Intrinsic Safety - Its Widening Horizons

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Introduction
The development of intrinsic safety has always been affected by the available technology and is probably at a point where it is about to make another leap forward. Within the United Kingdom the usually accepted starting point was the Senghenydd disaster in 1913 and from that point it had limited growth within the coal mining industry, primarily in communications and protective systems. Its use in surface industry was restricted by the available equipment and the understandable preference for pneumatic control. The balance changed in the late 1950's and early 60s as semiconductors became available and computer control of petrochemical installations became a practical possibility. The increased capability in computing and display which has recently emerged will make distributed systems possible, and these ought to be more effective, possibly cheaper and arguably safer.

Acceptable Spark Ignition Limits
The widely used ignition curves derived from the international spark-test apparatus have provided a satisfactory design basis for at least the last twenty-five years. Unfortunately there is mounting evidence that the capacitive curves are optimistic and consequently they will almost certainly be changed. What the overall effect of this change will be is difficult to predict, since it may be affected by the use of safety factors in the CENELEC and IEC standards. A beneficial factor is that almost certainly capacitive curves for IIB and IIA gases will emerge. It is a pity that the existing values cannot be maintained since, combined with the usual safety factors, they do not produce an ignition capable circuit even when tested by the spark test apparatus which is, in itself, more sensitive than normally occurring practical situations. There is considerable merit in not changing well established practice.

Temperature Classification
The concern about temperature ignition in intrinsically-safe circuits is largely removed by the 1.3 watt relaxation permitted for small components enabling a T4 temperature classification without test. In practice this restriction is the major factor in many IIB circuits.

The 1.3 watt temperature classification is a very conservative technique. The normal fault count is applied and the assumption made that the particular component has failed to a matching resistance. In practice the matching resistance is usually relatively low (100 ohms) and such factors as lead resistance reduce the possible dissipation considerably. This contrasts with other techniques such as flameproof where the temperature classification is based on normal operation. There would not appear to be any imminent change in this conservative view.

The other limitation of the 1.3 watt rules is that a literal interpretation of the present standard restricts its use to components having a surface area between $20mm^2$ and $10cm^2$. Generally this is interpreted as being applicable to any component larger than $20mm^2$ and possibly the standard should be modified in line with the practice. The increasing use of surface mount technology will almost certainly call for further adaptation of this clause.

Unfortunately no significant amount of work on ignition temperature by small objects with materials other than carbon disulphide and diethyl ether has been published, and consequently there is no corresponding power figure for T3. Of the 197 compounds listed in BS5345:Part 1, only one, carbon disulphide, is classified as T5 and six as T4. Perhaps the additional safety factor of always using T4 equipment provides a reassuring margin but it may be over cautious.

Fig. 1 Simulated Senghenydd bell explosion used for training purposes

Practical Limits
If a cable length of 500 metres is assumed to be adequate for most installations, with a cable capacitance of 200 picofarads/metre, a cable capacitance of 0.1 microfarad seems reasonable. Using the existing curve for IIC and the proposed curve for IIB then open circuit voltages of 30 volts and 73 volts emerge. As previously mentioned these limits may be moved in the next edition of EN50 020. Similarly an inductance of 1 microhenry/metre on 500 metres give short circuit currents of 266mA and 532mA for IIC and IIB respectively.

The 1.3 watt curve for T4 temperature classification largely influences IIB sources of power, however, an additional margin is available for encapsulated units with significant thermal capacity. The IIC and IIB non-reactive curves have usually a 1.5 factor of safety applied and are as plotted.

The resultant limits are shown in figure 2 and perhaps illustrate why the IIB gas classification should be exploited more frequently. It seems probable that a 70 volt source current limited to 50 milliamps is safe from a live working viewpoint. A 70 volt square wave at 50Hz from a 1.4 Kilohm source would produce a current of the order of 20 milliamps through a human being which could cause muscular paralysis. The CSA (Canadian) limits are 30 volts rms, 42.4 volts peak and this then possibly becomes the voltage limit if live working is to be permitted.

Design of Apparatus & Systems
This paper concentrates on the application and design of fixed apparatus connected by cables. Portable apparatus is an important sector of the intrinsically-safe market and has enormous potential for growth. However, it is not possible to discuss this subject adequately within the restrictions of this paper and hence it is omitted.

