A BRIEF INTRODUCTION TO EXPLOSION PROTECTION AND CERTIFICATION

SGS Baseefa often receives requests for basic information on how equipment can be protected in hazardous areas.

Protection is a two part exercise: The equipment must be designed and manufactured to appropriate standards for a chosen "Type of Protection" and then must be installed, inspected, maintained and repaired taking into account further standards for these activities.

In Europe, all these activities are subject to the requirements of two European Community Directives: ATEX 94/9/EC covers everything related to design and manufacture up to the point of "placing the equipment on the market"; ATEX 1999/92/EC covers the other activities, as the equipment is installed and maintained, as well as other aspects related to the running of a plant where materials are produced or stored that could lead to the formation of an explosive atmosphere.

In the UK, ATEX 1999/92/EC is implemented in a combined set of regulations (along with part of the Chemical Agents Directive), known as the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR).

In the rest of this document, for convenience, the colloquially accepted expressions are used: ATEX to describe rules concerning the design and manufacture of equipment; DSEAR to describe the other activities.

In parallel with ATEX and DSEAR, there is a voluntary international system of certification, known as IECEx, operated under the International Electrotechnical Commission. It is generally accepted that the IECEx systems are more rigorous than the equivalent ATEX or DSEAR procedures, so although a comparatively new system, the various certification schemes within the IECEx System are gaining acceptance throughout the world.

The IECEx Product Certification Scheme relates to ATEX, while the IECEx Service Facility Certification Scheme and the IECEx Personnel Competence Certification Scheme relate to DSEAR

STANDARDS

Although ATEX permits compliance with the Essential Health and Safety Requirements (EHSRs) of the directive without the use of standards, this is a tortuous path to undertake and the use of "Harmonised Standards" (that is those recognised by the European Commission and published as such in the Official Journal of the European Union (OJ)) is normal. IECEx only allows certification to a published international standard.

Amongst the European Certification Bodies involved in this field, SGS Baseefa has been the most active in helping to develop the standards and has worked hard to ensure that the International Standards (IEC version) and the European/British Standards (EN or BS EN version) are technically identical.

Therefore, unless stated otherwise, it can be assumed that referring to a standard by its IEC reference also includes reference to its EN or BS EN version. For example referring to IEC 60079-0 also includes EN 60079-0 and BS EN 60079-0. (Logically, it is the IEC version that is used for certification within the IECEx Scheme; it is the EN version that is "harmonised" for ATEX; but it is the BS EN version that would be bought in the UK and used for both purposes.)

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COMPONENTS

Both ATEX and the standards recognise the need for creating "building blocks" to assist the process of creating some types of complete equipment. For example, the lamp-holder in a luminaire will often be a bought-in component from a specialist manufacturer, and it is convenient for such a component to have its own "Component Certification" issued to the component manufacturer, easing the certification of the complete luminaire. Other common components include terminal blocks, switches and control elements (for example switch spindles) for mounting in the wall of an enclosure.

TYPES OF PROTECTION – ELECTRICAL EQUIPMENT

There are nine types of protection currently recognised for electrical equipment, all of which are supported by the "General Requirements" given in IEC 60079-0. This standard contains requirements that apply to more than one type of protection, including: limitations of light metals to control thermitic sparking; aging effects on non-metallic materials (for example UV exposure and medium term exposure at high humidity and high temperature);minimising electrostatic sparking from highly insulated parts; and limitation of RF output from communications equipment.

Each of the types of protection is also designated by a letter which is included in the marking of the equipment in the way specified in IEC 60079-0. EN 60079-0 also includes a specific European Annex that gives the marking required for ATEX, which supplements the international marking.

For a list of the major standards and their relevant dates as current and historical harmonised standards, please see SGS Baseefa Data Sheet DS08 on the SGS Baseefa web site at www.sgs.co.uk/sgsbaseefa

TYPE OF PROTECTION "FLAMEPROOF" Ex d – IEC 60079-1

The concept is simple: put the electrical equipment to be protected in a strong enclosure that is capable of withstanding an internal explosion without bursting or without allowing the escaping hot gasses to ignite an external explosive atmosphere.

Because of the simplicity of the concept, it has occasionally been known as the "dustbin concept" on the grounds that it can contain any old rubbish. This is only partly true and there are many limitations on the contents, particularly on the physical layout as this can change the explosion pressures developed and therefore the ability of the enclosure to withstand the internal explosion. A particularly inappropriate arrangement of the contents can more than double the explosion pressure. For this reason, although a number of manufacturers place empty enclosures on the market with component certification, the limitations on use are very strict and require verification by a separate certification body before the final arrangement is deemed acceptable.

