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The true measure

Weighing in hazardous areas

Requirements, applications and recommendations for use

IECEx
Weighing Platforms
FM
Gases
CSA
Hazardous Areas
Equipment
Load Cells
Flammable Substance
Protection
ATEX
Weighing Electronics
Dusts
Zoning

academy
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- ATEX directives and standards
- FM and CSA regulations and standards
- IECEx certification
- Comparison ATEX and FM/CSA
- Application examples for weighing solutions in hazardous areas

1. Weighing in hazardous areas

1.1 Whitepaper objective

This paper deals with the guidelines and requirements with respect to the selection and the safe operation of weighing equipment in explosion-risk environments. It is aimed at production managers, plant engineers, project engineers, health and safety officers and buyers in manufacturing companies as well as system integrators and machine builders in the food, chemical, pharmaceutical and construction materials industries. The document is intended to give you an informative insight into the current guidelines, with a focus on ATEX and the main parameters needed to simplify the selection of components to be used. For actual planning and consideration of new projects, please always consult the latest information and regulations.

1.2 History/Background information

As a key element of industrial safety technology, explosion protection deals with the task of preventing the ignition of flammable materials in explosive areas by electrical equipment, thus

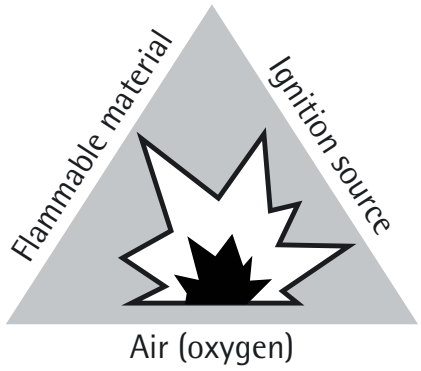


Figure 1: The prerequisites for an explosion

preventing damage to persons and operating systems as far as possible. Originally, techniques were developed for explosion protection in the mining sector in order to prevent the explosion of combustible gases through the mine pit lamps used at that time. In 1815, the chemist Sir Humphrey Davy developed the first explosion-proof device, an ignition-proof oil lamp. During the Industrial Revolution, in the late 18th century the first electrical equipment was used in mining thanks to their advantage in terms of being a significantly reduced risk as an ignition source. Simultaneously, the first accident prevention rules were developed which with the regulations "Guidelines for the implementation of firedamp protection structures of electrical machines, transformers and apparatuses" were first written down in the VDE 170.

1.3 Variety of regulations

Around the globe there is a wide range of national standards manufacturers have to deal with when offering technologies for the use in hazardous areas. Therefore, products which are sold in different countries also have different certifications for different environments at risk of explosion.

In some countries all equipment used in areas at risk of explosion must additionally be tested and approved by a national notified body (e.g. TIIS or NEPSI).

Apart from regional approvals, there are four standards providing an international acceptance. This White Paper focuses on

– ATEX (ATmosphere EXplosible)
– International Electrotechnical Commission (IEC)
– Canadian Standards Association (CSA)
– Factory Mutual Research Corporation (FM)

1.4 ATEX Directive

ATEX consists of two EU directives describing what equipment and work environment is allowed in an environment with an explosive atmosphere.

ATEX derives its name from the French title of the 2014/34/EU directive: Appareils destinés à être utilisés en ATmosphères EXplosives. There are two ATEX directives (one for the manufacturer and one for the user of the equipment):

The directive 2014/34/EU relating to equipment and protective systems intended for use in potentially explosive atmospheres (also referred to as ATEX 114).

The directive 1999/92/EC on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres (also referred to as ATEX 153).

The ATEX Product Directive describes rules for the design and development of products which are used in hazardous areas, and is designed to protect people who work in such areas. Through conformity assessment procedures, the manufacturer of such products must demonstrate compliance with the requirements and suitability for use in an explosion-risk area.

1.5 What is IECEx?

Beside the ATEX Directives which are accepted within the European Union, there are a lot of other national or regional directives, e.g. NEC (National Electrical Code) in the USA or CEC (Canadian Electrical Code) in Canada, which need to be fulfilled if a product is to be installed in this country or region. Although these directives have the same goal, their related norms and testing procedures, are slightly different such that manufacturers of electrical devices for explosion-risk areas need to apply separately for all the different local approvals. To harmonize the different testing procedures a new certification scheme "IECEx" was defined and, to date, 33 countries are members within this Ex Management committee. With this certification scheme it is now much easier to obtain the different local approvals as the main testing procedures have been harmonized. So IECEx is not a worldwide approval but a widely accepted standard to apply for a local approval.