The majority of the basic measurements are more than adequately covered by the technology which exists at this time and these are widely used and understood. A typical progression can be illustrated by considering a conventional 4-20 milliamp transmitter in the United Kingdom. In general these were certified apparatus for use in specifically certified systems until about 1963; a form of modular apparatus certification for use with different manufac-

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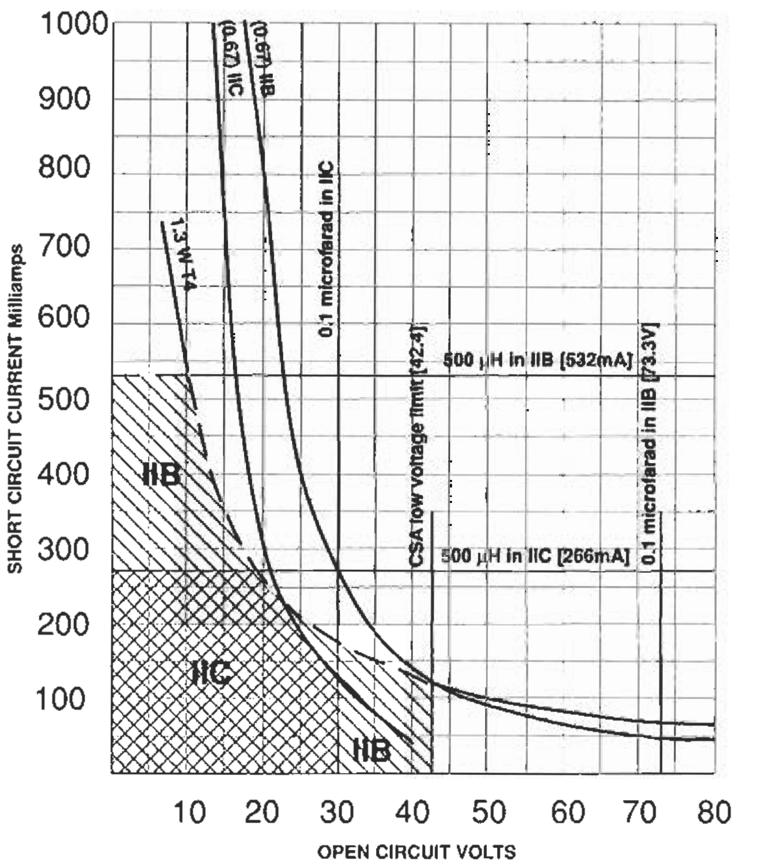

Fig. 2 Practical limits for intrinsically safe circuits

turers shunt diode safety barriers persisted until 1974. At this time apparatus with specified input parameters began to emerge and has progressed to the point of being the only way such apparatus is now certified. This progressive change coped with the wide range of multiple and active barriers and isolators from a number of manufacturers without appreciable difficulty. The change to "smart" transmitters introduced a number of operational problems but no significant safety difficulties.

The modular construction of systems is a practical reality which is well understood and gives great flexibility. There are a number of detailed arguments, the solution to which are not well documented. Some of these are being discussed within CENELEC and the necessary rules will emerge, but the present system is working well and hence the differences in detail are not too important.

The Case for Distributed Systems

The argument for distributed systems have been rehearsed extensively over the last few years but it is worthwhile reviewing the subject with intrinsic safety and hazardous areas in mind.

A major argument in favour of processing information in the field is the reduction in the amount of field wiring. There are some safety fringe benefits in that if a large multicore is reduced to a single pair then the possibility of getting the installation wrong is reduced and problems of cable parameters and faults between cores are completely removed. The reduction in the number of intrinsically-safe interfaces is an economic advantage but can be argued to statistically increase the overall safety of the plant if not significantly. In practice the number of cores would not usually be reduced to two because highways tend to be duplicated and information sub-divided to improve operational integrity. The discussion on the relative reliability of distributed and hard wired systems is quite complex and worthy of a paper in itself.

If the data has been collected and there is power at the transmitting end, then the use of a fibre optic link has the advantage of good electrical isolation and high immunity from electrical interference. In general however the bandwidth necessary for information transfer is within the range of conventional technology and cables and the introduction of another technology is not warranted. Similarly there have been advocates of low power radio links to eliminate the signal cables completely and in some particular cases it is the appropriate solution.

