1.8 INDUSTRIAL PROCESS WEIGHING IN HAZARDOUS AREAS

EXPLOSION PROTECTION

In addition to the type approval and certification of industrial weighing systems concerned with accuracy, equipment that is also used in a 'Hazardous Area' must be certified as compliant with the requirements of the Standards for "Explosion Protection". Such requirements provide for its safe use in an area in which a potentially explosive mixture of gas, vapour, mist or dust may be present due to the operation of an industrial process.

European Standards for Explosion Protection are applied to the design, construction, selection, installation, operation, inspection and maintenance of such equipment put into service in the United Kingdom (and indeed throughout Europe).

A common misconception is that any ATEX-approved components can be connected together to form a system. However, it is important to show that the compatibility of the various components have been assessed and that the complete system is compliant.

The plant owner's perspective

It is the industrial plant owner's responsibility (hereafter referred to as the owner) to define the hazards that may be present on their plant by undertaking 'Area Classification'. This process has to be done in accordance with, and by applying, the British Standard, BS EN 60079 Part 10.

Area classification will form part of a risk assessment that is used to determine the likely locations of the hazard(s) and the likely duration. Where there is a higher probability of presence for a longer period of time, the higher the reliability of the type of explosion protection is required. The result is to classify the hazardous areas of the plant into Zones:-

Non-hazardous area: An area in which no explosive gas/air mixture is expected (often referred to as 'Safe Area').

Zone 0, 1, 2 (for Gases, vapours and mists)
and/or
Zone 20, 21, 22 (for dusts).

The definitions of these are provided for reference at the end of the section.

The nature of the hazard(s); the ease of flammability, and other physical properties of the ignitable substances appearing in the zones, will need to be known such that the ignition prevention requirements of suitable apparatus may be specified:-

- the Apparatus Group, i.e. II, IIA, IIB or IIC
  and
- the Temperature Rating, i.e. T1, T2, T3, T4, T5 or T6

These are defined in the Standard BS IEC 60079 Part 0 or EN50014, which cites the general requirements for explosion protection in hazardous areas (other than mines).

Once known, the owner can purchase weighing apparatus that is certified to be adequately safe in the appropriate zones of use.

The manufacturers' approach

The manufacturers offer weighing equipment that is certified to European Standards for Explosion Protection. There are a number of different types of protection that may be used depending on a variety of factors. The type of protection used defines the permitted zones of use; according to the Standard BS EN 60079 Part 14: Installation of explosion protected apparatus in hazardous areas.

One of the most common types of protection used for electronic industrial weighing applications that are made suitable for integration into process control systems is known as "Intrinsic Safety". This is referred to as 'I.S.' or, more correctly now, 'Ex i'. It requires that circuit design is made incapable of causing the ignition of flammable atmospheres. This is achieved by reliably limiting the levels of energy and power, even under specified fault conditions, in apparatus and circuits entering a hazardous area. The construction Standard to which apparatus is certified as compliant is EN50020.

Ex ia circuits are permitted in Zone 0 (the most onerous degree of hazard), or Zone 1 and 2.
Ex ib circuits are only permitted in Zones 1 and 2.

The explosion protection marking seen on apparatus, say, EEx ia IIB T4 (which is also referred to as it's safety code) can be interpreted as meaning:-

EEx: Explosion protected to conform to a European Standard
ia: Permitted to be mounted or connected into a Zone 0
IIB: Permitted to be mounted or connected into hazardous areas requiring IIA or IIB grade of apparatus
T4: Permitted to be mounted or connected into hazardous areas where the hazard's ignition temperatures are not below 135ºC (Maximum ambient temperatures limits must also be observed.)

Often, a weighing application comprises several component hardware modules:-

- the system power supply;
- the operator control;
- local and/or remote ancillary devices such as printers, indicators etc.; and
- the weighing platform, incorporating the loadcell(s).

These component modules, together with any cabling and junction boxes, are interconnected to provide the function that the purchaser needs for the application.

Intrinsically Safe Apparatus

Some or all of these modules may be located in one or more zones of the hazardous area depending on the application. They must be marked with appropriate safety codes indicating how each module is protected. Intrinsically safe apparatus is marked 'Ex i'. Where a module is marked, typically "[EEx ia] IIC", the square brackets indicate that it is 'Associated Apparatus' and MUST be mounted in a safe area, although it is connected to apparatus in the hazardous area according to the manufacturer's instructions.