1.6 Setup and operation of electrical equipment in hazardous areas

Safety in hazardous areas needs to be ensured by all involved parties such as manufacturers, installers, service providers authorities and operators. The health and safety officer is responsible for the safety of the plant and must judge the risks of explosion and organize the zoning according to IEC 60079-14 or national regulations. He/she must then ensure that the system is installed and checked properly prior to equipment commissioning. Through regular audits and maintenance, the proper state of the system can be ensured. The installer must observe installation requirements and select the electrical equipment properly.

2. Explosion protection according to ATEX

2.1 Safety requirements

For safe operation of equipment in hazardous areas, it is crucial that the safety measures specified by the Health and Safety officer and the safety level of the devices are compatible.

The safety requirements of the plant arise from the EU Directive ATEX 153, which must be implemented by the member states. The Health and safety officer must assess the potential danger that is present in any hazardous areas and carry out a clearly marked division into zones. To carry out this assessment there are three essential questions:

1. In what operating environment is the system to be installed?

- Mining (Underground mining)
- Industry (Above ground)

2. What type of flammable substance is present?

- Gases, vapours and mists (hydrogen, acetone, etc.)
- Dusts (flour, cotton, etc.)

3. How frequently does an explosive mixture occur?

- Continuously, frequently, often
- Sometimes
- Briefly, not normally

Manufacturers are subject to the EU Directive 2014/34/EU (ATEX 114, formerly 94/9/EC (ATEX 95)). The Directive and its associated standards regulate the requirements that are placed on the equipment, production and quality assurance to meet the safety requirements for hazardous areas.

2.2 Definition of zones for explosive mixtures

Regarding the ATEX 153 directive, the requirement is that employers must classify areas where hazardous explosive atmospheres may occur into zones. The classification given to a particular zone, and its size and location, depends on the likelihood of an explosive atmosphere occurring and its persistence if it does.

Areas classified into zones (0, 1, 2 for gas-vapor-mist and 20, 21, 22 for dust) must be protected from sources of ignition. Equipment and protective systems intended to be used in zoned areas must meet the requirements of the directive.

This classification is also defined as Equipment Protection Level (EPL), which is equivalent to the categories of the EU Directive.

IECEx classification for hazardous areas with gas-air and dust-air mixtures – EPL
A risk assessment approach for the acceptance of Ex equipment has been introduced as an alternative method to the current prescriptive and approach linking equipment to zones.

To facilitate this, a system of equipment protection levels has been introduced to clearly indicate the inherent ignition risk of equipment, no matter what type of protection is used.

The EPL is a level of protection assigned to equipment based on its likelihood of becoming a source of ignition which differenciates between explosive gas atmospheres, explosive dust atmospheres, and the explosive atmospheres in mines susceptible to firedamp.

ATEX classification for hazardous areas with gas-air and dust-air mixtures

Directive 2014/34/EU			Directive 1999/92/EC		Norm IEC 60079-0	
Equipment group	**Equipment category**	**Equipment safety**	**Zone**	**EX-Atmosphere**	**Equipment group**	**Equipment protection olevel (EPL)**
I (Mining)	M1	Very high	–	In rare errors	I (Mining)	Ma
	M2	High	–	Until switching off the unit		Mb
II (Industry)	1G	Very high	0	Continuously, frequently	II (Gas)	Ga
	2G	High	1	Sometimes		Gb
	3G	Normal	2	Rarely, briefly		Gc
	1D	Very high	20	Continuously, frequently	III (Dust)	Da
	2D	High	21	Sometimes		Db
	3D	Normal	22	Rarely, briefly		Dc

For Gases (device group II):
Gases are grouped together based upon the amount of energy required to ignite the most explosive mixture of the gas with air.

- IIA (slightly flammable gases/propane)
- IIB (easily flammable gases/ethylene)
- IIC (highly flammable gases/hydrogen)

Explosion group	Typical gas	Risk potential
IIA	Propane	
IIB	Ethylene	
IIC	Hydrogen	

Table 1: Explosion Groups for Gas

For Dusts (device group III):
Electrical equipment of Group III is subdivided according to the nature of the explosive dust.

- IIIA (combustible lint/cotton)
- IIIB (non-conductive dust/flour)
- IIIC (conductive dust/coal dust)

Explosion group	Typical gas	Risk potential
IIIA	Combustible lint	
IIIB	Non-conductive dust	
IIIC	Conductive dust	

Table 2: Explosion Groups for Dust

2.3 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 IEC 60079, formerly IEC 50014 and subsequent standards.

If electrical equipment is to be used in areas with combustible dust, the standards series IEC 60079 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 ATEX Directive 2014/34/EU (ATEX 114).

