The Current State of the IEC Intrinsically Safe Standards

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The part of the IEC organisation, which relates to intrinsic safety is largely controlled by the committee TC 31which oversees the standards on electrical equipment for use in hazardous atmospheres. There is of course a large hierarchy of the IEC, which provides the framework within which TC31 operates, but this rarely impinges on the committee's activities. SC 31G is the sub-committee, which is responsible for intrinsic safety aspects of this subject and reports directly to TC31. The interaction between the committees is limited largely because heavy current engineers who regard milliamps as leakage currents, which are not relevant, predominantly people TC31. However TC31 does control the 'General Requirements' standard [IEC 60079-0] which sets the basic safety requirements which are common to all methods of protection. The intrinsic safety standards do manage to exclude many of the general requirements but unfortunately are not permitted to exclude some of the more ludicrous requirements such as marking.

The intrinsic safety committee relies heavily on maintenance teams to produce the three standards for which it is responsible. National committees always have the opportunity to comment and vote at the various stages in the development of a standard but inevitably it is the maintenance team [in particular the convenor] who have the major influence. Maintenance teams were introduced in an attempt to speed up the response to technical change, but the time scale is still about five years between editions,and there is strong opposition to the publishing of 'interpretations'. It is inevitable that national committees filter the inputs to the IEC. Hence care has to be taken that the views of minorities are taken into account and are not lost in the inevitable bureaucratic process of creating an IEC standard.

The standards writing process is inevitably unsatisfactory, but in common with democracy, it is a poor system but better than any other that is available. The people who do the work are generally rather old, employed by organisations with an 'axe to grind' and possessed of a fascination with the subject and/or themselves. An interesting aspect is that the participants frequently reflect the cartoon stereotype of their country. If you do not believe national stereotypes exist, attendance at an IEC meeting will change that opinion

In Europe there are CENELEC standards and the ATEX Directive. The CENELEC standard is the IEC standard with an Annex to make it compatible with the ATEX Directive. The Directive is a badly written piece of legislation intended to ensure 'freedom of trade' within Europe and a 'level playing field' of safety. Within the UK, BSI publishes what is effectively the CENELEC standard and there is local legislation enacting the Directive. As well as the apparatus directive there is a 'user' directive which attempts to control the use of equipment on hazardous plants which is difficult to understand and will be even more difficult to enforce. In the UK this directive is translated into law as part of a regulation, the Dangerous Substances and Explosive Atmospheres Regulations 2002 [DSEAR] which further confuses the matter. The most effective defence against all this legislation appears to be to collect a mass of documentation to deter any factory inspectors and offer a few prayers to your appropriate god that you do not have an explosion.

Intrinsic Safety Standards

Intrinsic safety is essentially a low energy concept which has its origins in the coal mining industry and to some extent these early influences are still present.

There are three standards, which are directly relevant to the technique of intrinsic safety, and these are:

IEC 60079-11 Apparatus standard

IEC 60079-25 System standard

IEC 60079-27 FISCO standard

This paper concentrates on the content and status of these three standards but there is considerable interaction with other standards in the IEC 60079 Series, which are considered individually as follows.

The major interaction is with IEC 60079-0 General Requirements, which contains the requirements, which are common to two or more of the methods of protection. For example the precautions considered necessary to avoid a significant risk from electrostatic discharge from plastic enclosures are included in this standard. Each individual method of protection standards lists the clauses of IEC 60079-0, which are applicable to the particular standard. In practice this means that IEC 60079-0 is essential reading whatever method of protection is being considered.

IEC 60079-14 the installation code of practice interacts with the three specific standards. In particular the borderline between the contents of the system standard [-25] and the code of practice requirements is difficult to define. The author's view is that the system designer should produce an installation drawing which permits the installing technician to install a system without having to consider the safety details. If this viewpoint is accepted then almost all the requirements should be in the system standard. However this opinion is not universally accepted and hence a compromise position has been adopted.