A possible advantage of using Type N systems in Zone 2 locations is the reduction in cost achieved by the removal of intrinsically-safe interfaces. Where their number is reduced by using this type of system then the cost differences are removed. Possibly this development will further reduce the need for time to be spent developing the rather ill-defined technology and code of practice.

Similarly, because the number of interfaces is small, nearly all distributed systems use isolated interfaces rather than shunt diode safety barriers. The digital signal and the operational need for isolation and freedom from earthing limitations makes the marginally more expensive isolator the natural choice in the majority of circumstances.

The safety implications of using distributed systems are possibly best illustrated by considering the transmission of information from a compressor skid. Local monitoring, control and display of monitored variables is all currently possible. In some applications the control system on the skid can be almost comprehensive with only updating of the control set points from the central control. In the majority of systems the shutdown controls are arguably better adjacent to the relevant control mechanisms. It is impossible to generalise but the ability to choose to mount the controls and displays within the hazardous areas without the limitations of the less desirable methods of protection is a useful addition to the possible solutions in maximising the reliability of safety interlock designs.

Where controls and interlocks can be built into prefabricated structures, then the pre-commissioning inspection and testing can be comprehensive. It is very much easier to inspect and rectify an intrinsically-safe installation within a protected workshop than an exposed installation on an offshore rig. The use of preformed and tested cables with plugs and sockets is also an effective aid to ensuring that an installation will have a higher probability of a short start-up time.

Power Supplies for Distributed System

The total power required for a distributed system is likely to exceed the limits permitted by intrinsic safety. The usual source of power is the local mains supply in an Ex 'e' mode, with a small back up battery facility in the outstation. 24 volt standby options are useful in situations where the voltage drop in leads is not excessive. Solar power has not been used to any large extent but its simplicity of installation and the wide availability of both natural and artificial light has considerable appeal.

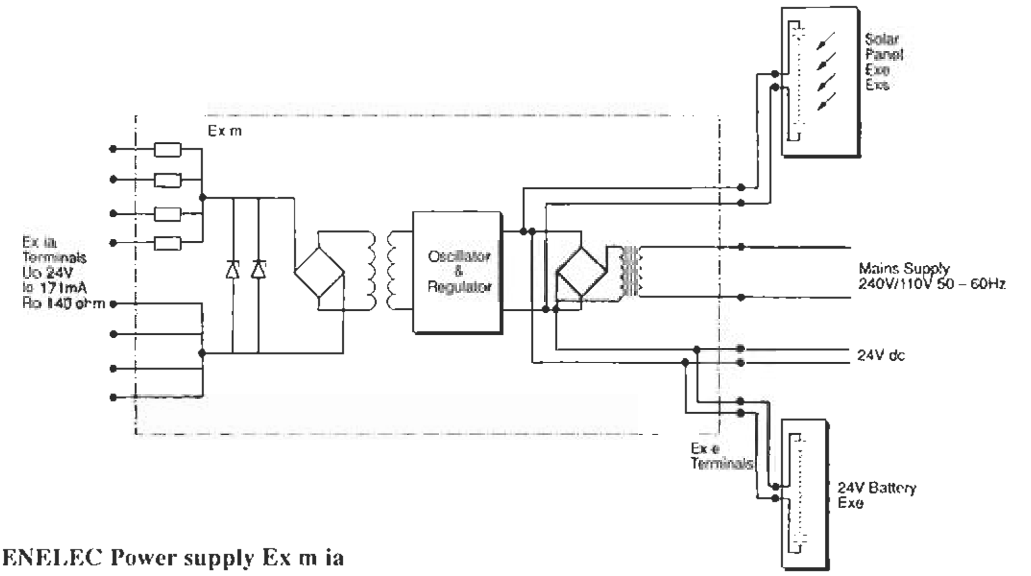

Fig. 3. CENELEC Power supply Ex m ia

A possible power supply is illustrated in Fig. 3. The output voltage of 24 volts is arbitrarily chosen. It is not the optimum for intrinsic safety purposes but is a popular voltage and compatible with some existing certified apparatus. The sketch shows an encapsulated supply [Ex m] which would be the normal practice for a relatively small system. In larger more complex systems sand filled Ex q and oil filled Ex o systems would be a better solution if the second edition of the CENELEC standards removes some of the questionable aspects of these methods of protection.