Ignition protection	Symbol	ATEX Zone	Protection principle	Main application
Increased safety "e" IEC 60079-7 Gas	eb ec	1 2	Additional measures are applied to increase the level of safety and prevent the possibility of inadmissibly high temperatures and the occurrence of sparks or electric arcs within the enclosure or on exposed parts of electrical equipment where such ignition sources would not occur in normal operation	Junction boxes, housings, engines, lamps, clamps
Intrinsic safety "i" IEC 60079-11 Gas / Dust	ia ib ic	0, 20 1, 21 2, 22	Limiting the electrical energy to prevent an ignition by either sparking or heating	Measuring and control technology, fieldbus technology, sensors, actors
Flameproof Enclosure "d" IEC60079-1	da db dc	0, 1, 2 1, 2 2	Type of protection in which components that could ignite a potentially explosive atmosphere are fitted in an enclosure that will contain the pressure of an explosion, preventing ignition of flammable gas outside the enclosure	Switchgear, lamps, fuses, power supplies
Encapsulation "m" IEC60079-18	ma mb mc	0,1, 2 and 20, 21, 22 1, 2 and 21, 22 2 and 22	Parts that could ignite a potentially explosive atmosphere by means of sparks or heat are potted so as to prevent ignition	Static coils in ballast, solenoid valves or motors, relays and other control gear of limited power, complete PCBs with electronic circuits
Ignition protection "n" nA = non-sparking equipment IEC 60079-15 Gas	nA	2	Electrical equipment cannot ignite an explosive atmosphere surrounding it during normal operation and under defined abnormal conditions	All electrical equipment for Zone 2
Protection by enclosure IEC 60079-31 Dust	ta tb tc	20 21 22	Electrical equipment in a housing which is protected against entry of dust and measures taken to limit the surface temperature	Junction boxes, housings, engines, lamps, cabinets, plugs

Table 3: Ignition protection types

2.4 Temperature classes

Another factor influencing the safety of a device is the maximum surface temperature. It is the temperature at the casing surface but also on any other part of the device – e.g. component surfaces – which can come into contact with the explosive atmosphere. The maximum surface temperature and the resulting temperature class is not to be confused with the operating or ambient temperature of the device.

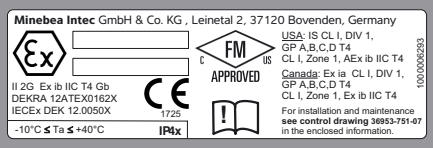
For Gases, after the determination of the maximum surface temperature – based on the IEC 60079-0 classification of the unit, there are six temperature classes T1 ... T6, which will be indicated on the device label. The temperature classes represent gases that have been classified by their ignition temperatures.

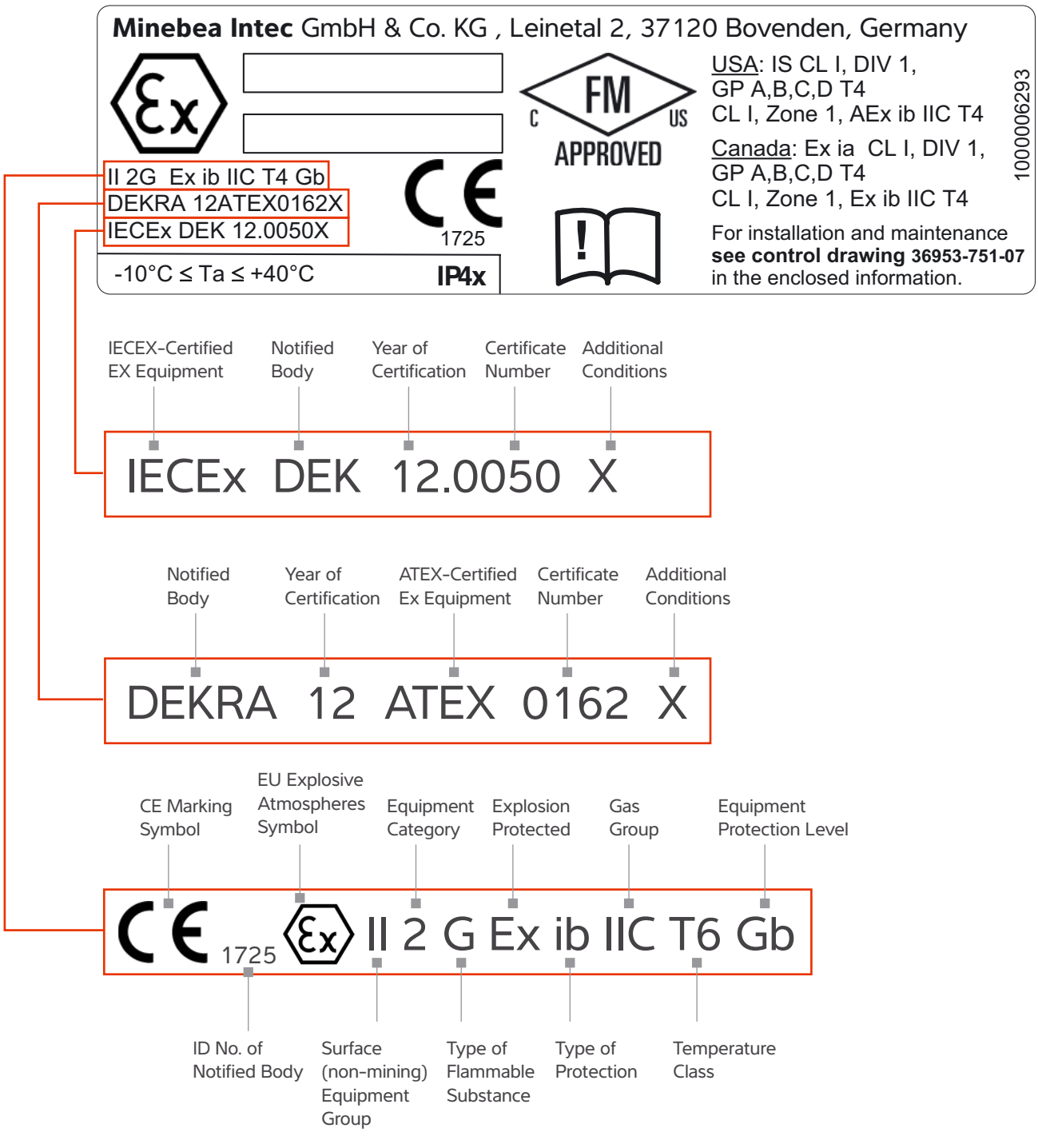
Ignition temperature of gases and vapors in °C	Temperature class	Maximum surface temperature of equipment in °C
>450	T1	450
>300 – 450	T2	300
>200 – 300	T3	200
>135 – 200	T4	135
>100 – 135	T5	100
>85 – 100	T6	85

