Intrinsic Safety

Intrinsically Safe Solutions

Accurate Weighing in Hazardous Areas

Accidents in hazardous areas can have dramatic consequences for businesses in terms of both human life and profit. Intrinsically safe equipment is essential to ensure safety and to comply with hazardous area regulations.

Two primary considerations must be taken into account when choosing the right weighing equipment for hazardous areas. They are the right classification and the appropriate method of ignition protection.

Among several ignition protection methods, the intrinsic safety and flameproof protection methods are similar to the design of weighing equipment for hazardous areas. Intrinsic safety, however, is one of the safest protection methods. It also completely different from any other recognized method of protection for certified hazardous areas.

This paper describes the principles of the intrinsic safety protection method, highlights its benefits and gives some examples of possible weighing configurations in hazardous areas. The paper also covers the principles of the flameproof protection methods and its areas of application.

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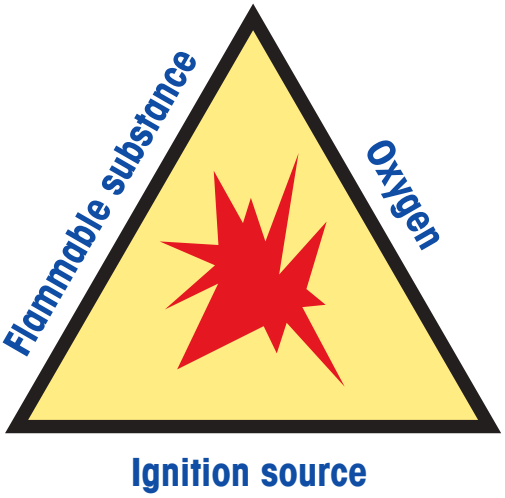
METTLER TOLEDO

1 Hazardous Areas and their Classifications

An explosion is the sudden exothermic chemical reaction of a flammable material with oxygen and the simultaneous release of high energy. To eliminate the risk of explosion, one of the three elements of the "Triangle of Fire" must be removed.



Picture 1. Triangle of Fire

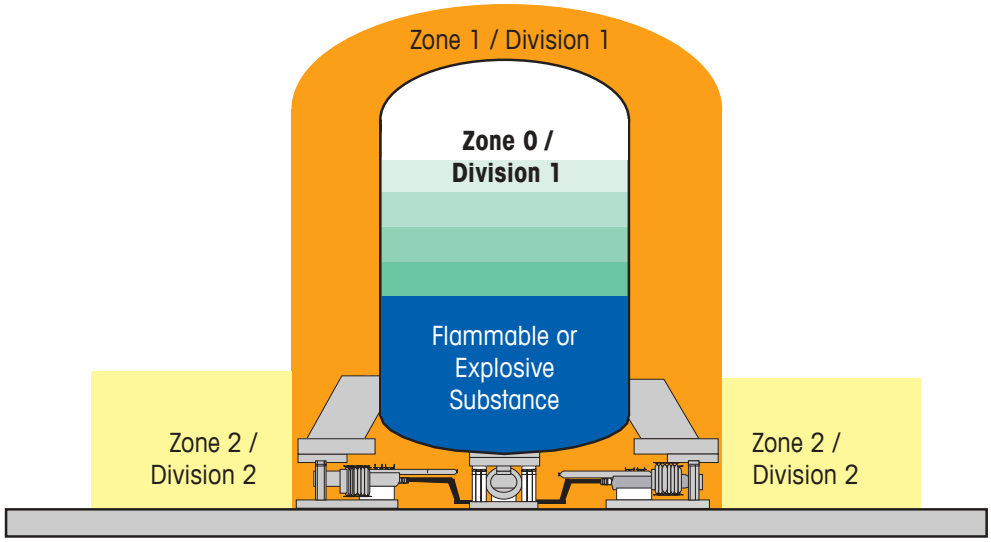
Flammable or explosive materials may be present in the form of gases, vapors, mists or dusts. Each material is present in the production area in the defined concentration and for a certain period of time.

