EL, L, M, S	220 to 300	T 3	II A
Hydrogen	560	T 1	II C[2]
Hydrogen sulphide	270	T 3	II B
i-Amyl acetate	380	T 2	II A
Methane	595	T 1	II A
Methanol	440	T 2	II A
Methyl chloride	625	T 1	II A
Naphthalene	540	T 1	II A
n-Butane	365	T 2	II A
n-Butanol	325	T 2	II B
n-Hexane	230	T 3	II A
n-Propyl alcohol	385	T 2	II B*
Petrol fuels	220 to 300	T 3	II A
Phenol	595	T 1	II A
Propane	470	T 1	II A
Toluene	535	T 1	II A

*The gas group for this substance has not yet been determined.
[1]Also gas groups II B + CS2 [2]Also gas groups II B + H2 [3]Also gas groups II B + C2 H2

7.3 Classification of Hazardous Locations in North America

Table 19: **Classification of Hazardous Locations in North America**

Gases, vapors or mists Classification Class I		Dusts	Fibres and flyings
NEC 500-5 CEC J18-004	NEC 505-7 CEC 18-006	NEC 500-6 CEC 18-008	Fibres and flyings Classification Class III
Division 1 Locations where ignitible concentrations of flammable gases or vapors can exist under normal operating conditions as well as frequently because of repair or maintenance operations or because of leakage.	Zone 0 Locations where ignitible concentrations of flammable gases or vapors are present continuously or for long periods of time.	Division 1 Locations where ignitible concentrations of combustible dust is in the air under normal operating conditions.	Division 1 Locations where easily ignitible fibres or materials producing combustible flyings are handled, manufactured or used.
	Zone 1 Locations where ignitable concentrations of flammable gases or vapors are likely to exist under normal operating conditions or may exist frequently because of repair or maintenance or because of leakage.		
Division 2 Locations where ignitible concentrations of flammable gases or vapors can exist under abnormal operating conditions.	Zone 2 Locations where ignitible concentrations of flammable gases or vapors are not likely to occur in normal operation, and if they do, will exist only for a short period.	Division 2 Locations where ignitible concentrations of combustible dust is in the air under abnormal operating conditions.	Division 2 Locations where easily ignitible fibres and materials producing combustible flyings are stored or handled other than in the process of manufacture.
Class I Groups		Class II Groups	Class III
NEC 500-3 CEC J18-050	NEC 505-7 CEC J18-050	NEC 500-3 CEC J18-050	
Division 1 and 2 A (Acetylene) B (Hydrogen) C (Ethene) D (Propane)	Zone 0, 1 and 2 IIC (Acetylene + Hydrogen) IIB (Ethene) IIA (Propane)	Division 1 and 2 E (Metal) F (Coal) G (Grain)	Division 1 and 2 none
Class I Temperature classes Division 1 and 2	Zone 0, 1 and 2	Class II Temperature classes Division 1 and 2	Class III Temperature Division 1 and 2
T1 (≤ 450 °C, 842 °F)	T1 (≤ 450 °C)	T1 (≤ 450 °C, 842 °F)	none
T2 (≤ 300 °C, 572 °F)	T2 (≤ 300 °C)	T2 (≤ 300 °C, 572 °F)	
T2A, T2B, T2C, T2D (≤ 280 °C, ≤ 260 °C, ≤ 230 °C, ≤ 215 °C) (536 °F, 500 °F, 446 °F, 419 °F)		T2A, T2B, T2C, T2D (≤ 280 °C, ≤ 260 °C, ≤ 230 °C, ≤ 215 °C) (536 °F, 500 °F, 446 °F, 419 °F)	
T3 (≤ 200 °C, 392°F)	T3 (≤ 200 °C)	T3 (≤ 200 °C, 392°F)	
T3A, T3B, T3C (≤ 180 °C, ≤ 165 °C, ≤ 160 °C) (356 °F, 329 °F, 320 °F)		T3A, T3B, T3C (≤ 180 °C, ≤ 165 °C, ≤ 160 °C) (356 °F, 329 °F, 320 °F)	
T4 (≤ 135 °C, 275°F)	T4 (≤ 135 °C)	T4 (≤ 135 °C, 275°F)	
T4A (≤ 120 °C, 248°F)		T4A (≤ 120 °C, 248°F)	
T5 (≤ 100 °C, 212°F)	T5 (≤ 100 °C)	T5 (≤ 100 °C, 212°F)	
T6 (≤ 85 °C, 185°C)	T6 (≤ 85 °C)	T6 (≤ 85 °C, 185°C)	

7. appendix

7.4 Constructional Requirements for Explosion Protected Electrical Equipment

Table 20: **Constructional Requirements in Europe, USA, Canada, and International Comparison, Part 1**