Table 4: Temperature classes

For dust there is no such division into temperature classes. In this case the actual measured maximum surface temperature of the device indicated on the labeling. The user must therefore ensure that he selects a device appropriate for its application; that which ensures reliable operation in the anticipated dust atmosphere.

2.5 Ex-marking and labeling





3. Explosion protection according to IEC, CSA and FM

3.1 IEC

The IEC (International Electrotechnical Commission) is an independent organization that defines International Standards for electrical, electronic and related technologies. The IEC manages three global conformity assessment systems that certify whether equipment, system or components conform to its International Standards.

IECEx certification describes safety requirements for equipment to be used in (potentially) hazardous areas, based on the IEC 60079-14 standard, which has no government involvement.

The objective of the IECEx System is to provide a single globally recognised and accepted Certification System for hazardous area products, services providers and competent personnel related to explosive atmosphere equipment and locations.[1] This System allows certified products, services and personnel in some countries to be accepted and used without restriction and without further testing/documentation. Eliminating the need for multiple national certifications, IECEx certifications have a global focus and facilitate international trade in Ex equipment for explosive atmospheres.

To be certified, a product must go through a IECEx test laboratory for both the product and the manufacturing facility, with surveillance of the procedure. The certificate of conformity will attest that the equipment's design conforms to the relevant IEC standards and that the manufacturer is manufacturing the product under a quality system and associated quality plan(s), meeting the requirements of the scheme and under the surveillance of an IECEx Certification Body (ExCB).

(1) IEC System for Certification to Standards relating to Equipment for use in Explosive Atmospheres, IECEx 01A, Edition 2.0 2014-04

3.2 CSA

The CSA Group (formerly CSA, Canadian Standards Association), is an organization which develops standards in a wide range of areas. The Group not only publishes standards but also provides training and advisory services. The organization brings together representatives from industry, government and consumer groups.

CSA Group is accredited by the Standards Council of Canada[2], a crown corporation which promotes efficient and effective standardization in Canada. This accreditation verifies that CSA is competent to carry out standards development and certification functions, and is based on internationally recognised criteria and procedures.

Whether with the addition of "US" in the logo or without, the CSA registered mark shows that a product has been independently tested and certified to meet North American standards.

(2) https://www.scc.ca

3.3 FM

FM Factory Mutual (FM) Approvals is the independent testing division of FM Global, and it focuses on researching and testing all products to ensure that they meet only the highest standards for safety[3]. FM Approvals standards are based on performance of products or services rather than prescriptive conditions. Where applicable, requirements for conformance to an FM Approvals standard include limiting values and tolerances. Test methods are defined, as appropriate, for verification.

The classifications of FM and CSA are almost identical and widely mutually recognized by both countries – USA and Canada.