Some intrinsically safe weighing systems use external mounted 'Shunt Zener Diode Safety Barriers' (Barriers) that are located in between the Hazardous Area mounted modules (usually loadcells) and the Safe Area modules. These are the safety devices that specifically limit the fault energy and power available to the hazardous area circuits to within safe limits. These are normally mounted in enclosures in the safe area and also require connection to a suitable earthing system (known as an Intrinsic Safety Earth) in accordance with the Installation Standard BS EN60079-14:2003.

Weighing systems may be battery-operated and can be self-contained for mounting completely in the Hazardous Area. Where there is a facility for charging the battery whilst in the Hazardous Area, or for bringing out communication signals to external weighing equipment mounted in the Safe Area, barriers will also be required to interface the signals between areas.

In other cases, the energy limiting circuits (the function performed by the Barriers) are built into the electronics of the modules. In these cases, safety earthing may or may not be required, depending on the design and the safety certification, which will state if it is necessary. In all cases, the manufacturer will supply installation information which must be followed.

Other types of protection

In some cases, other types of explosion protection may be used for some modules or parts of the weighing system. These could be as listed below with a brief description of how they prevent ignition of a surrounding flammable atmosphere:

Ex p, Ex o, Ex q and **Ex m** are considered as "separation" techniques; the use of inert gas, liquid, semisolid (particulate) or solid media, respectively, to surround an ignition capable electrical arrangement. Thus, contact with a flammable gas/air mixture is physically prevented. An additional effect is that heat generated by the arrangement may be dispersed through the media. Arcing and sparking may be quenched by the fluid medium in the case of Ex o.

Ex e and **Ex n** avoid being ignition capable by considering the mechanical design and layout of an electrical arrangement. Electrical components are mounted in an enclosure. A flammable gas/air mixture is not specifically prevented from entering and surrounding the internal electrical components. The design prevents the electrical arrangement from causing ignition by the elimination of sparking and control of heating effects. Although it is thought that they use the same basic concepts, the philosophy is very different between the two types and these must not be confused. Ex e apparatus is carefully designed and constructed so as to completely prevent any sparking effect occurring. In addition, the heating effects caused by the conduction of electricity are reduced. It is therefore of much higher integrity than Ex n, which simply relies on normal industrial design to avoid excess heating and sparking with little additional precautions taken and no faults considered.

Ex d permits ignition to occur inside a strong enclosure where a gas/air mixture may enter and be ignited by ignition-capable electrical equipment contained within. The resultant flame must not be transmitted to the outside surrounding atmosphere through any joint. Thus the enclosure is said to be 'flame-proof' and is designed to withstand the force of an internal explosion.

Ex s is applied where none of the above types of protection are actually used but ignition prevention is adequately guaranteed.

The Installation

It is the owner's responsibility to ensure that equipment is installed correctly. This is also in accordance with the Standard, BS EN 60079 Part 14. Thereafter, its safe operation will be determined by the requirements of the apparatus certification depending on the type of explosion protection used. The manufacturer's instructions must also be followed where safety is concerned.

After installation, the equipment must be operated safely and properly maintained to ensure its continued safe operation for the life of the installation, according to existing health and safety Law. The requirements for an initial inspection to verify the correct installation and then subsequent periodic inspections are given, together with some guidance, in another Standard, BS EN 60079 Part 17.

An 'Intrinsically Safe System'
Where pieces of Ex i-certified apparatus are connected together using cables, they form an 'Intrinsically Safe System'. The combination of apparatus must be correctly matched together and shown to meet the Ex i requirements. This is in accordance with Standard, BS EN 60079 Part 25, which is known as the 'Systems Standard'.

Where a manufacturer or weighing equipment supplier provides a standard range of intrinsically safe apparatus-certified devices that are connected together in an application, a Systems Certificate may have been obtained from a testing authority. This is not mandatory for the manufacturer. If obtained, such a certificate permits the safe interconnection of that apparatus and provides information, such as maximum cable parameters, that the installation in the hazardous area must meet. The systems certificate cannot state the actual installation conditions, as they are unique to each given application.

