1. Introduction

This article deals with explosion protection relating to instruments installed in hazardous locations.

Explosion protection is a complex subject but is rarely covered in technical syllabi. Plant staff therefore has to rely on knowledge gained from published literature and some scattered courses and may struggle to gain a comprehensive view of explosion protection concepts.

A framework for managing instrumentation in hazardous locations should address all the aspects mentioned in the following.

2. Selection of equipment

An explosion protected instrument as shown above does not per se provide safety. Two aspects are to be determined during a process known as the classification of the hazardous location: The level of protection required and the ignition characteristics of the atmosphere.

The level of protection (officially called the Equipment Protection Level or EPL) provided by typical explosion protection concepts applied to instrumentation for gas or vapour atmospheres varies as follows:

- Intrinsically safe Ex i: Zone 0 (category ia), Zone 1 (category ib)
- Flameproofing Ex d: Zone 1
- Pressurization Ex px: Zone 1 (with automatic interlocks)

(Note that this relationship between EPL and zone can be changed in certain cases due to a particular risk.)
Besides the explosion protection concepts mentioned above, other concepts used for instruments and instrument junction boxes include non-sparking Ex nA, increased safety Ex e and dust-ignition-protected Ex tD.

This information is provided in national standard SANS 10108.

The ignition characteristics of the explosive atmosphere is expressed as the subgroup (I for underground mines; IIA, IIB or IIC for gases and IIIA, IIIB or IIIC for dusts) and the ignition temperature (temperature class T1 to T6 for gases and layer and cloud ignition temperature for dusts).

The subgroup relates to the energy involved in igniting or extinguishing the explosive atmosphere with a spark. In the case of flameproof apparatus, for example, the physical dimensions of joints in the enclosure are increased to improve the cooling ability of such joints when a flame resulting from an internal explosion passes through them (see sketch below left). The energy that can be released by an electronic circuit is determined by its resistive, capacitive and inductive energy converting capability during normal operation or under fault conditions; an intrinsically safe design ensures that safe energy levels will not be exceeded under such conditions (see sketch below right).

The above paragraphs illustrate that an explosion protected instrument will not provide safety unless it matches the explosive gas, vapour or dust atmosphere to which it is to be exposed!

Also, not all explosion protected equipment will have legal status. SANS 10108 refers to ARP 0108 that clearly defines certification requirements. In essence, the design of explosion protected equipment has to be verified for compliance with a suitable standard, while the production process of such equipment must be controlled (by means of quality management) to ensure that each unit is produced to this design. Certification systems that effectively cover these two aspects (type testing and production control) are included in ARP 0108. An example of an IA certificate for successful type testing is shown below (even imported Ex equipment must be accompanied by such a certificate).
The onus is in the first instance on the supplier to ensure that his apparatus meets the above requirements. Information supplied must cover certification, installation, use, maintenance and repair of his equipment.

3. Installation of equipment

Connections to enclosures and cables. The cable connection to apparatus must complement the explosion protection. The normal rule is to use like with like, i.e., a flameproof cable gland must be used with apparatus with a flameproof enclosure, and an increased safety gland with apparatus with an increased safety enclosure, etc. Technicians are often getting this wrong where techniques are used in combination on the same apparatus or where the apparatus has double certification. Examples are North American instruments that may be flameproof ("explosion proof") as well as intrinsically safe, and European Ex e d or Ex d ib instruments.

In the same vein, the plugging of unused openings is a trap for the unwary. Often, a flameproof or increased safety enclosure with a press-in plastic plug or conduit/water plug, or a gland sealed with a piece of sponge is found. Attention to detail is literally of life-saving importance.

Cables (together with cable installation methods and glands) are chosen to be resistant to mechanical damage and chemical attack, to provide protection against ingress of moisture and dust through the cable and also, in the case of flameproof enclosures, to prevent propagation of an explosion. As the purpose of an installation in a hazardous location is to prevent ignition of an explosive atmosphere by means of sparks, arcs and/or heat, the correct electrical rating, earthing and bonding, screening and the presence of a working electrical protection system is extremely important.

Many industrial cables complying with a suitable standard meet these requirements. Instrumentation cable for intrinsically safe circuits must at least provide an insulation resistance of 500 V core-to-core.

Specific conditions of use. Certain Ex equipment comes with so-called specific conditions of installation or use. For instrument installations, this may involve the connection of flying leads inside a suitably protected connection box, limiting programmable units to certain values or providing protection against impact or dust/moisture ingress by means of an enclosure. Such conditions, without which the explosion protection is not fully functional, are either indicated by an instruction on the equipment, or where lack of space does not permit this, an "X" after the certificate.
number marked on the apparatus label. The certificate must be consulted for the conditions in this case.