(3) https://www.fmapprovals.com

3.4 Comparison ATEX and FM/CSA

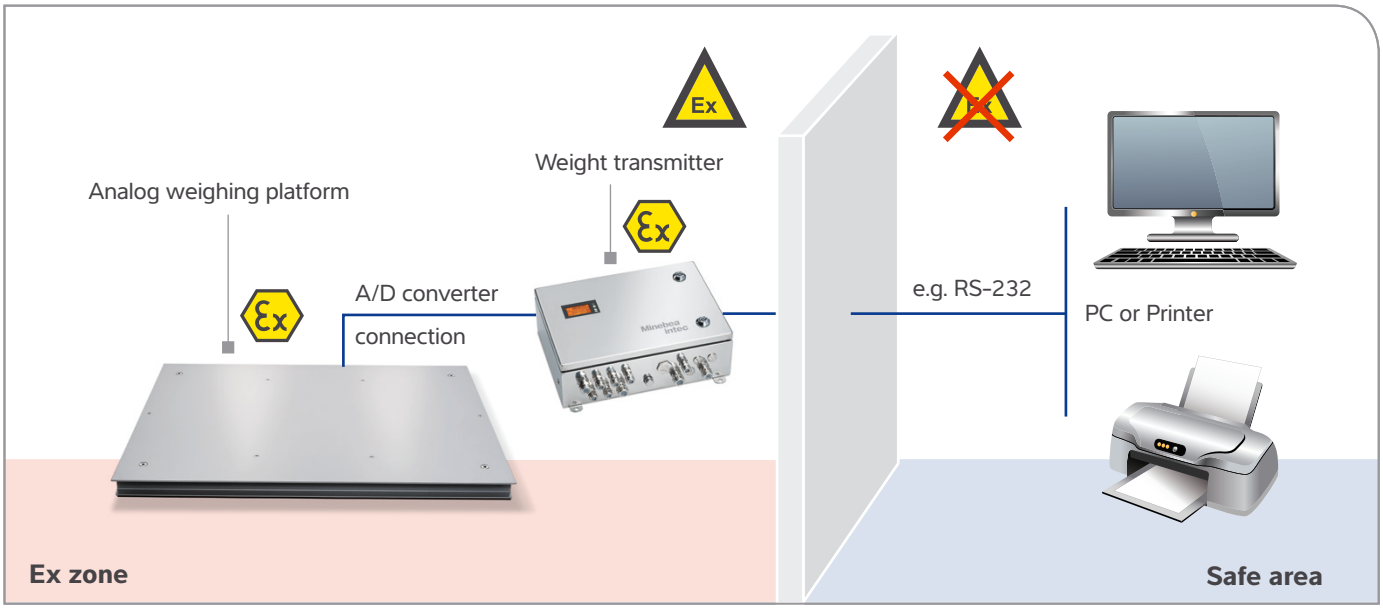
European and IEC Classification	Definition of zone or division	North American Classification
Zone 0 (gases / vapors)	An area in which an explosive mixture is continuously present or present for long periods.	Class I Division 1 (gases) Gr. A, B, C, D
Zone 1 (gases / vapors)	An area in which an explosive mixture is likely to occur in normal operation.	Class I Division 1 (gases) Gr. A, B, C, D
Zone 2 (gases / vapors)	An area in which an explosive mixture is not likely to occur in normal operation and if it occurs it will exist only for a short time.	Class I Division 2 (gases) Gr. A, B, C, D
Zone 20 (dusts)	An area in which an explosive mixture is continuously present or present for long periods.	Class II Division 1 (dusts) Gr. E, F, G Class III Div. 1 (Fibers)
Zone 21 (dusts)	An area in which an explosive mixture is likely to occur in normal operation.	Class II Division 1 (dusts) Gr. E, F, G Class III Div. 1 (Fibers)
Zone 22 (dusts)	An area in which an explosive mixture is not likely to occur in normal operation and if it occurs it will exist only for a short time.	Class II Division 2 (dusts) Gr. E, F, G Class III Div. 2 (Fibers)