Ignition sources are the sources related to an equipment. These can be hot surfaces, sparks, high energy or intense electromagnetic fields. Equipment suppliers reduce the risk of explosion by eliminating the ignition source and by keeping the system's active ignition energy at the lowest possible level: - lower than the minimum ignition energy. The minimum ignition energy is the least amount of energy required to ignite a combustible vapor, gas or dust cloud. The minimum ignition energy is measured in joules.

For example, the explosive "hydrogen-air" mixture can ignite with very low energy input; its minimum ignition energy at atmospheric pressure is about 10^{-5} joules. The minimum ignition energy of dusts is in the range of several milijoules up to 100 milijoules.

Businesses conducting collection, transformation and production processes with inflammable substances are obliged to conduct hazardous risk analysis to identify the potentially hazardous areas where dangerous concentrations of explosive mixtures of flammable or explosive materials can occur. Such areas are called "hazardous areas."

When electrical equipment is used in a location classified as hazardous, it must be appropriately certified and provide the required level of protection. The selection of an appropriate protection method is based on the classification of the hazardous area. That is why it is important to understand area classifications and their differences. Picture 2 shows a weighing tank and the distribution and classification of hazardous areas.



Picture 2. Hazardous Area Definitions

Classification varies throughout the world, but generally, there are two types of classification. Europe has adopted the International Electro Technical Commission (IEC) philosophy referred to as "Zoning."

Information and specifications for zone classification are defined in the norm IEC EN60079-10 and in national standards. Furthermore, the installation and operation of electrical systems in hazardous locations and the zone classification within the European Community are defined in the ATEX 94/9/EC Directive.

Table 1 shows an overview of the zones, divisions and the allocation of equipment for the relevant hazardous area classification.

According to the ATEX Directive, hazardous areas are divided into three zones for gases and three zones for dust substances. The classification is defined according to the probability of the presence of an explosive atmosphere. Each zone is corresponding to the particular equipment category (Table 1).

In North America, areas are classified into classes. Classes are further categorized into Division 1 and Division 2, according to the probability of materials present in a potentially hazardous quantity. Class I (Gases) and Class II (Dust) hazardous areas are divided into subgroups based on the type of flammable gas, vapor or particles present. Class III (Fibers) is not divided into subgroups.

Substance	Hazardous Area Characteristics	Hazardous Area Classification			Equipment Category
		USA NEC500	USA NEC505 / NEC506	ATEX 94/9/EC	
Gases / Vapors	Explosive atmosphere is present **continuously**	Division 1	Class 1 (NEC505)	Zone 0	1G
	Explosive atmosphere is likely to occur **occasionally**			Zone 1	2G (1G)
	Explosive atmosphere is likely to occur **infrequently** or for **short periods of time**	Division 2		Zone 2	3G (1G and 2G)
Dusts	Explosive atmosphere is present **continuously**	Division 1	Class 2 (NEC506)	Zone 20	1D
	Explosive atmosphere is likely to occur **occasionally**			Zone 21	2D (1D)
	Explosive atmosphere is likely to occur **infrequently** or for **short periods of time**	Division 2		Zone 22	3D (1D and 2D)

Table 1 - Hazardous Area Classification according to Europe and USA Standards.

2 Ignition Protection Methods

The basic safety concept is to eliminate the simultaneous existence of the possible ignition sources.
The method of protection will likely depend on the degree of safety needed for the type of hazardous location. Besides the degree of safety required for the classified area, other considerations must be made, such as the size of the equipment, its normal function, power requirements, installation costs and flexibility of the protection method for maintenance.

Table 2 shows an overview of the standardized types of protection. It describes the basic principle of each protection method as well as the applicable standard and the classified area.