Type of ignition protection	Abbreviation	Region	Installation location	Standard
General requirements		US	Class I, Division 1 & 2	FM 3600
	AEx	US	Class I, Zone 0, 1, & 2	ISA 60079-0
	Ex	CA	Class I, Zone 0, 1, & 2	CSA E60079-0
	Ex (EEx)	EU	Zone 0, 1 & 2	EN 60079-0
	Ex	IEC	Zone 0, 1 & 2	IEC 60079-0
Increased safety	AEx e	US	Class I, Zone 1	ISA 60079-7
	Ex e	CA	Class I, Zone 1	CSA E60079-7
	Ex e (EEx e)	EU	Zone 1	EN 60079-7
	Ex e	IEC	Zone 1	IEC 60079-7
Non-incendive	(NI)	US	Class I, Division 2	FM 3611
	(NI)	CA	Class I, Division 2	C22.2 No. 213
Non-sparking apparatus	AEx nA	US	Class I, Zone 2	ISA 60079-15
	Ex nA	CA	Class I, Zone 2	CSA E60079-15
	Ex nA (EEx nA)	EU	Zone 2	EN 60079-15
	Ex nA	IEC	Zone 2	IEC 60079-15
Explosion-proof	(XP)	US	Class I, Division 1	FM 3615
	(XP)	CA	Class I, Division 1	C22.2 No. 30
Flameproof enclosure	AEx d	US	Class I, Zone 1	ISA 60079-1
	Ex d	CA	Class I, Zone 1	CSA E60079-1
	Ex d (EEx d)	EU	Zone 1	EN 60079-1
	Ex d	IEC	Zone 1	IEC 60079-1
Powder filling	AEx q	US	Class I, Zone 1	ISA 60079-5
	Ex q	CA	Class I, Zone 1	CSA E79-5
	Ex q (EEx q)	EU	Zone 1	EN 50017
	Ex q	IEC	Zone 1	IEC 60079-5
Protected facilities and components	AEx nC	US	Class I, Zone 2	ISA 60079-15
	Ex nC	CA	Class I, Zone 2	CSA E60079-15
	Ex nC (EEx nC)	EU	Zone 2	EN 60079-15
	Ex nC	IEC	Zone 2	IEC 60079-15
Intrinsic Safety	(IS)	US	Class I, Division 1	FM 3610
	(IS)	CA	Class I, Division 1	C22.2 No. 157
	AEx ia	US	Class I, Zone 0	FM 3610
	AEx ib	US	Class I, Zone 1	FM 3610
	Ex ia	CA	Class I, Zone 0	CSA E60079-11
	Ex ib	CA	Class I, Zone 1	CSA E60079-11
	Ex ia (EEx ia)	EU	Zone 0	EN 60079-11
	Ex ic	EU	Zone 2	EN 60079-11
	Ex ib (EEx ib)	EU	Zone 1	EN 60079-11
	Ex ia	IEC	Zone 0	IEC 60079-11
	Ex ic	IEC	Zone 2	IEC 60079-11
	Ex ib	IEC	Zone 1	IEC 60079-11

Table 21: **Constructional Requirements in Europe, USA, Canada and International Comparison, Part 2**

Type of ignition protection	Abbreviation	Region	Installation location	Standard
Energy-limited apparatus	AEx nC	US	Class I, Zone 2	ISA 60079-15
	Ex nL	CA	Class I, Zone 2	CSA E60079-15
	Ex nL (EEx nL)	EU	Zone 2	EN 60079-15
	Ex nL	IEC	Zone 2	IEC 60079-15
Pressurized enclosure	Type X	US	Class I, Division 1	FM 3620
	Type X	CA	Class I, Division 1	NFPA 496
	Type Y	US	Class I, Division 1	FM 3620
	Type Y	CA	Class I, Division 1	NFPA 496
	Type Z	US	Class I, Division 2	FM 3620
	Type Z	CA	Class I, Division 2	NFPA 496
	AEx px	US	Class I, Zone 1	ISA 60079-2
	Ex px	CA	Class I, Zone 1	CSA E60079-2
	Ex px (EEx px)	EU	Zone 1	EN 60079-2
	Ex px	IEC	Zone 1	IEC 60079-2
	AEx py	US	Class I, Zone 1	ISA 60079-2
	Ex py	CA	Class I, Zone 1	CSA E60079-2
	Ex py (EEx py)	EU	Zone 1	EN 60079-2
	Ex py	IEC	Zone 1	IEC 60079-2
	AEx pz	US	Class I, Zone 2	ISA 60079-2
	Ex pz	CA	Class I, Zone 2	CSA E60079-2
	Ex pz (EEx pz)	EU	Zone 2	EN 60079-2
	Ex pz	IEC	Zone 2	IEC 60079-2
Purged/pressurized	AEx nR	US	Class I, Zone 2	ISA 60079-15
	Ex nR	CA	Class I, Zone 2	CSA E60079-15
	Ex nR (EEx nR)	EU	Zone 2	EN 60079-15
	Ex nR	IEC	Zone 2	IEC 60079-15
Encapsulation	Ex ma (EEx ma)	EU	Zone 0	EN 60079-18
	Ex ma	IEC	Zone 0	IEC 60079-18
	AEx m	US	Class I, Zone 1	ISA 60079-18
	Ex m	CA	Class I, Zone 1	CSA E60079-18
	Ex mb (EEx mb)	EU	Zone 1	EN 60079-18
	Ex mb	IEC	Zone 1	IEC 60079-18
Oil immersion	AEx o	US	Class I, Zone 1	ISA 60079-6
	Ex o	CA	Class I, Zone 1	CSA E79-6
	Ex o (EEx o)	EU	Zone 1	EN 50015
	Ex o	IEC	Zone 1	IEC 60079-6