4. Possible configurations for weighing in hazardous areas

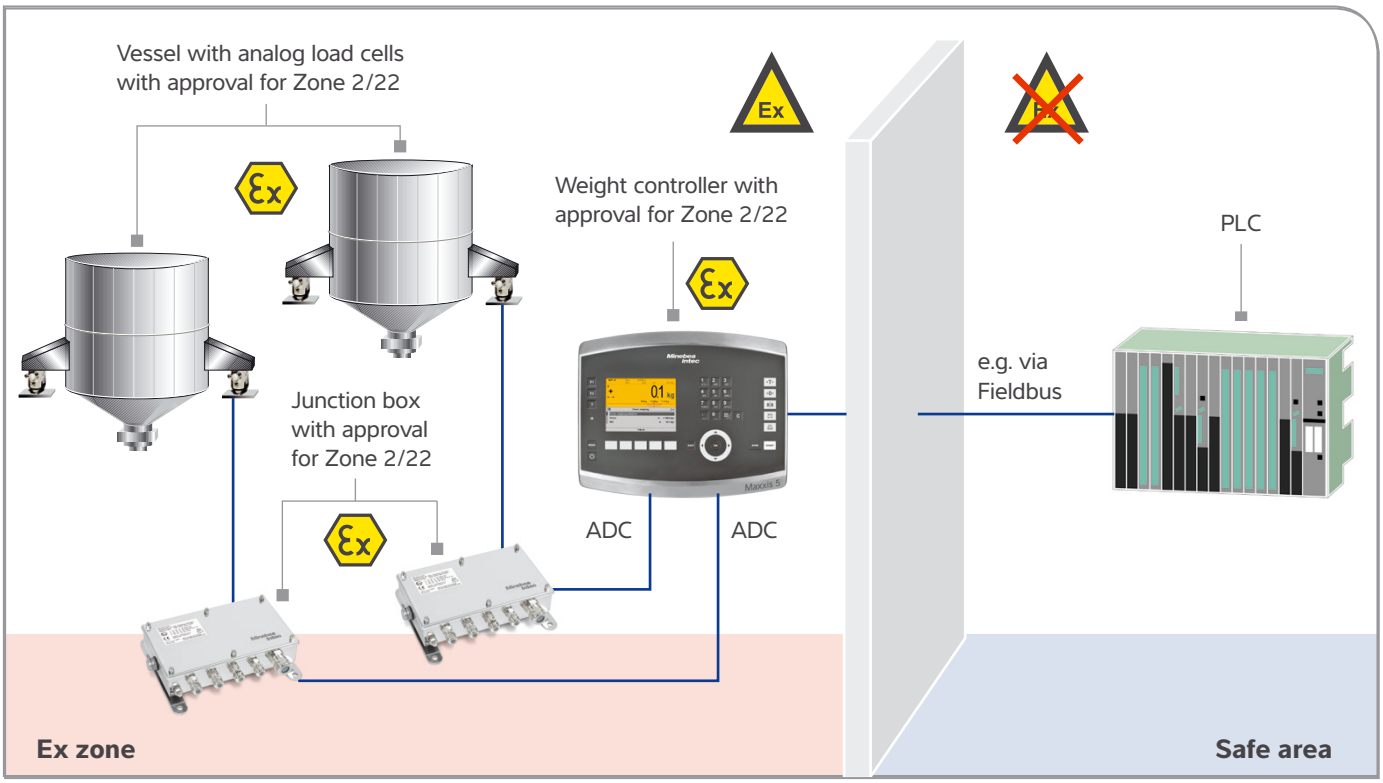
4.1 Application examples for weighing in hazardous areas

Below you will find application examples showing static weighing, e.g. using strain gauge load cells or digital and analog weighing platforms in the context of industrial storage, filling or packaging processes.