The protection methods are standardized and the standards vary in different countries. However, the principles of protection are the same regardless of the country. When it comes to designing and developing weighing equipment for hazardous areas, the two methods, intrinsic safety and flameproof, are mainly applied. However, intrinsic safety provides numerous technical and economical advantageous, which makes it the preferred protection method for weighing equipment.

Protection Type	Marking		Principle	Standard			Area Classification	
	EU	USA		IEC / EN	USA	CSA	Zone(s) (ATEX 94/9/EC)	Division (NEC 500)
General Regulation	Ex	AEx	Basis for protection type	60079-0	FM 3600 UL 60079-0	60079		
Intrinsic Safety	Ex ia	AEx ia	Limit energy; no sparks or surface temperature	60079-11	FM 3610 UL 60079-11	60079-11	0, 1 and 2	1 and 2
	Ex ib	AEx ia					1 and 2	
	Ex ic						2	
Flameproof	Ex d	AEx d	Contain the explosion, quench the flame	60079-1	ISA 60079-1 UL 60079-1	60079-1	1 and 2	1 and 2
Increased Safety	Ex e	AEx e	Dust / water tight enclosure	60079 -7	ISA 60079-7 UL 60079-7	60079-7	1 and 2	1 and 2
Non-Sparking	Ex nA	AEx nA	No sparking device	60079-15	ISA 60079-15 UL 1203	60079-15	2	2
	Ex nC	AEx nC	Sparking devices and components					
	Ex nL	AEx nL	Limited energy; no sparks or hot surfaces					
Encapsulation	Ex m	AEx m	Keep the explosive atmosphere away from any source of ignition	60079-18	ISA 60079-18 UL 60079-18	60079-18	0, 1 and 2	1 and 2
Pressurized	Ex p	AEx p	Purge enclosure with the inert pressurized air	60079-2	FM 3620 UL 60079-2	60079-2	1 and 2	1 and 2
Oil Immersion	Ex o	AEx o	Keep the explosive atmosphere away from the ignition source	60079-6	ISA 60079-6 UL 60079-6	60079-6	1 and 2	1 and 2

Table 2. Protection Methods and Related Electrical Standards

3 Intrinsic Safety – Basic Principles

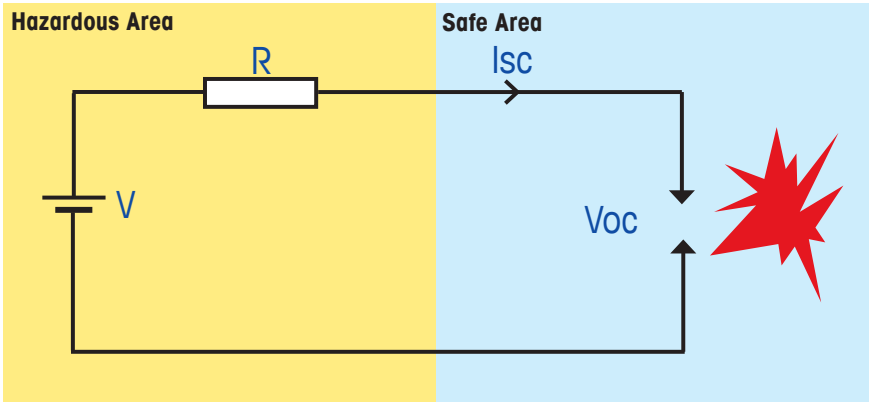
Since it was introduced in non-mining applications, intrinsic safety has evolved to become one of the most commonly used protection methods in process industries. Today, intrinsic safety is one of safest and most advanced methods of ignition protection. It has become the method of choice because, independent from the application, it keeps the entire system safe.

Intrinsically safe technology prevents explosions by ensuring that the energy transferred to a hazardous area is well below the energy required to initiate an explosion. As such, it is restricted to electrical apparatuses and circuits in which the output or consumption of energy is limited. Intrinsically safe systems enable equipment to be used without risk of igniting any flammable gas, dust or fibers that may present in hazardous areas.