7. appendix

7.5 Degrees of Protection according to IEC 60 529 - IPXX

Table 22: **Degrees of Protection according to IEC 60 529 - IPXX**

Digit	First digit Physical protection	Foreign body protection	Second digit Water protection
0	No protection	No protection	No protection
1	Protection against back of hand contact	Protection against solid foreign bodies 50 mm ∅	Protection against water drops falling vertically
2	Protection against finger contact	Protection against solid foreign bodies 12.5 mm ∅	Protection against water drops falling at an angle (15°)
3	Protection against contact from tools	Protection against solid foreign bodies 2.5 mm ∅	Protection against water-spray at an angle up to 60°
4	Protection against contact with a wire	Protection against solid foreign bodies 1.0 mm ∅	Protection against water spray from all directions
5	Protection against contact with a wire	Protection against dust	Protection against water jets
6	Protection against contact with a wire	Dust-tight	Protection against strong water jets
7			Protection against intermittent immersion in water
8			Protection against continuous immersion in water

7.6 Degrees of Protection according to NEMA Standards

Table 23: **Degree of Protection provided by Enclosures according to NEMA (Publication No. 250 Enclosures for Electrical Equipment 1000 Volts Maximum)**

Digit	Degree of Protection	Use
Type 1	Protection against incidental contact with the enclosed equipment.	Indoor
Type 2	Protection against limited amounts of falling water and dirt.	Indoor
Type 3	Protection against rain, sleet, windblown dust, and damage from external ice formation	Outdoor
Type 3R	Protection against rain, sleet, and damage from external ice formation.	Outdoor
Type 3S	Protection against rain, sleet, windblown dust, and for operation of external mechanisms when ice laden.	Outdoor
Type 4	Protection against, rain, splashing water, hose directed water, and damage from external ice formation.	Indoor or outdoor
Type 4X	Protection against, rain, splashing water, hose directed water, and damage from external ice formation. Protection against corrosion.	Indoor or outdoor
Type 5	Protection against settling airborne dust, falling dirt, and dripping non-corrosive liquids.	Indoor
Type 6	Protection against hose directed water, penetration of water during occasional temporary submersion at a limited depth, and damage from external ice formation.	Indoor or outdoor
Type 6P	Protection against hose directed water, penetration of water during prolonged submersion at a limited depth, and damage from external ice formation.	Indoor or outdoor
Type 7	For use in locations classified as Class I, Groups A, B, C or D as defined in the NEC.	Indoor
Type 8	For use in locations classified as Class I, Groups A, B, C or D as defined in the NEC.	Indoor or outdoor
Type 9	For use in locations classified as Class II, Groups E, F or G as defined in the NEC.	Indoor
Type 10	Constructed to meet the applicable requirements of the Mine Safety Health Administration.	Mining
Type 11	Protection against the corrosive effects of liquids and gases by oil immersion.	Indoor
Type 12, 12K	Protection against circulating dust, falling dirt, and dripping non-corrosive liquids.	Indoor
Type 13	Protection against dust, splashing water, oil, and non-corrosive liquids.	Indoor

8. literature

8. Literature

Directive 94/9/EU of the European Parliament and the council of 23 March 1994 on the approximation of the laws of the member states concerning equipment and protective systems intended for use in potentially explosive atmospheres. Official Journal of the European Communities, No. L 100/1

The Equipment and Protective Systems for Use in Potentially Explosive Atmospheres Regulations, 1996 (EPS), ATEX 95 (UK). Explosionsschutzverordnung (ExVO) – Verordnung über das Inverkehrbringen von Geräten und Schutzsystemen für explosionsgefährdete Bereiche. 11. GPSV (Explosion Protection Regulation). – Germany

Directive 99/92/EC on the "Minimum requirements for improving the health and safety protection of the worker at risk from explosive atmospheres" 16/12/1999, Official Journal of the European Communities, L23/57–64