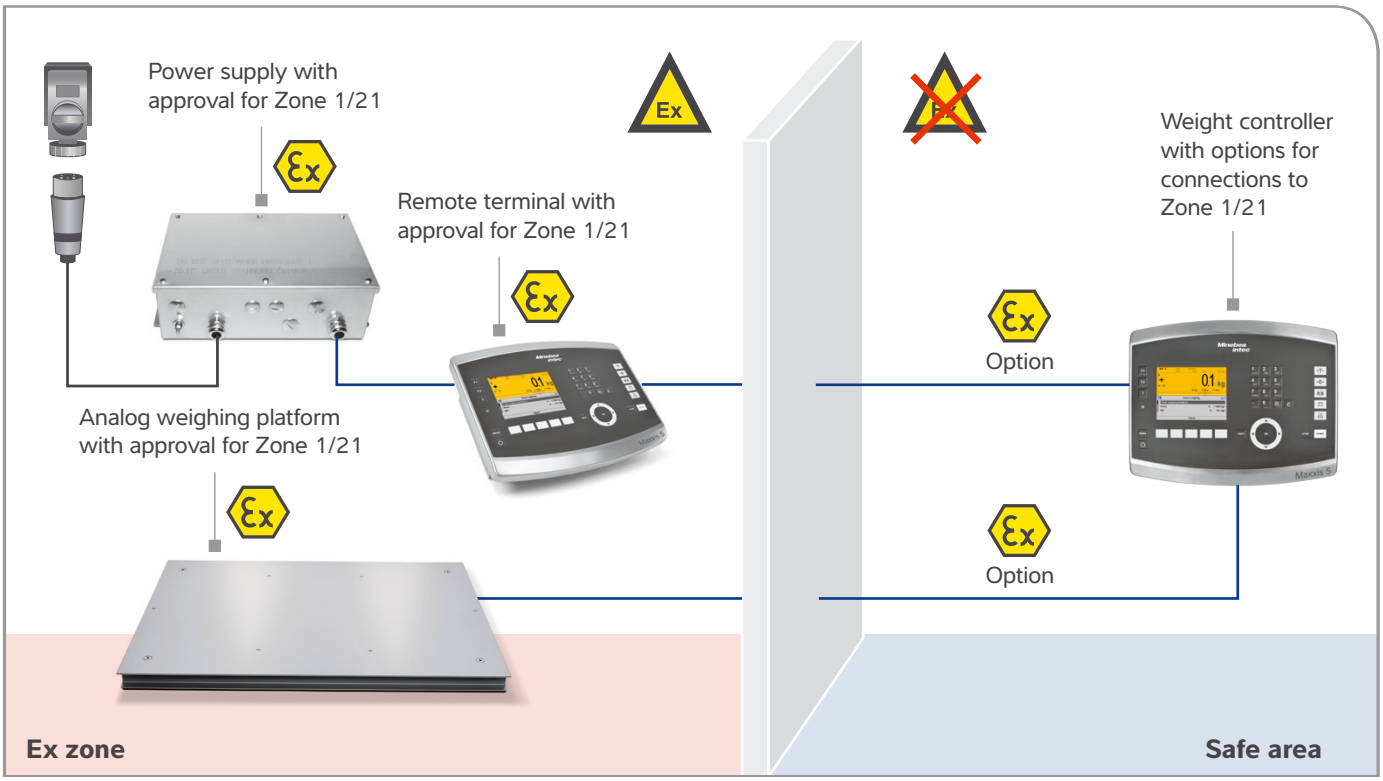
ATEX Zone 2/22 – analog weighing platform plus weight transmitter



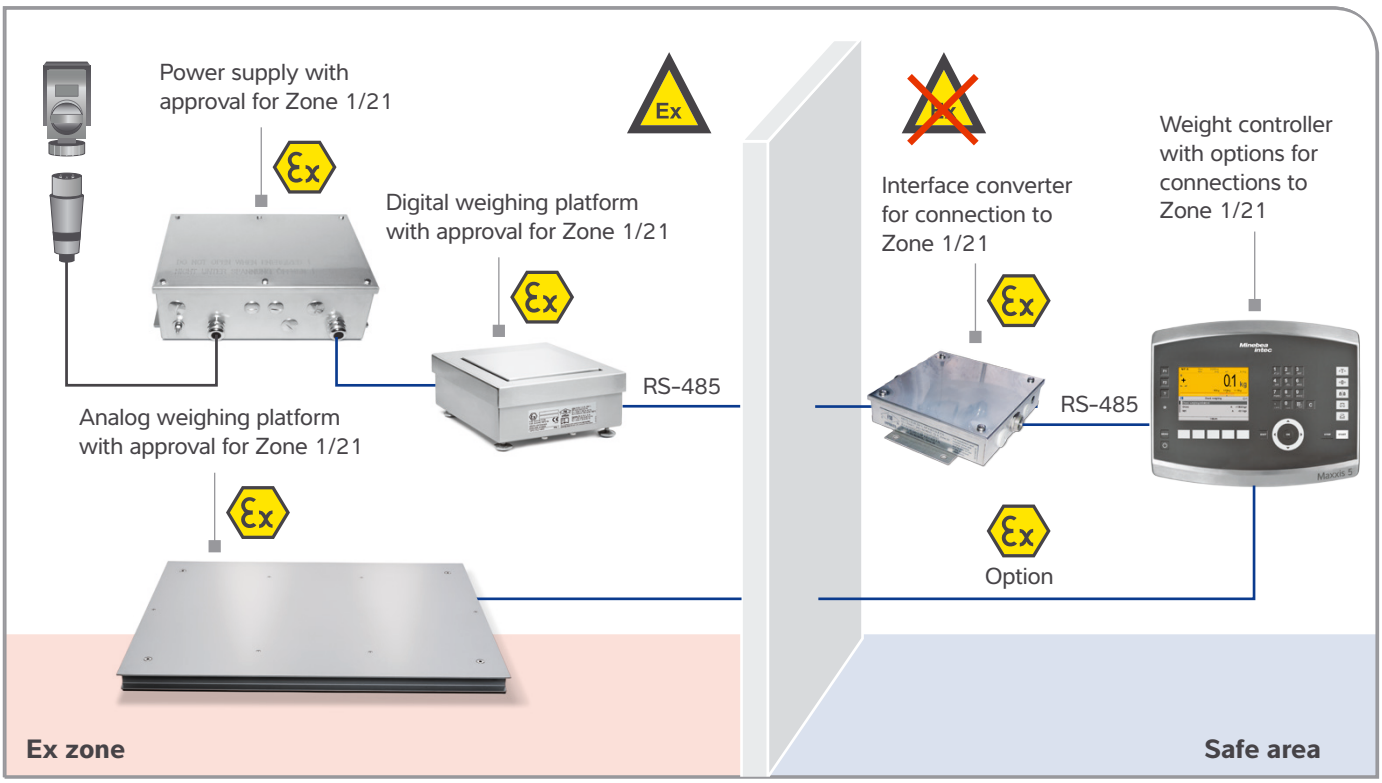
ATEX Zone 2/22 – analog load cells under vessels plus weight controller