Intrinsically Safe Circuit

An electrical circuit is intrinsically safe when it produces energy below the minimum ignition energy (MIE), which is defined by the appropriate standards. In Europe, IEC EN60079-11 specifies the construction and testing of intrinsically safe equipment; in the USA, FM3610 does this. Intrinsically safe electrical equipment is designed to limit the open circuit voltage (Voc) and the short circuit current (Isc) to keep the produced energy at the lowest possible level.

It also must be done in such a way that sparks produced when opening, closing or earthing the circuit or produced by any other hot part of the circuit itself would not cause ignition. Intrinsically safe electrical equipment and wiring can be used in Zone 1 / Division 1 hazardous areas as long as they are approved for the location.



Picture 3 Intrinsically Safe Circuit.

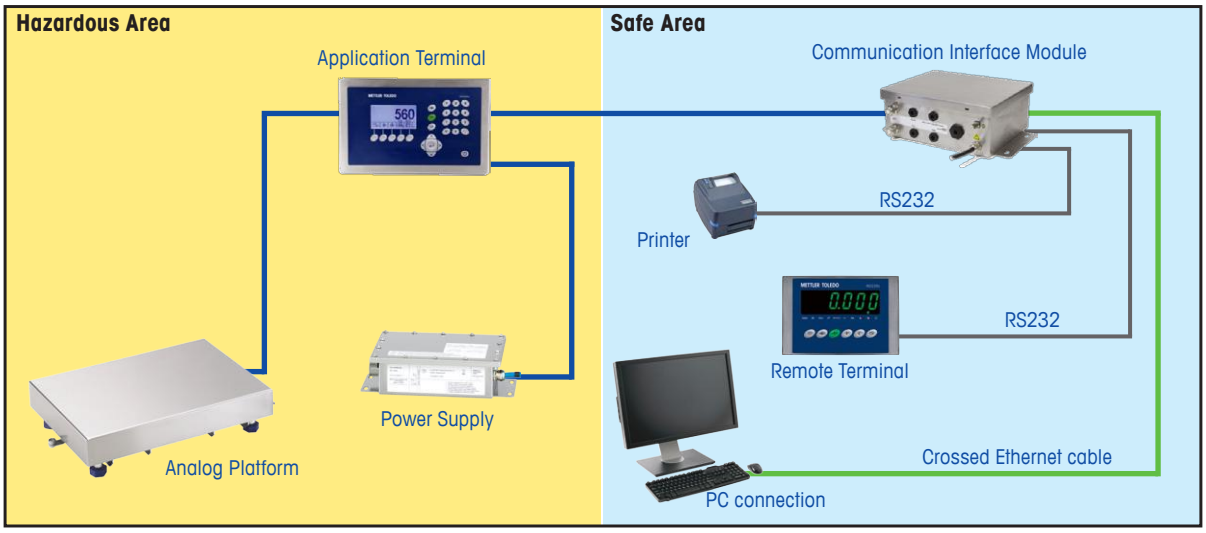
Intrinsically Safe System

An intrinsically safe weighing system is different from a standard weighing system. It combines intrinsically safe elements, associated elements and special approved wiring with standard equipment, which is installed in the non-hazardous safe area. In a hazardous area, all elements of the system must be compatible to form an intrinsically safe system.

Let's consider an example with an intrinsically safe weighing system. In our example, the intrinsically safe apparatus is an analog weighing platform and intrinsically safe weighing terminal IND560x. The intrinsically safe power supply APS768x serves as the power source for the weighing terminal and is defined as a simple apparatus. Communication to the standard peripherial instruments, such as PC, barcode reader or

even remote control terminals, is possible through a special barrier. This is achieved via a communication interface ACM 500, which encompasses both intrinsically safe and non-intrinsically safe electrical circuits.

In an intrinsically safe system, physical barriers are used between the hazardous and safe areas to limit the energy that enters the hazardous area. Intrinsically safe barriers maintain approved levels of voltage and current via power limiting components. They ensure that even under fault conditions, no more than the approved voltage or current enters the hazardous area. This allows standard electrical devices installed in the safe area, such as printers, computers and PLC systems, to be directly linked into a hazardous area.