4. Inspection

Despite the fact that two-yearly inspection of explosion protected equipment is a legal requirement (this interval is also recommended by SANS 10086-1), confusion reigns as to how and by whom inspections should be done. It has been observed that few plants have a properly working system for inspection and maintenance, because of this.

How to inspect  SANS 10086-1 gives valuable guidelines based on IEC 60079-17. Close, visual and detailed inspections are defined, the advantage being that visual inspections are less disruptive, quicker and require a less skilled inspector. The point being missed is that, starting from a point in time where the installation is in good shape, the majority of the inspections should be the visual type. This should work well if effective use is made of random inspections that would typically be close or detailed. In this way, and by using a computerized database, typical inspection profiles can be determined within a couple of years

In addition, the IEC has introduced the concept of Continuous Supervision. Apparatus under the constant attention of a skilled operator can in this way be kept in a safe condition.

Who has to inspect  There is no doubt that a qualified instrument or electrical technician trained in the concepts of explosion protection is required for detailed inspection. However, the possibility exists to use not-yet-qualified staff for visual and possibly close inspections, provided of course that the correct training has been given. Such training should be focused on the specific equipment in the plant.

5. Maintenance

The word “maintenance” as used here indicates processes carried out without having to remove the apparatus from its installed position. In general, maintenance operations will temporarily render the explosion protection of the apparatus useless and must therefore be carried out under permit-to-work conditions. The exception is intrinsically safe apparatus where live work is allowed. However, there are exceptions, and maintenance staff must be familiar with these (from the information marked on the equipment or given in the certificate).

Even after disconnection from the electrical supply, certain explosion protected apparatus may require a delay period before opening of the enclosure. Examples are apparatus containing hot components or charged capacitors. Such precautions are identified by the earlier mentioned “X” on the label.

Maintenance staff must understand the explosion protection concept involved so as to appreciate the importance of:
- The sealing (IP rating) of enclosures. The IP rating must at least provide protection against plant staff touching live parts, but higher IP ratings have an essential role in non-sparking, increased safety and dust-ignition-protected apparatus, by keeping dust and moisture partially or completely out.

- The condition of flameproof joint surfaces: Scratches, corrosion, paint, silicone sealant and uneven surfaces can all influence the flame-stopping ability of a joint, while it is not good practice to install apparatus such that the joint is within 300 mm from a solid object.

- A window forms part of the enclosure and therefore has to have suitable strength, chemical and UV resistance. Replacement components must be of identical material and dimensions.

- Worn/lost OEM labels must be replaced where possible, for example by examining the certificate of identical equipment. Only the most recent repair label must be kept. Painted-over labels must be cleaned, and labels must be protected against mechanical damage during maintenance and repair.

- Replacement of components: Only replacements of whole modules with original parts should be attempted by plant staff, unless they have been trained by the supplier. A component with wrong ratings or tolerances, the re-soldering of a joint or the damaging of an insulating layer can cause unsafe conditions.

6. Repair

The goal of repair work is safety first, functionality next. This requires repair shops to have knowledgeable staff, suitable equipment and a quality management system, such as afforded by a recognized product certification scheme (mark scheme).

The standard SANS 10086-3 (based on IEC 60079-19) makes internationally tried best repair practice available to repairers. Each repairer can gain from incorporating these methods into his quality management system

It should not be attempted to repair certain components, such as (small) cable glands, windows, and seals.

Often, a repairer will be confronted by apparatus not complying with the latest acceptable standard(s), as in the case of older or imported apparatus. Best practice in our experience is to repair to the new standard where mechanically and economically possible, but otherwise to retain the apparatus in its as-built state.

In general, modifications that directly affect the explosion protection aspects of apparatus require re-testing and certification of that apparatus by an ATL (an Ex test laboratory recognized by the relevant Regulators). Examples pertaining to instrumentation include replacing of certain pcb
components or changing of circuits. On the other hand, capable repairers belonging to a product certification scheme should be allowed to make such modifications provided that the effect of the modification has been determined by a type test and that the necessary adjustments to the repairer’s quality management system have been effected and audited.

7. Summary

To operate instrumentation in hazardous locations successfully, plant staff needs some basic technical skills plus specific Ex knowledge and operations have to be supported by a suitable quality management system. If aspects such as system design, training and record keeping are given appropriate attention, these goals can be achieved.

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