In an international context, the option of housing the power supply in a flameproof box [Ex d] or an American explosion-proof enclosure would almost certainly be necessary (see fig.4). All engineers who deal with the world's national certifying authorities must have a strong masochistic streak but the man who attempts to get a light powered encapsulated supply incorporating batteries accepted internationally will need an especially high level of pain tolerance. Among other things, the discussion on acceptable techniques for charging batteries in hazardous areas has been going on for at least ten years and is still unresolved. It is almost inevitable that no single internationally acceptable solution to the power supply problem will emerge. This is a further illustration of the problems which exist on an international scale for non-intrinsic systems.

Field Bus

The principal hope for an international digital highway system for process control appears to rest with Fieldbus, which sometimes appears to be making real progress toward an acceptable solution. Fortunately the voltage and current levels appear to be compatible with intrinsic safety.

Consideration of the intrinsically-safe aspects seem to be restricted to IIC applications with the possibility of up to three transmitters being fed through some type of locally powered isolator. There will be a need for further consideration of other types of hazardous area mounted equipment such as the recovery of information from process analysers but no doubt this type of application will follow the solution of the more common problems.

The possibility of mounting significant parts of the data collection system within the hazardous area does not appear to have been considered but this is probably regarded as a minority interest and will need to be considered when other problems have been resolved.

Intrinsically-Safe Lighting

The LED has for many years been used as an intrinsically-safe indicator, and their brightness has been considerably enhanced. There are also some incandescent lamps which are quite visible which can be driven from an intrinsically-safe source but are themselves protected by mechanical means.

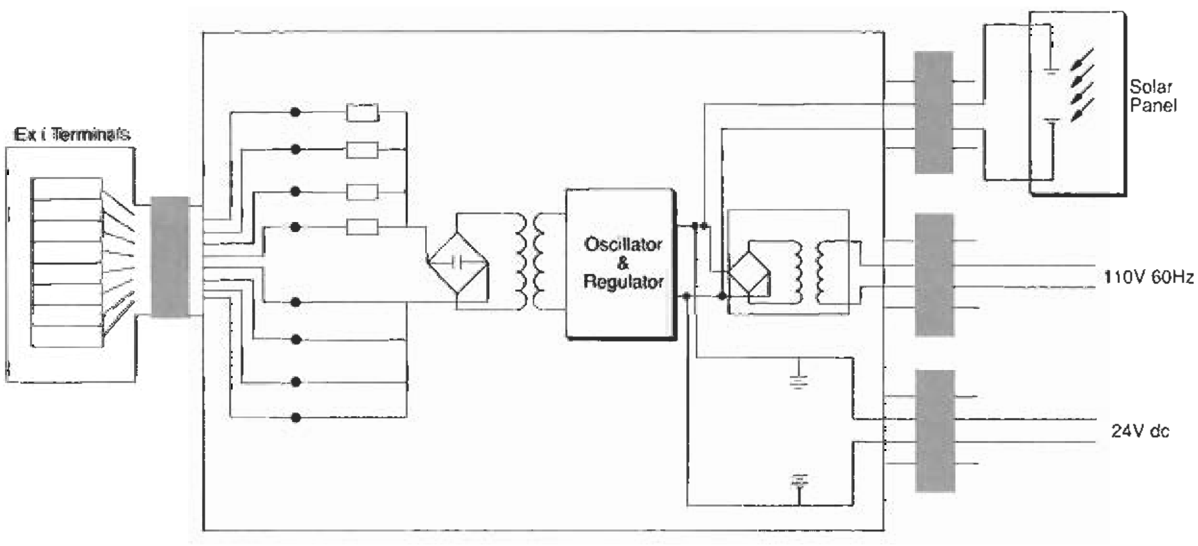

Fig. 4 U.S. Explosion – proof power supply

In the past they have usually been certified Ex s, presumably some of them would now be certified as Ex m.

The development of low voltage phosphors for electro-luminescent products is opening up the possibility of these being intrinsically-safe, probably in IIB circumstances but possibly in IIC. Obvious applications are escape route indication and back lighting of LED displays but as the range of colours, brightness of indication and life of lamps increases many other possibilities will emerge.