The Dangerous Substances and Explosive Atmospheres Regulations 2002, Statutory Instrument 2002 No. 2776 (UK). Verordnung über Sicherheit und Gesundheitsschutz bei der Bereitstellung von Arbeitsmitteln und deren Benutzung bei der Arbeit, über Sicherheit beim Betrieb überwachungsbedürftiger Anlagen und über die Organisation des betrieblichen Arbeitsschutzes – Betriebssicherheitsverordnung (BetrSichV) (Regulation on safety and health protection in the provision of work equipment and its use, on safety when operating installations requiring special state regulation and supervision and on the organisation of safety at work) – Germany

Regeln für das Vermeiden der Gefahren durch explosionsfähige Atmosphäre – Explosionsschutzregeln (ExRL) (Rules for the avoidance of hazards from explosive atmospheres – Explosion Protection Rules) published by the "Hauptverband der gewerblichen Berufsgenossenschaften", Fachausschuss Chemie der BGZ, BGR 104

E. Brandes, W. Möller
Sicherheitstechnische Kenngrößen Band 1:
Brennbare Flüssigkeiten und Gase
(Safety Characteristics Vol. 1:
Flammable Liquids and Gases)
Wissenschaftsverlag NW
Verlag für neue Wissenschaft GmbH

Molnárné, Schendler, Schröder
Sicherheitstechnische Kenngrößen Band 2:
Explosionsbereiche von Gasgemischen
(Safety Characteristics: Vol. 2:
Explosion regions of gas mixtures)
Wissenschaftsverlag NW
Verlag für neue Wissenschaft GmbH

M. Hattwig, H. Steen
Handbook of Explosion Prevention and Protection
Wiley VCH, 2004, ISBN 3527307184

IEC 60079 or EN 60079 series
Electrical apparatus for explosive gas atmospheres
VDE-Verlag GmbH, Berlin

IEC 61241 and EN 61241 series
Electrical apparatus for use in the presence of combustible dust

EN 60 529
Specification for degrees of protection provided by enclosures (IP code)

EN 13463 Part 1 – Part 8
Non-electrical equipment for potentially explosive atmospheres

Dust explosion prevention and protection for machines and equipment
ISSA Prevention Series No. 2033 (G)

Dust explosions
ISSA Prevention Series No. 2044 (G)

The basics of dust explosion protection
R. STAHL Schaltgeräte GmbH

Operators of electrical installations in plants with potentially explosive atmosphere
R. STAHL Schaltgeräte GmbH

9. adresses

Europe

Austria
R. STAHL Schaltgeräte GmbH
Birkengasse 17
2435 Ebergassing
Tel. +43 2234 / 734 01
Fax +43 2234 / 734 15
Mobile +43 664 / 438 96 15
E-mail: wilhelm.gall@stahl.de

Azerbaijan
SIRIUS Construction
93, Nizamy St.
1000 Baku
Tel. +994 12 4931820
Fax +994 12 4985331
E-mail: sirius_c@azeurotel.com

Belarus
Eximelektro
ul. Serafimowitscha 13–23
Minsk 220033
Tel. +375 17 2984457
Fax +375 17 2984156
E-mail: eximelektro@tut.by

Belgium
STAHL N.V.
Sint Gillislaan 6, bus 3
9200 Sint Gillis – Dendermonde
Tel. +32 52 211351
Fax +32 52 211347
E-mail: mail@stahl.be

Bulgaria
TELECON CO.
29, Ilijantzi Blvd.
Sofia 1220
Tel. +359 2 8130813
Fax +359 2 8130815
E-mail: sa@telecon-co.com

Croatia
TEHMAR d.o.o.
Palmoticeva 23
21000 Split
Tel. +385 21 530564
Fax +385 21 530564
E-mail: info@tehmar-st.hr
zoran.babic@st.htnet.hr

Czech Republic
EX-TECHNIK spol. s.r.o.
Na Peconce 1903/21
710 00 Ostrava
Tel. +420 69 6242548
Fax +420 69 6242551
E-mail:
martin.balek@ex-technik.cz

Denmark
Max Fodgaard A/S
Sydholmen 10
2650 Hvidovre
Tel. +45 70261700
Fax +45 70263110
E-mail: max@fodgaard.dk

Egypt
Eagle Co. (S.A.E.)
23, Fawzy Moaaz Str.
432 Alexandria
Tel. +20 3 4257011
Fax +20 3 4257061, 4257079
E-mail: eagle.co@tedata.net.eg

Estonia
TALGER-ELEKTROTEHNICA OÜ
Betooni 14
11415 Tallinn
Tel. +372 6838800
Fax +372 6838810
E-mail: talger@talger.ee