Picture 4. Intrinsically Safe Weighing System

Levels of Classification and Protection

Intrinsic safety offers three classification levels, "ia," "ib" or "ic," which are based on the safety level and number of faults possible. Each classification attempts to balance the probability of an explosive atmosphere being present against the probability of an ignition occurring. The level of protection "ia" is a prerequisite for Category 1 equipment and is suitable for use in Zone 0. The level of protection "ib" for Category 2 equipment is suitable for use in Zone 1 / Division 1. The level of protection "ic" for Category 3 is suitable for use in Zone 2 / Division 2.

The classifications ensure that the equipment is suitable for an appropriate hazardous application. For example, having equipment classified as "EEx ib" means that the equipment is designed containing an intrinsically safe circuit and can be installed in the certified hazardous areas Zone 1 / Division 1. Moreover, the "ib" classification indicates that one fault is possible.

Equipment classified as "[EEx ib]" or "EEx [ib]" is defined as an associated electrical apparatus and contains both intrinsically safe and non-intrinsically safe circuits. The square brackets indicate that the associated electrical apparatus contains an intrinsically safe electric circuit, which may be introduced into Zone 1 / Division 1. In the first case, "[EEx ib]," the equipment must be installed in the safe area. In the case of "EEx [ib]," the equipment can be installed in both Zone 1 / Division 1 hazardous areas and in the safe area.

However, it is also possible for different parts of the system to have different levels of protection. Table 3 presents different protection levels, the numbers of faults possible and the appropriate hazardous area.

Protection level	ai	ib	ic
Hazardous Area	Zone 0, 1, 2 / Division 1	Zone 1, 2 / Division 1	Zone 2 / Division 2
Faults possible	2	1	Normal operation

Table 3. Intrinsically Safe Protection Levels.

4 Intrinsic Safety – Benefits

One of its greatest benefits is that intrinsic safety enables equipment maintenance within hazardous areas without the need to interrupt the power supply and to obtain a gas clearance certificate, which is necessary with open flameproof equipment. This especially applies to instrumentation because fault finding on de-energized equipment is more complex and time consuming.

Intrinsically safe technology provides a flexible and modular solution to most industrial applications within hazardous areas. It is possible to communicate with the multiple components through specially designed communication elements.

Intrinsically safe equipment and their components, such as cables and cable glands, are relatively inexpensive. Therefore, the installation costs and costs of maintenance and inspection when using intrinsically safe equipment are significantly lower compared to flameproof equipment.

In addition, it is the only technique that limits power output. With intrinsically safe equipment, no sparks or increasing temperature in the electrical circuit can ignite the surrounding atmosphere.

Moreover, the technology is globally accepted by the international certification bodies IECEx, as well as most of the local legislations, such as ATEX in Europe, FM in the United States as well as NEPSI in China, GOST-R in Russia, KTL in Korea and INMETRO in Brazil.

Intrinsically safe equipment generally satisfies all dust and gas legislative requirements and it can essentially be used for every industrial application.

Finally, intrinsic safety offers the best level of safety and accuracy in all hazardous areas. The technology offers the maximum level of precision. Using the advanced hybrid design and a high-precision electromagnetic force compensation with up to 32000 approved calibration points, the weighing system delivers highly accurate and reliable results. It is safer and less prone to accidental errors than other protection methods and it ensures high uptime in the case of an incident, unlike the flameproof solution.

5 Intrinsically Safe Weighing Configurations

There are many hazardous weighing applications in the industrial value chain.