As a result a system designer must have access to IEC 60079-0, -11, -14, -25 and possibly –17 [maintenance] and –19 [repair]

IEC 60079-17 specifies inspection and maintenance matters. Maintenance aspects affect apparatus and system design since 'live maintenance' is an essential aspect of the intrinsically safe technique and influences some aspects of the design. The need for adequate instruction manuals is increasingly obvious and should be part of the design process. A comprehensive manual should indicate the preferred maintenance techniques and arguably an acceptable inspection routine. Hence access to this standard during the design process is also desirable

IEC 60079- 19 covers repair and overhaul and is largely irrelevant to intrinsically safe apparatus, since the majority of electronic circuitry is virtually irrepairable. Even the manufacturers tend not to spend much time repairing and fault finding on individual circuit boards since it is frequently both difficult and uneconomic to do so. The majority of repairs are done by substitution of modules. The need is for the instruction manual to designate the permitted practice.

There are frequent references to other IEC standards within these standards, for example IEC60664 on Insulation Co-ordination in IEC 60079-11. These cross-references often lead on a long paper chase without revealing useable information and should preferably be avoided. However an overstretched committee often seizes upon them as a possible solution to a difficult problem

It has been decided to amalgamate the ‘dust’ standards with the ‘gas’ standards and this means that recent drafts of the intrinsically safe standards have attempted to incorporate the requirements for protection against the dust hazard. Inevitably the differences in the nature of the two hazards will create problems particularly since the expertise on the dust hazards interaction with light current engineering is limited. The need for an intensive training course for most of the committee members is obvious and the probability of the early drafts of the standards being correct on dust issues remote.

The three standards directly related to intrinsic safety are discussed in detail below:

1. ***Intrinsically safe apparatus standard IEC 60079-11***

   The fifth edition of this standard appeared in 2006. It is 234 pages of A4 long [half of them French] and all the old codgers reminisce about the halcyon days of BS 1259: 1958 with its 14 pages of A5 comprehensively covering the essential aspects of the subject. It is unfortunate but inevitable that standards get longer and more complex as a subject develops. One aim of the IECEx scheme is to achieve uniform interpretation of the requirements across the world. This idealistic target will never be achieved but attempting it does mean that as far as possible the standard must give positive guidance on every known problem, and possibly try to anticipate future concerns. A consequence is that the standard will continue to grow.

   The foreword of the fifth edition lists fourteen significant changes from the previous edition and there are some other small changes within the standard. The most significant change is the introduction of the ‘ic’ concept, which is intended to replace the ‘energy limitation’ [nL] concept of IEC 60079-15. This is effectively intrinsic safety without countable faults intended to be used predominantly in Zone 2, and the implications are discussed more fully later in another paper.

   Another change is the introduction of Annex F, which allows a reduction in segregation requirements when the installation location or the enclosure has reduced the pollution degree. This is an attempt to align the intrinsic safety requirements with the requirements of other safety – related standards such as IEC 1010. It draws heavily on IEC 60664 which covers ‘insulation co-ordination’ .It is not easy to understand the full implications, since it uses some concepts and terms not familiar to the majority of instrument engineers. For example it requires users to be aware of the ‘over-voltage category’ of the mains supply, which is puzzling since very little ‘associated apparatus’ and no intrinsically safe apparatus is ‘energised directly from the mains supply’. However the table does contain some useful relaxations of creepage and clearance distances and a pattern of usage will emerge as the document is used by designers and certifying authorities. Hopefully this experience will enable the next edition to give clearer guidance on the application of this annex.

   The ‘ic’ section of this annex inherited a requirement from the ‘nL’ standard to have transient protection, which limits transients to 140% of the nominal voltage of the apparatus. This meaningless requirement [however it is interpreted] has never been achievable and will probably continue to be ignored as it was in the past.