Finland
Ex-Tekniikka OY
Sörnäisten Rantatie 27
00500 Helsinki
Tel. +358 9 774422-0
Fax +358 9 774422-44
E-mail: info@extekniikka.fi

France
R. STAHL France SAS
Immeuble NAXOS
56, Rue des Hautes Pâtures
92737 Nanterre Cedex
Tel. +33 (0)1 41 19 48 58
Fax +33 (0)1 41 19 48 59
E-mail: info@stahl.fr

Germany
R. STAHL Schaltgeräte GmbH
Niederlassung Nord
Grusonstr. 55
22113 Hamburg
Tel. +49 40 736054-0
Fax +49 40 736054-54
E-mail: info.ex@stahl.de

R. STAHL Schaltgeräte GmbH
Niederlassung West
Brügelmannstr. 5
50679 Köln
Tel. +49 221 962569-0
Fax +49 221 962569-25
E-mail: info.ex@stahl.de

R. STAHL Schaltgeräte GmbH
Niederlassung Süd
Am Bahnhof 30
74638 Waldenburg
Tel. +49 7942 943-0
Fax +49 7942 943-1777
E-mail: info.ex@stahl.de

R. STAHL HMI Systems GmbH
Im Gewerbegebiet Pesch 14
50767 Köln
Tel. +49 221 59808-200
Fax +49 221 59808-260
E-mail: office@stahl-hmi.de

Great Britain
R. STAHL Ltd.
Stahl House
43 Elmdon Trading Estate
Bickenhill Lane
Birmingham B37 7HE
Tel. +44 121 767 6400
Fax +44 121 767 6490
E-mail: info@rstahl.co.uk

Greece
ADICON
6 Selefkou
13676 Thrakomakedones/Athens
Tel. +30 210 243 3383
Fax +30 210 243 5073
E-mail: tsakarelos@tee.gr

Hungary
STAHL Magyarország Kft
17. Maglódi str., C/I/107.
1106 Budapest
Tel. +36 1 4333360
Fax +36 1 4333361
E-mail: rstahl@rstahl.hu

Italy
R. STAHL Srl
Leivi
16040 S. Colombano (Genova)
Tel. +39 0185 3583-91, -92
Fax +39 0185 358219
E-mail: info@stahl.it

Kazakhstan
BORKIT Ltd
86, Gogol St.
Office No. 323
Almaty, 480091
Tel. +7 3272 506128
Fax +7 3272 506129

BORKIT Ltd
74A, Azattyk Ave.
Atyrau, 060005
Tel. +7 3122 457190
Fax +7 3122 457346

Latvia
BALTIJAS ELEKTRO
SABIEDRIBA SIA
Krustpils Iela 38a
1057 Riga
Tel. +371 7100100
Fax +371 7188862

Lithuania
UAB ELEKTROBALT
Liepkalnio g. 85
02120 Vilnius
Tel. +370 5 2660091
Fax +370 5 2660097

Makedonia
KEYING
Prolet 39
1000 Skopje
Tel. +389 23 230203
Fax +389 23 110046

Netherlands
ELECTROMACH B.V.
Hamerstraat 10
P.O. Box 175
7550 AD Hengelo
Tel. +31 74 2472472
Fax +31 74 2435925
E-mail: info@electromach.nl

Norway
STAHL-SYBERG A.S.
Prof. Birkelandsvei 27b
1081 Oslo
Tel. +47 24084410
Fax +47 24084411
E-mail:
g.steffenssen@stahl-syberg.no

Poland
ASE-Automatic
Systems Engineering
ul. Narwicka 6
80557 Gdansk
Tel. +48 58 5207720
Fax +48 58 3464344

Portugal
Industrias STAHL, S.A.
sucursal em Portugal
Largo Piramide nº 3 M
Sala E Gab. 7
2795-156 Linda-a-Velha
(Conçeio Oeiras), Lisboa
Tel. +351 21 4145315
Fax +351 21 4145317
E-mail: stahl@stahl.pt

Romania
COELCO TRADE
Blv. Iuliu Maniu nr. 19C
Bucuresti 6, RO 061076
Tel. +40 21 4119621
Fax +40 21 4119781
E-mail: office@coelco.ro

Russia
INTERPROMPRIBOR
6th floor No. 10,
Zvyozdnyi bulvar 21
129085 Moskau
Tel. +7 495 6163252
Fax +7 495 6163464
E-mail: imprompr@rol.ru

ITC Novosibirsk
Krasniy Prospekt 82/1
630091 Novosibirsk
Tel. +7 383 2277888
Fax +7 383 3356930
E-mail: nsk@itc-electronics.com

Serbia
KEYING d.o.o.
Vuka Karaždića 79
23300 Kikinda
Tel. +381 230 401770
Fax +381 230 401790
E-mail: keying@flashnet.co.yu