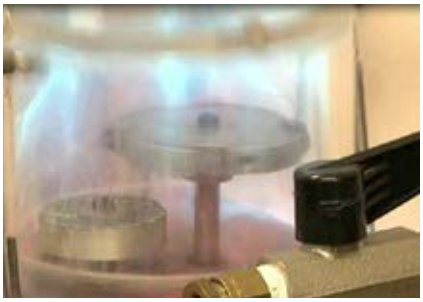
However, it is acceptable to use normal industrial items within the enclosure, subject to consideration of heat generation and layout. There are specific limitations on batteries which might vent hydrogen and/or oxygen into the enclosure and create even higher pressures.

Component manufacturers can supply component certified items such as push-button actuators and indicator lamps that penetrate the walls of the enclosure.

Component certified flameproof switch blocks are readily available for inclusion within enclosures of other types of protection where sparking contacts would otherwise not be acceptable.

Although most flameproof equipment is built in a metal enclosure, some smaller items can be made from plastic materials but additional tests are required to ensure that "flame erosion" will not defeat the protection.

TYPE OF PROTECTION "INTRINSIC SAFETY" Ex i – IEC 60079-11



In contrast to flameproof, an intrinsically safe item of equipment will have been studied at the component level on the circuit board to ensure that any possible sparking due to faults on the board is at an energy level below the Minimum Ignition Energy of the explosive atmosphere for which the equipment is designed. It is assumed that the gas has access to all components and that any ignition will lead to a full explosion. Energy is controlled by voltage and current limitation, and by protection of energy storage components such as inductors, capacitors and batteries. Complex circuits may have to be broken down into component parts, with energy limitation applied separately to each part in order to have a design that is safe but is still capable of carrying out its designed function. Temperature of individual components is controlled and some components are specifically de-rated as "safety components".

Typical circuits will operate at design voltages of 24 volts or less and consume no more than 1.3 watts of power. A detailed analysis of both the schematic

circuit and its physical layout are required and it is common for circuit boards to require modification after the first analysis. In complex cases, the final acceptable design may have required several iterations. However, in simple cases, the analysis can be very quick.

Unlike the other types of protection, unless battery powered, intrinsically safe equipment requires to be supplied from the "safe" area by a suitably limited power supply. This is often referred to as a "barrier" as its function is to prevent excessive energy getting to the intrinsically safe circuit. Barrier design can be simple or complex, depending on the exact function, and there are a number of manufacturers who specialise in designing and selling barriers for specific purposes.

TYPE OF PROTECTION "INCREASED SAFETY" Ex e – IEC 60079-7

Increased Safety can only be applied to equipment which has controlled temperatures and a total absence of any sparking in normal operation. Thus the standard can be applied to an induction motor but not to a commutator motor. Luminaires and junction boxes are also commonly designed to meet the requirements of the standard which are concerned with making failure into a condition of high temperature or sparking unlikely.

Typical requirements include: especially secure terminals that won't come loose under conditions of vibration; enhanced electrical segregation; thermal de-rating of insulating materials, as well as many specific requirements for particular types of equipment. Most equipment is housed in a strong dust and water resistant (IP 54) enclosure, to prevent the outside environment contaminating the equipment, but which neither keeps the gas out nor will withstand an internal explosion.

TYPE OF PROTECTION "ENCAPSULATION" Ex m – IEC 60079-18

By encapsulating the equipment in potting compound, the explosive atmosphere is kept away from the electric circuits. Some attention has to be given to potential faults in the circuit and most often the simplest way is to include in-built thermal fuses in series with the supply lines that will permanently disconnect the equipment if there is a fault. There are many requirements on the potting compound and the distances through it, both to the outside surface and between parts of the circuit.

In Europe, there is a tendency to minimise the amount of encapsulated equipment as it is not amenable to repair and therefore difficult to justify under the WEEE Directive.

TYPE OF PROTECTION "POWDER FILLED" Ex q – IEC 60079-5

This can be compared to the "fire bucket" approach. If the incipient explosion is covered in a pile of sand, it will be snuffed out. The term "powder filled" is a bit of a misnomer as the "powder" is either glass or quartz of a coarseness equivalent to granulated sugar.