   The remaining changes listed all relate to clarification of various aspects of the subject, which have caused difficulties in the past and are now clarified. There is increasing concern among the certification organisations about the risk from circuits containing both inductance and capacitance. Some requirements are included under testing considerations in clause 10.1.5.2, which effectively halve the permitted inductance, and capacitance when both significant lumped inductance and capacitance is present. Fortunately the restrictions do not apply to the distributed inductance and capacitance of cables. The tendency of notified bodies to wish to complicate standards to take care of perceived improbable previously unrecognised risks is beautifully illustrated by this unlisted change.

Work on the next edition [there is an approximate five-year cycle] has begun and a document for comment by national committees was circulated in May this year. The principal tasks are the merging of the dust and gas requirements and the incorporation of the FISCO apparatus requirements so that IEC 60079-27 can eventually be withdrawn. There are a number of minor topics and corrections arising from the fifth edition which have been addressed but the inclusion of the dust requirements are likely to be the significant hurdle since only limited expertise on this subject is available. The questions of resistance to contamination and the determination of safe temperatures both need some thought and clarification. There is a need for anyone with any interest and knowledge of this subject to obtain a copy of the document for comment and make any constructive comments to their national committee. The most effective comments are made early, before the document has achieved any momentum.

2. *Intrinsically safe system standard IEC 60079-25*

The first edition of the system standard was published in August 2003 and followed closely a preceding CENELEC standard. Previously systems had been constructed using the principles contained in the apparatus standard and the installation code. Frequently system certificates were created for specific combinations of apparatus. The increased flexibility required to permit the combination of equipment from different suppliers and the development of the 'entity' concept eventually led to the system standard being created. Practice differs from country to country but generally system documentation can be created by any competent person and is not the prerogative of approved certification bodies. For example within Europe a system comprised of equipment from different manufacturers assembled in a plant is not required to be certified to the ATEX Directive.

The current edition of the system standard is only applicable to Group II [surface industry with a gas hazard] and does not cover Group I [mining] or Group III [dust]. This is because initially it was thought that mining systems were fundamentally different, particularly in the need for certification, and required a separate standard. There was and still is a further problem in that no IEC installation code of practice covering the use of intrinsic safety in the mining industry exists and consequently the system standard has to include some 'code of practice' matters so as to be useable. A separate standard was produced as a CENELEC standard but this was never transferred to the IEC. An Annex to the standard describes an acceptable technique for establishing the safety of a combination of non-linear power supplies. A short study of this annex will convince any user that resistively limited linear power supplies have much to commend them.

The system drawing which illustrates the safety aspects of the system is the key to successful system analysis and is the critical document in most 'descriptive systems documents'

The next edition of the system standard is intended to cover all three Apparatus Groups. A document for comment [a CD] was issued to national committees at the end of April and interested persons should obtain a copy and make their comments

The CD contains a number of modifications to include Group I applications and an Annex, which discusses the use of 'simple apparatus'. It also attempts to explain when it is necessary to take into account the interaction between lumped inductance and capacitance. This is in practice only rarely a problem when creating a system from certified apparatus but must be covered. Unfortunately intrinsic safety is particularly prone to these irritating minority problems. For example a major part of the system standard is used discussing cable parameters, which rarely if ever present a practical problem. In particular for 'ic' circuits the use of a unity safety factor removes the problem and with the experimental evidence demonstrating that long leads actually make circuits safer perhaps the whole subject should be revisited. In practice it is worth accepting a small exceptional risk to simplify the standard. A simple standard commands respect and complicated standards are ignored because they are too complex.

3. Fieldbus intrinsically safe concept (FISCO) IEC 60079-27

The Fieldbus Intrinsically Safe COncept (FISCO) was developed from a report on some experimental work done by the German certification body PTB. The initial IEC document was a Technical Specification issued in 2002 which was then developed into a standard in 2005. The standard covers the use of Fieldbus in Zone 2 using the energy limited technique [nL] called FNICO. In February a CDV proposing the replacement of FNICO with an 'ic' version of FISCO was published. In the slightly longer term [4-5 years] the FISCO requirements will be incorporated in the apparatus and system standards and IEC 60097-27 will be withdrawn.