Slovakia
HAGARD:HAL
Prazska 6
94911 Nitra
Tel. +421 37 7913000
Fax +421 37 7411508

Slovenia
SYNATEC d.o.o.
Vojkova ulica 8B
5280 Idrija
Tel. +386 5 3720650
Fax +386 5 3720660

Spain
INDUSTRIAS STAHL S.A.
Aragoneses, 2 Acceso 10
Polígono Industrial
28108 Alcobendas (Madrid)
Tel. +34 91 6615500
Fax +34 91 6612783
E-mail: stahl@stahl.es

Sweden
R. STAHL SVENSKA AB
Bagspännarvägan 14
17568 Järfälla
Tel. +46 8 389100
Fax +46 8 389198

Switzerland
STAHL-Fribos AG
Industriestr. 26
5070 Frick
Tel. +41 62 86540-60
Fax +41 62 86540-80
E-mail: info@stahl-fribos.ch

Republic of South Africa
ESACO Pty. Ltd.
P.O. Box 3095
1610 Edenvale
Tel. +27 11 6083100
Fax +27 11 6083165
E-mail: esaco@esaco.co.za
rpanis@esaco.co.za

Ukraine
DONETSK ENGINEERING GROUP
17, 50th Gvardeyskaya Diviziya str.
83052 Donetsk
Tel. +380 62 3828977
Fax +380 62 3828412
E-mail: marketing@deg.com.ua

America

Argentina
NORRI S.R.L.
Bogota 2384
1640 Martinez
Pcia. Buenos Aires
Tel. +54 11 4717-6991, -6334
Fax +54 11 4798-6991, -6334

Brazil
Instrumentos Lince LTDA.
Rua Luiz Ferreira, 84
Bonsucesso
21042 - 210 Rio de Janeiro - RJ
Tel. +55 21 25732344
Fax +55 21 25615326

Chile
INGENIERIA DESIMAT LTDA.
Av. Puerto Vespucio
9670 Pudahuel Santiago
Tel. +56 2 7470152
Fax +56 2 7470153

Colombia
Automatización Avanzada S.A.
Carrera 98 No. 41A-23, Bodega 3
Santafe de Bogota
Tel. +57 1 4188867, 4132324
Fax +57 1 4159788

Mexico
Implementos y Servicios
Electrónicos S.A. de C.V. (ISEL)
Via Lopez Mateos No. 128
Col. Jacarandas
C.P. 54050 Tlalnepantla
Estado de Mexico
Tel. +52 55 5398-8088
Fax +52 55 5397-3985
E-mail: isel2@prodigy.net.mx

Peru
DESIMAT PERU SAC
Av. Velasco Astete 2371
Surco-Lima
Tel. +51 1 2752765
Fax +51 1 2752776
E-mail: ventasperu@desimat.com

USA/Canada
R. STAHL Inc.
9001 Knight Rd.
Astro Business Center
Houston, Tx 77054
Tel. +1 713 7929300
Fax +1 713 7929301
E-mail: sales@rstahl.com

Venezuela
TEXCA C.A.
Edificio LIPESA, Piso 3, Oficina 32
Avenida Orinoco, Bello Monte
Caracas
Tel. +58 212 9532769
Fax +58 212 9521504

Asia

Abu Dhabi
Al Sahwa Trading Co. L.L.C.
P.O. Box 45491
Abu Dhabi
Tel. +971 2 6273270
Fax +971 2 6270960
E-mail: rajantawade@alhassan.ae

Australia
NHP Electrical Engineering
Products Pty. Ltd.
43-67 River Street
Richmond Victoria 3121
Tel: +61 3 9429 2999
Fax +61 3 9429 1075
E-mail: mel-sales@nhp.com.au

Brunei
Aisha Automation Company
No.137, Lot 4034
Jalan Jaya Negara
Kuala Belait KA1931
P.O. Box 629, Kuala belait KA1131
Negara Brunei Darussalam
Tel. +673 3331312, 3342529
Fax +673 3342529
E-mail:
enquiry@aishaautomation.com

P.R. China
R. STAHL EX-PROOF CO. Ltd.
(SHANGHAI)
Unit D, 9th Floor, Building No. 4
889 Yishan Road
Shanghai 200233
Tel. +86 21 64850011
Fax +86 21 64852954
E-mail: benjamin@rstahl.com.cn

India
R. STAHL (P) Ltd.
9, Arcot Road
Lakshmi Nagar, Porur
Chennai 600 116
Tel. +91 44 24766674
Fax +91 44 24767835
E-mail: stahl@vsnl.com

Indonesia
PT MUSTIKA STAHL
Jl. Griya Agung No. 81
Griya Inti Sentosa – Sunter Agung
Jakarta 14350
Tel. +62 21 6450574
Fax +62 21 6404249
E-mail: m.stahl@dnet.net.id