This type of protection is similar to encapsulation in many ways but has the advantage that equipment can be opened for recycling or repair, but only by the original manufacturer who has the necessary ability to refill the enclosure after the repair is completed.

TYPE OF PROTECTION "OIL IMMERSED" Ex o – IEC 60079-6

A rarely used form of protection, suitable for items such as power transformers, but which would more normally be sited outside the hazardous area and therefore not need specific protection.

TYPE OF PROTECTION "PRESSURISATION" Ex p – IEC 60079-2

This type of protection is unique in that it relies on the continued presence of an external agent (the source of the pressurising medium) to remain effective. Therefore the equipment must be accompanied by a suitable control device that supervises the "purging" part of the cycle and will shut the equipment down if the pressurisation source fails.

The source may be a local supply of "instrument air" or a bottle of an inert gas, such as nitrogen. For large equipment, a significant amount of the purging medium is required to clear out any explosive atmosphere before the equipment can be switched on. This time delay (usually between 5 and 30 minutes but sometimes longer) can mean that pressurisation is not viable for equipment that must be started quickly. The cost of the controller and the requirement to supply the purging/ pressurisation medium mean that this type of protection is not favoured for smaller equipment where other types of protection can be applied. Specialist control panels (particularly those requiring a gas line to be passed through them) and large electric motors are among the favoured applications.

Although normally sparking equipment is easily accommodated in this type of protection, as sparking ceases immediately the equipment is de-energised, equipment with hot surfaces may be a problem as calculations must be undertaken to show that the surface will have cooled to an acceptable temperature before any gas might get in if pressurisation fails. Thus the internal, rather than the external, temperature is usually taken as the limiting factor.

TYPE OF PROTECTION "NON-SPARKING" Ex n – IEC 60079-15

Ex n has its origin in selecting industrial equipment which is non-sparking and low temperature in normal operation. From being a very thin standard in the late 1960's it has grown in complexity but is currently getting thinner as some of the content is transferred to other standards.

For much of the equipment it can be regarded as "Increased Safety Lite" and is suitable for installation in Zone 2 only (whereas all the other types of protection have versions for use in at least Zone 1, if not other Zones as well). Latterly, this equipment has been marked Ex nA. Currently the Increased Safety Standard is being revised to incorporate Ex nA equipment, with the designation Ex ec.

The one section of the standard unique in principle to Ex n is "Restricted Breathing". Here the equipment may, within specific limitations, have some sparking and some hot surfaces, but the enclosure is sufficiently well sealed that in the time an explosive gas atmosphere may be present in Zone 2, insufficient of it can breathe into the enclosure to create an explosion. This equipment is now marked Ex nR.

"Enclosed Break" (Ex nD) is a form of "Flameproof Lite" and will be transferred to IEC 60079-1 as Ex dc, but the sections on Ex n Encapsulation, Energy Limitation (Ex nL) and Simplified Pressurisation have already been deleted from the latest edition and now appear as an optional reduced level of protection in IEC 60079-18, IEC 60079-11 and IEC 60079-2 respectively.

"PROTECTION BY ENCLOSURE FOR EXPLOSIVE DUST ATMOSPHERES" Ex t – IEC 60079-31

Unlike gas, combustible dust can be considered as not being able to enter an enclosure with adequate Ingress Protection. This standard tabulates different degrees of Ingress Protection and different ways of considering temperature based on the Zone of hazard and the type of dust (conducting or non-conducting). Older standards used the marking Ex tD or DIP.

TYPES OF PROTECTION – NON-ELECTRICAL EQUIPMENT

At the time of writing, only European Standards are available for non-electrical equipment. Work is underway in the international committees to take the European standards into the international field, but this is still some time away. Therefore what follows is currently applicable within Europe only.

Unlike the types of protection for electrical equipment which were in existence, in previous versions, long before the ATEX Directive, the non-electrical standards were written as a direct response to the publishing of the directive and created some new types of protection specifically for non-electrical equipment. They cover both explosive atmospheres of gas and vapours and explosive atmospheres containing dusts.

EN 13463-1 the "General Requirements" for non-electrical equipment has a lot in common with IEC 60079-0 (consideration of light metals, electrostatics, aging of non-metallic enclosures, etc.), but additionally requires an initial "Ignition Risk Assessment". Electrical equipment can always be assumed to be a source of ignition, but this cannot be said of all mechanical equipment. Based on the results of that assessment, one or more of the specific types of protection may be employed.