The purpose of the experimental work was to permit the higher currents necessary for the useful operation of Fieldbus circuits and to simplify the analysis and documentation of a safe combination of a number of field devices on one power bus. The FISCO standard has significant implications for the use of Fieldbus in hazardous locations and in the longer term may influence the design criteria for other intrinsically safe apparatus.

These subjects are further discussed in a later paper.

An Analysis of the Change from 'nL' to 'ic'

The concept of 'ic' as a simplified form of intrinsic safety for use in the less hazardous area of Zone2 is not new. It was proposed by Russia some thirty years ago and rejected for no good technical reason. More recently the type'n' committee realised that it was not competent to decide on low current techniques and decided to off load the work to the intrinsic safety committee. [A committee recognising that it has only limited expertise must be without precedent] There has always been confusion between the IEC use of ‘energy-limited’ and the American use of ‘non-incendive’ and ‘non-arcing’ and hopefully in the fullness of time this confusion will disappear.

The use of a third intrinsically safe level of protection does clarify a number of factors, which were not clear in ‘nL’ applications. The factors in favour of the ‘ic’ concept are:

The rules for systems are clarified

The use of intrinsically safe apparatus of all levels of protection is permitted

‘Live maintenance’ as defined for other intrinsically safe apparatus is permitted.

The rules for segregation and/or combining with other intrinsically safe circuits [for example in multicores] are defined

The requirements of ‘simple apparatus’ are applicable.

The requirements of earthing and bonding are established

Personnel involved in installation and maintenance only need to learn one technique.

Cable parameters still have to be calculated but are never restrictive.

Temperature classification is done in normal operation, hence T4 is readily achieved.

The requirements for ‘ic’ apparatus design are relaxed but the majority of manufacturers of field devices will still opt for ‘ia IIC T4’ certification so as to maximise their potential market. The exceptions will be when larger powers are required or when a much lower cost product can be produced or when it is technically difficult to make it ‘ia’.

In practice most of these advantages are within the scope of ‘nL' but they are not defined and the uncertainty is restrictive. Some end-users who exploited the lack of definition to make up their own rules will not welcome ‘ic’. Inevitably it will be many years before a comprehensive changeover occurs

Advice to the First-time Designer

If apparatus is intended to be sold and certified for use in hazardous areas then there are a number of factors to be taken into account to avoid long delays and escalating costs. The following is a possible procedure:

1) At an early stage consult with the certification body that will be used. In particular make sure that your existing quality control system is acceptable to that organisation. The problems created in trying to get a finalised design certified can be insurmountable, and should only be attempted by the brave or desperate. The certification body has to avoid offering a design consultancy service [because of the potential conflict of interests] but they can help to avoid basic mistakes.

2) Keep things simple. Use as little power and as low a voltage as possible. Things are easier at less than 10V and 500mW.

3) From a system viewpoint, ensure that the residual effective capacitance and inductance at the apparatus terminals is less than 1nF and 10μH respectively. Where possible use only reistive limited sources of power.

4) Create a large flat space for the label.

Above all remember it is going to cost a lot and take a long time. Costs differ widely with the complexity of the apparatus. Initial certification costs are very rarely less than £5000 and the costs within the design organisation are usually three times the certification costs. It has also to be remembered that there are ongoing costs of inspections and the inevitable variations to the certificate because of design modifications. Further certification may prove necessary as other markets open up. It is difficult to convince a rampant sales director that a certificate in another country cannot be obtained in two weeks at negligible cost.

Summary

The IEC will continue to produce standards. They will inevitably be out of date before they are published and they do not begin to be really functional until several years after they are published. Everything takes a long time and meanwhile plants operate without explosions being caused by out of date certified and/or uncertified electrical equipment, but occasionally exploding for other reasons.

The IEC aims to make the world safer and will never achieve a perfect solution as the targets change. If you wish for a consoling thought, be grateful that you are not responsible for ensuring the compliance and safety of mechanical equipment. These requirements have only recently begun to be set down. At least in electrical aspects of instrumentation we have some years of experience to guide us.