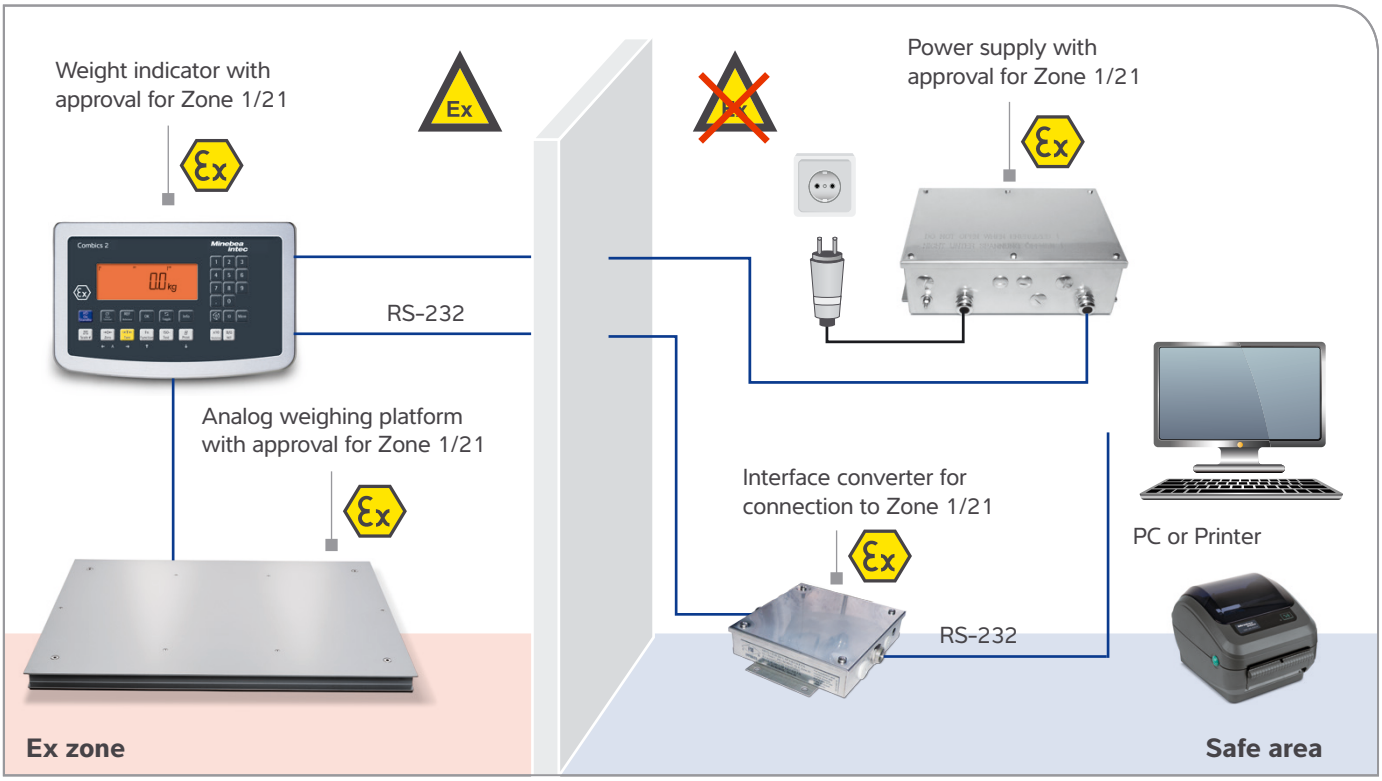
ATEX Zone 1/21 – weight controller and analog weighing platform with remote terminal



ATEX Zone 1/21 – weight controller, digital and analog weighing platforms without remote terminal



ATEX Zone 1/21 – weight indicator with weighing platform in Ex zone and power supply in safe area



FM/CSA Class 1, Div. 1 – weight indicator with digital weighing platform and Profibus connection via transmitter