The Systems Standard requires the production of a 'Descriptive System Document' (DSD). This details the safety considerations of the actual installation. Its purpose is to demonstrate that all aspects of the installation meet the Ex i requirements and are therefore safe. Suggested formats are included in the Standard for guidance.

The DSD must include information from the apparatus certification, provided by the manufacturer or supplier of apparatus. It may cite a system certificate, if there is one, but must show that the apparatus, when connected together, meets the system requirements for Ex i and that the maximum cable parameter values have not been exceeded.

The owner is ultimately responsible for the preparation of the DSD; the manufacturer may provide much of the required initial safety information, such as that stated on the individual apparatus certificates. The installer, who may, of course, be a third party, may be required to complete the DSD as part of their contractual obligations. The document is then passed on to the owner. It is always the owner's responsibility to ensure the safety of the installation. The DSD is effectively the means by which safety is proved.

The DSD is therefore a key document. It is subsequently used for inspection and maintenance because it details all the safety aspects of the given application.

Other types of protection
Other types of protection, for example; Ex d, e, n and/or p, may be used on a weighing arrangements or a part of them depending on the application and suitability. This is much less common than Ex i. The requirements for that type of protection must be followed for installation and maintenance purposes. Whilst no DSD is required, safety must be described as required by the ATEX Directives.

ATEX and DSEAR
In the UK, as from 1st July 2003, all explosion protected apparatus provided by manufactures and suppliers must comply with the ATEX Directives. In addition, any hazardous area installation commenced after this date must comply with the requirements of the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR). As from 1st July 2006, existing installations must be shown to comply with ATEX and DSEAR.

In essence, these Directives and Regulations merely formalise the requirement for users to put into place properly documented safety assessments and solutions such that plant risks are adequately minimised. It requires that personnel are adequately trained and supervised. Management systems must be in place for a safe system of work, such that risks are identified and controlled. A 'responsible person' shall be appointed to oversee these matters.

The DSD's for all Ex i circuits shall be included, together with other safety related documents, in a justification of safety, often referred to as a 'Safety Case', as required by the DSEAR. The Safety Case describes the hazards and the management of all related activities that show how steps are taken to minimise the risks posed.

Conclusion

The Standards and Directives mentioned in this section cover a specific situation where equipment is used in Hazardous Area. This is in addition to Standards for weighing accuracy. Personnel who design, install, operate and maintain a plant in which potentially explosive atmospheres can exist should be familiar at appropriate levels with these Standards. The emphasis is on good management and adequate training to understand the risks and the precautions taken for safety.

Reference section
Relevant Standards are listed in Section 2.3.5 (ATEX documentation)

Definition (and determination) of Zones is to BS EN 60079-10

Zone 0	An area in which an explosive gas/air mixture is continually present or present for long periods
Zone 1	An area in which a gas/air mixture is likely to occur in normal operation
Zone 2	An area in which a gas/air mixture is not likely to occur in normal operation, and if it occurs, it will exist only for a short time
Zone 20	An area in which combustible dust, as a cloud, is present continuously or frequently, during normal operation, in sufficient quantity to be capable of producing an exposable concentration of combustible dust in mixture with air, and / or where layers of dust of uncontrollable and excessive thickness can be formed.
Zone 21	Zone 21 is a Zone not classified as Zone 20 in which combustible dust, as a cloud, is present continuously or frequently, during normal operation, in sufficient quantity to be capable of producing an explosable concentration of combustible dust in mixture with air.
Zone 22	Zone 22 is a Zone not classified as Zone 21 in which combustible dust, as a cloud, is present continuously or frequently, during abnormal operation, in sufficient quantity to be capable of producing an explosable concentration of combustible dust in mixture with air.

Apparatus Grouping

Required Hazardous Area Apparatus Group (determined by ease of ignition of hazardous gas in BSEN60079-20)	Apparatus Group useable I the Hazard
IIC	IIC Only
IIB	IIC and IIB
IIA	IIA, IIB and IIC

'Temperature Rating'

Temperature mark on apparatus	Maximum surface temperature to which gas has access
T1	450°C
T2	300°C
T3	200°C
T4	135°C
T5	100°C
T6	85°C

[If no other mark appears on the apparatus it is assumed ambient temperature range is –20°C to +40°C.]