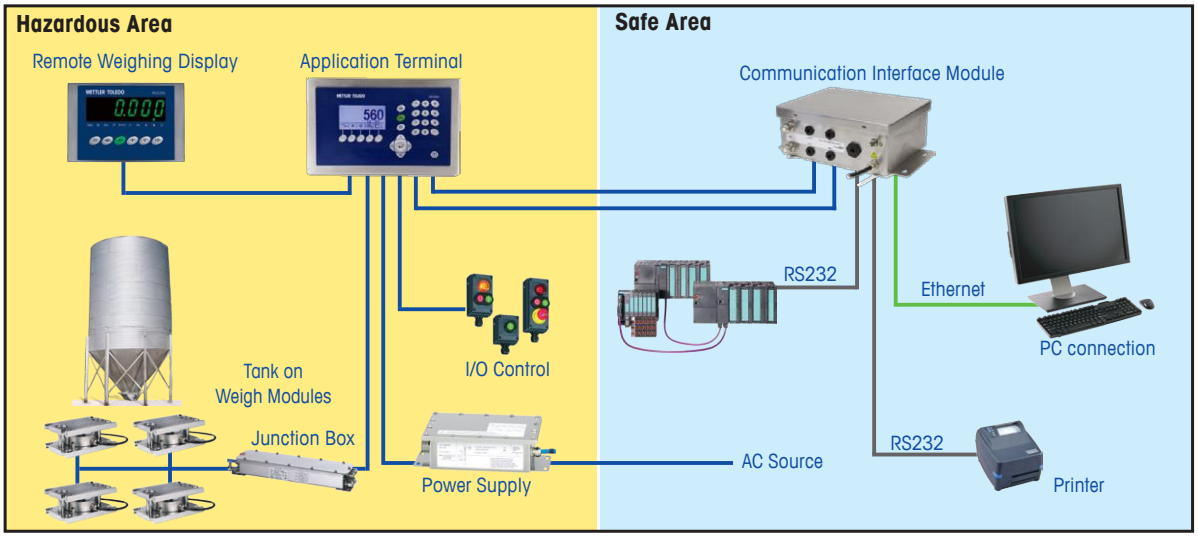
As many industrial processes incorporate aggressive chemical agents, scales in industrial environments must withstand not only harsh conditions and corrosion, but also must have an inherently safe design to withstand explosive and flammable substances.

Also, the requirements for many weighing applications in which intrinsically safe weighing systems can be applied are very different. Among them are train and truck scales, tank weighing, formulation and recipe applications, filling and dispensing applications, conventional floor and bench scales and control of weighing terminals.

The requirements for weighing systems vary not only by industry and process conducted, but they also vary by level of accuracy required and application-specific needs. Their means of connection to peripheral devices and fieldbus and network connections also varies.

Picture 4 shows a possible hazardous area installation. METTLER TOLEDO's intrinsically safe weighing terminal, IND560x, communicates with intrinsically safe digital high-precision platforms, such as Kx-T4 or intrinsically safe analog load cells, forming an intrinsically safe circuit. The intrinsically safe power supply is an associated part of the intrinsically safe circuit, which serves as a power source for several METTLER TOLEDO intrinsically safe weighing terminals. Communication in the safe area allows users to interface with the PC, printers or network to a PLC through an intrinsically safe fieldbus, Ethernet or serial RS 232/422/485.

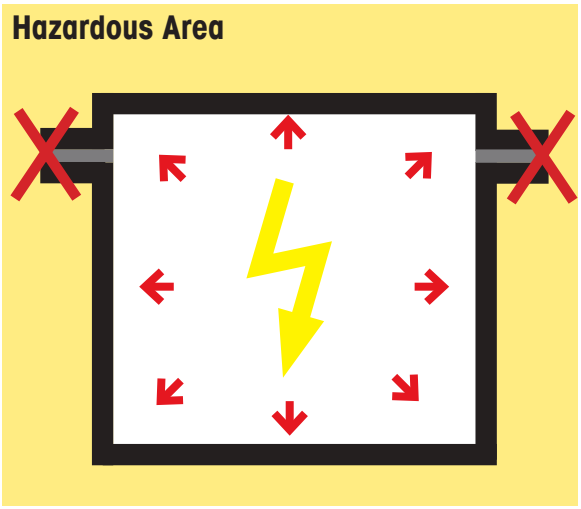
A comprehensive range of modular intrinsically safe components can be flexibly combined to work together in an intrinsically safe system and in all types of hazardous areas. That ensures not only an efficient and risk-free weighing process, but also simple installation and maintenance as well as technical documentation registration to meet the company's safety requirements.