A "Flow Restricting Enclosure" Ex fr – EN 13463-2 is identical in concept to the electrical "Restricted Breathing" and, similarly, is restricted to use only in Zone 2.

"Constructional Safety" Ex c – EN 13463-5 is based on the principles of the electrical "Increased Safety" and lists the additional things that can be done to make mechanical equipment more reliable.

"Liquid Immersion" Ex k – EN 13463-8 is derived from the electrical "Oil Immersed" but is more versatile as it allows splash lubrication of gearboxes, without total immersion.

"Protection by Control of Ignition Sources" Ex b – EN 13463-6 has no direct equivalent at international level, but the recently published EN 50495 covers some of the same ground for electrical equipment at European level. The two standards are radically different in approach to the same subject, though it is anticipated that the next edition of EN 13463-6 may be more closely aligned with EN 50495.

For "Flameproof" and "Pressurisation", there is direct reference to the equivalent electrical standards as neither of these types of protection is influenced by the nature of the ignition source.

INSTALLATIONS AND DSEAR

Although DSEAR is specifically a UK regulation, it is based on the European Directive and can also be used as shorthand for similar requirements anywhere in the world.

ZONING AND AREA CLASSIFICATION – IEC 60079-10-1 AND IEC 60079-10-2

In order to correctly select the equipment that will be installed in every area that might be endangered by a hazardous gas or vapour (Part 1 of the standard) or by a hazardous dust (Part 2 of the standard), an area classification exercise must be completed by a competent person. The assessment will include identifying all potential sources of release, the probability of the potential becoming an actual source of release, and the extent of the release in terms of distance from the point of release at which the hazardous atmosphere may occur.

Zones 0, 1 and 2 are the gas and vapour areas where the hazard may be present continuously, for shorter periods in normal operation or under unexpected circumstances for a short time only.

Zones 20, 21 and 22 are the equivalent areas for a dust hazard, but additionally take account of layers of dust that may be stirred up to form a cloud.

SELECTION AND INSTALLATION – IEC 60079-14

Based on the result of the Area classification, appropriate equipment must be selected, so that the best protected equipment is used in Zone 0 or Zone 20, but the least protected equipment is used only in Zone 2 or Zone 22.

The standard now relies on the defined "Equipment Protection Levels" (EPLs) to match the zones but also allows historical equipment without a defined EPL to be used. An indirect correspondence may be justifiable subject to a detailed risk assessment.

Although historically only Intrinsic Safety had two levels of protection "Ex ia" and Ex ib", more of the types of protection are introducing differing levels, particularly as the requirements from IEC 60079-15 have been transferred into the different standards. The correspondence is given in the following table (with the ATEX Categories added for convenience):

ZONE	EPL	ATEX CATEGORIES	PERMITTED PROTECTION CONCEPTS
0	Ga	1G	Ex ia, Ex ma
1	Gb	2G	Ex ib, Ex mb, Ex px, Ex py, Ex d, Ex o, Ex q, Ex e
2	Gc	3G	Ex ic, Ex mc, Ex pz, Ex n
20	Da	1D	Ex iaD, Ex ma, Ex ta
21	Db	2D	Ex ibD, Ex mb, Ex tb
22	Dc	3D	Ex icD, Ex mc, Ex tc

The standard also includes a lot of details on equipment mounting and cabling as well as the competence criteria for those selecting or installing the equipment.

INSPECTION AND MAINTENANCE – IEC 60079-17

Correctly manufactured, selected and installed equipment must be subjected to an appropriate inspection and maintenance regime to ensure that it remains in a safe condition. The standard details differing inspection regimes and maintenance schedules according to specific circumstances and the appropriate level of competence of the people entrusted with these important tasks.

REPAIR, OVERHAUL AND RECLAMATION – IEC 60079-19

High cost equipment is often repaired or refurbished before being returned to service following failure on inspection or an actual equipment breakdown. This standard provides the level of detail needed to have confidence that the repaired or refurbished item is equivalent to the manufacturer's specification and therefore may be re-installed in the hazardous area.

The IECEx Scheme for Certification of Service Facilities is directed at those operating to this standard whilst the parallel IECEx Scheme for Certification of Personnel Competence has units linked to this standard and also to parts 10, 14 and 17.

Safety demands not just equipment built to standards, but that it should be selected, installed, inspected, maintained and repaired throughout its life by individuals having the necessary competence.

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