PT ULTRA DELTA MAJU
Kedoya Elok Plaza
Blok DD No. 59–60
Jl. Panjang Kebon Jeruk
Jakarta 11520
Tel. +62 21 58300678
Fax +62 21 58300686, -87

PT Maxima Pro Corpora
(Instrumentation only)
GEDUNG PESONA 1st Floor,
Suite 102 Jl. Ciputat Raya No. 20
Tanah Kusir, Kebayoran Lama
Jakarta Selatan 12310
Tel. +62 21 7292 158
Fax +62 21 7292 159
E-mail:
contactus@maximapro.co.id

PT Prakarsa Daya Juang
(Switchgear & Lighting)
Wisma Kosgoro
16th Floor, Suite 1603
JL MH Thamrin Kav 49
Jakarta 10350
Tel. +62 21 3983 6063
Fax +62 21 3983 6062

Iran
TBN Co.
Apt. 13, 7th Floor, No. 92
West Sepand St, South Aban Ave
Karim Khan Zand Blvd
Tehran
Tel. +982 188 927 264
E-mail: nader@tbnco.com

Japan
R. STAHL K.K. Co. Ltd.
Sinyurigaoka – City Bldg. 4F
1-1, Manpukuji 1-chome, Asou
215-0004 Kawasaki-shi,
Kanagawa
Tel. +81 44 9592612
Fax +81 44 9592605
E-mail:
sakae-nishimine@par.odn.ne.jp

Korea
R. STAHL Co. Ltd.
No. 503 Keang Nam Bldg.
#163-16 Sung Nae-Dong
Kang Dong-Ku
Seoul
Tel. +82 2 4708877
Fax +82 2 4718285
E-mail: korea@stahl.co.kr

9. adresses

Kuwait
Rezayat Trading Company
P.O. Box 106
Safat 13002
Kuwait
Tel. +965 481 6838
E-mail:
kmoryani@rezayatkwt.com

Malaysia
ESTEEM LINK (LU) SDN BHD.
(Agent for East Malaysia:
Switchgear&Lighting)
321, Jalan Nahkoda Gampar,
PO Box 1140,
98008 Miri, Sarawak
Tel. +60 85 417230
Fax +60 85 414352
E-mail: ellusb@tm.net.my

EMPIRE ENGINEERING SDN BHD.
(Agent for West Malaysia:
Switchgear & Lighting)
Unit D3A02, Kelana Square
17, Jalan SS7/26, Kelana Jaya
47301 Petaling Jaya, Selangor
Tel. +60 37803 1477
Fax +60 37803 1377
E-mail: info@empire-engr.com

VECTOR INFOTECH SDN BHD
(Instrumentation only)
Block C-5-7 & 8 (Level 7)
UE3 Menara Uncang Emas
No. 85, Jalan Loke Yew
55300 Kuala Lumpur
Tel. +60 3 92001396/1397
Fax +60 3 92001398
E-mail: dshii@vectorinfotech.com

New Zealand
ELECTROPAR Ltd.
P.O. Box 58623
Greenmount
Auckland 1701
Tel. +64 9 2742000
Fax +64 9 2742001
E-mail: mikeb@electropar.co.nz

Oman
Al Hassan Group of Companies
P.O. Box 1948
Postal Code 112
Ruwi
Tel. +968 248 10575-209
E-mail: vinita@al-hassan.com

Pakistan
Clipsal Pakistan (PVT) Ltd.
101–102, Sector 15
Korangi Industrial Estate
Karachi
Tel. +92 21 5067278
Fax +92 21 5063369

Philippines
MATERIALS UNLIMITED
CORPORATION
No. 2 Congressional Avenue
Project 6, Quezon City
Tel. +63 2 4263856/57
Fax +63 2 9248664
E-mail: matcor@pldtdsl.net

Qatar
Petroleum Technology Co. W.L.L.
P.O. Box 16069
8th Floor, Toyota Tower
Airport Road
Doha
Tel. +974 441 9603
E-mail: mohan@petrotecnet.com

Saudi Arabia
Al-Quraishi
Electrical Services of S.A.
Jubail Branch
Kingdom of Saudi Arabia
Tel. +966 3 835 1155 Ext. 300
E-mail: bashara@aqesa.com

Singapore
R. STAHL PTE Ltd.
No. 3791 Jalan Bukit Merah
#09-08/09 E-Centre@Redhill
Singapore 159 471
Tel. +65 62714065
Fax +65 63770111
E-mail: rstahl@singnet.com.sg

BENWIN SINGAPORE PTE Ltd.
(Switchgear & Lighting)
237 Kaki Bukit Ave 1
Shun Li Industrial Park
Singapore 416053
Tel. +65 6842 6880
Fax +65 6842 6836
E-mail: benny@benwin.com.sg