Picture 5. Weighing Station Installation in Hazardous Area Zone 1 / Division 1.

6 Flameproof – Basic Principle

The flameproof protection method is based on the explosion-containment concept and is in accordance with IEC EN60079-1 classified as "Ex d." This concept relies on equipment and wiring enclosures to prevent an internal ignition from escaping to the surrounding atmosphere. In other words, the explosion is allowed to take place, but it must remain confined in the enclosure that is designed to resist the excess pressure the internal explosion causes (Picture 6).



Picture 6. Flameproof Enclosure

The theory supporting this method is that the resultant gas jet coming from the enclosure is cooled rapidly through the enclosure's heat conduction and the expansion of the gas. The hot gas is then diluted in the colder external atmosphere. That is only possible if the enclosure openings or interstices have sufficiently small and well-controlled dimensions.

A flameproof system is generally considered somewhat simpler to design than an intrinsically safe system as it doesn't require completely new equipment design. However, it is generally more expensive to install because of the high cost of running field wiring inside a conduit, which must be sealed between the safe and hazardous areas. It is also often physically larger and much heavier than an intrinsically safe solution.

Flameproof equipment is also more difficult and time-consuming to maintain because either the area must be known to be non-hazardous or the equipment must have the energy drained before covers can be removed. Hot permits are required to perform maintenance work on these systems.

Further, when covers are re-installed, extra care must be taken that fasteners are precisely torqued to specified values.

7 Summary

There are several options when it comes to ignition protection in hazardous environments. Installing intrinsically safe weighing equipment is the safest method, providing at the same time high accuracy and reliability weighing results. It safely facilitates activities in the hazardous area and is low maintenance. In the case of incidents, the intrinsically safe equipment can be serviced without halting production, and it eliminates heat and sparks in the production area.

METTLER TOLEDO focuses on development of intrinsically safe weighing systems. Intrinsically safe weighing solutions provide the user with the highest level of accuracy, safety, broad functionality, and low installation and maintenance costs. A wide range of high precicion and analog weighing platforms ensures high speed and high accurate weighing results in applications, such as filling or dosing. Weighing modules and control terminals and the flexibility of interface communication provide full scope of functionality and enables flexible and modular solution setup in both the hazardous area and in the safe area.

Global acceptance by IECEx, ATEX, FM and relevant local certification bodies provide an additional security to the user.

8 Additional References

- IEC EN 60079-0: Explosive Atmospheres – Part 0: Equipment – General Requirements
- IEC EN 60079-10-1: Explosive Atmospheres – Part 10-1: Classification of Areas – Explosive Gas Atmosphere
- IEC EN 60079-11: Explosive Atmospheres – Part 11: Equipment protection by intrinsic safety "i", 5th Edition
- ATEX Directive 94/9/EC: Guidelines on Application, Europe Commision, Fourth Edition, 2012
- National Electrical Code®, Article 500, NFPA 70, 2011, Delmar: Nacional Electric Code
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- METTLER TOLEDO Hazardous On-Demand Webinar Basic – **www.mt.com/ind-haz-basics**
- METTLER TOLEDO Hazardous On-Demand Webinar Advanced – **www.mt.com/ind-haz-advanced**
- METTLER TOLEDO Hazardous Catalog – **www.mt.com/ind-hazcat**
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www.mt.com/ind-intrinsic-safe

For more information

Mettler-Toledo AG
Industrial
CH 8606 Greifensee
Switzerland
Phone +41-44-944 22 11
Fax +41-44-944 30 60