VECTOR INFOTECH
PRIVATE LIMITED
(Instrumentation only)
91 Defu Lane 10, #04-01
Swee Hin Building
Singapore 539221
Tel. +65 6356 7333
Fax +65 6356 7322
E-mail:
ahtan@vectorinfotech.com

Taiwan
Wan Jiun Hsing Enterprise Co.
Ltd.
11F-1, No. 178, Sec. 4
Cheng Te Rd.
Taipei
Tel. +886 2 28822211
Fax +886 2 28817562

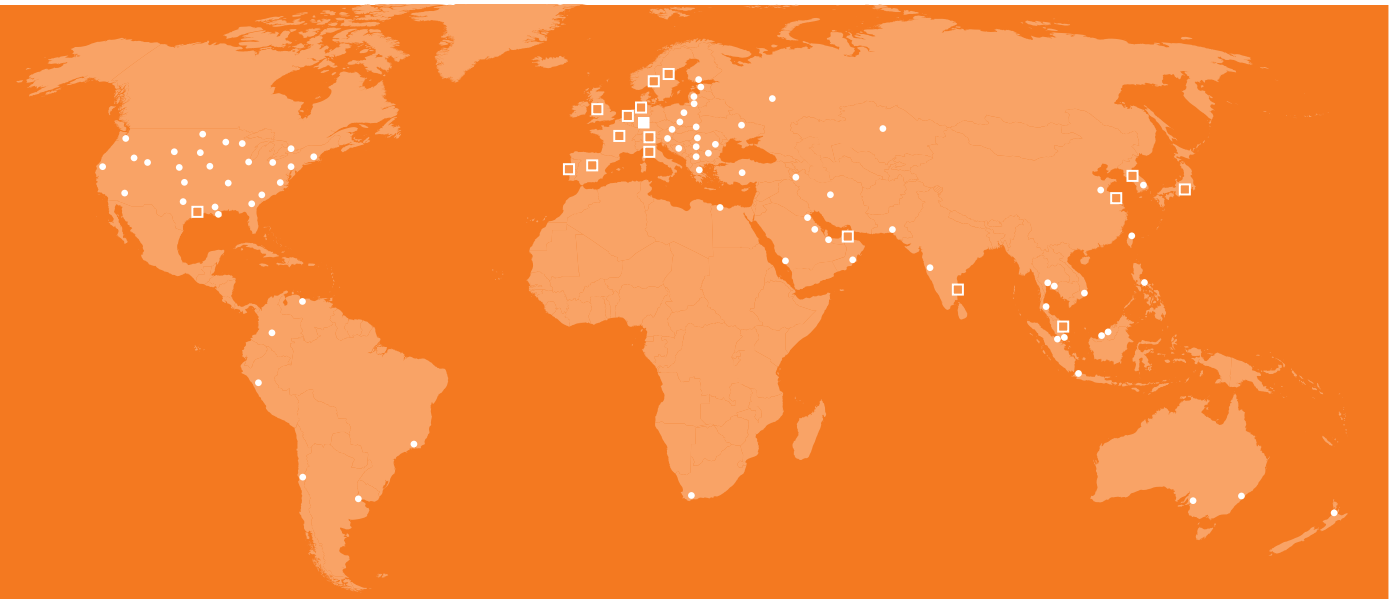
Thailand
C.K. Electech Co. Ltd.
31/14 Dhamrongruk Rd.
Pomprab
Bangkok 10100
Tel. +66 2 2800150-4
Fax +66 2 2803663-4

Contrologic Co. Ltd.
343, 345 Soipattanakarn 3
Pattanakarn Road
Suan Luang
Bangkok 10250
Tel. +66 2 3187499
Fax +66 2 3182818

Turkey
KAS PAZARLAMA A.S.
Sedat Simavi Sk. No. 52/2
06550 Cankaya/Ankara
Tel. +90 312 4414335
Fax +90 312 4414336
E-mail: info@kaspazarlama.com.tr

UAE
R. STAHL MIDDLE EAST FZE
P.O. Box 17784
Jebel Ali Free Zone
Dubai
Tel. +971 4 8835855
Fax +971 4 8834685

Vietnam
HAI SON COMPANY Ltd.
A20-K34 Tran Thien Chanh Street
District 10, Hochiminh City
Tel. +84 8 8630919
Fax +84 8 8630920
E-mail: hai@haison.com.vn



VISUELL, Stuttgart

R. STAHL Schaltgeräte GmbH
Am Bahnhof 30, 74638 Waldenburg, Germany
Telephone +49 7942 943-0
Fax +49 7942 943-4333

www.stahl.de

ID-NR. 00 006 25 77 0
S-PB-ExBasics-03-en-05/2007 · Printed in the Federal Republic of Germany