Liquid crystal displays are a very common feature of intrinsically-safe instrumentation and their visibility and temperature range is adequate for the majority of applications. There is no widespread use of colour but this will inevitably become common in the not too distant future.

Sound

Only a very few installations have made use of intrinsically-safe public address systems. In general other methods of protection are not very successful but it is quite difficult to generate more than 1 watt in each intrinsically-safe circuit. A system with either banked 1 watt speakers or better still a number of well distributed speakers does however produce an audible intelligible system.

Various programmable audible warning systems are widely used already.

Conclusion

Intrinsic safety will inevitably follow the process control instrumentation tendency toward distributed systems. Fortunately the available technology is keeping step with the requirements. Progress will be slow because the petrochemical industry always reacts slowly to change. The whole process of certification is a further deterrent to change because new techniques have not been addressed in the existing standards which are inevitably out of date by the time they are published. There is an undisputed requirement to move forward cautiously and safely but the cost is significant and the under-utilisation of technology significant,.

If intrinsic safety can move to a simpler code of practice and reduce costs then perhaps the demands for instrumentation techniques usable in Zone 2 will be stilled and technicians will be trained to work safely with a single technique and overall safety will be enhanced.

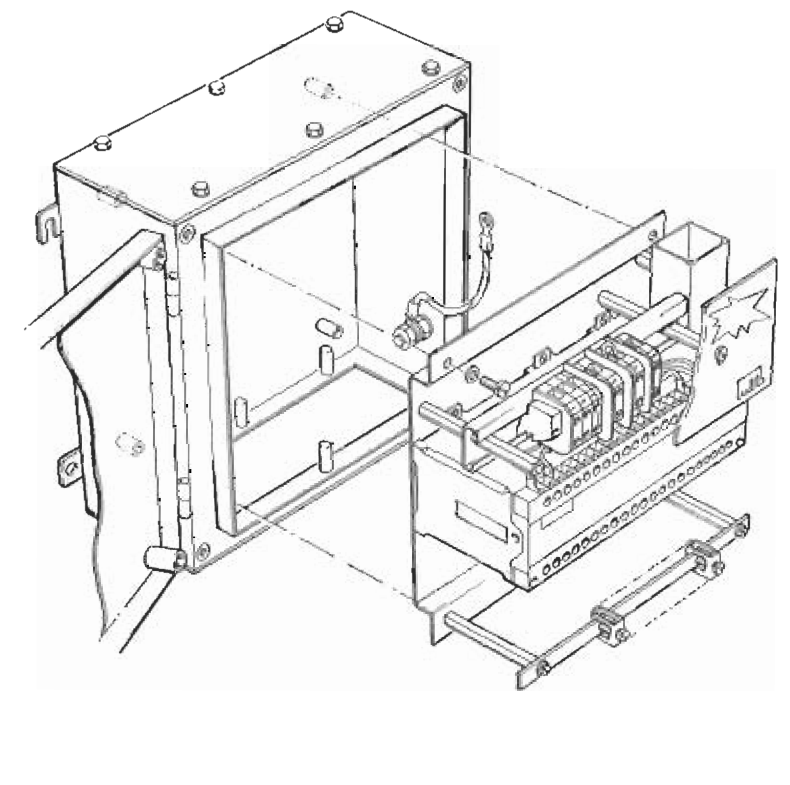

Fig. 5 Field mounted source of intrinsically safe power

Further Reading

There is an extensive range of technical articles, application notes and training courses available from MTL. Current European activity is possibly best reflected in the following documents.

Background

TP1091 Intrinsic safety rules OK for process instrumentation
I.C. Hutcheon 1989
A very good summary of the art

AN9003 A users guide to intrinsic safety

AN9007 A users guide to shunt diode safety barriers

AN9008 A users guide to MTL 2000 and 3000 series isolating interface units

These three application notes are a very good readable set of reference documents.

All the above are available from MTL

Area Classification

Area Classification Code for Petroleum Installations
Model Code of Safe Practice part 15
Institute of Petroleum, recently published guide which is well worth reading.
Draft: Classification of Hazardous Areas
CENELEC document CLC/SC31-1 (sec 8)

Draft for comment, available from National Committees.

Intrinsic Safety

pr EN 50.014. Final Draft, General Requirements March 91
CENELEC document for voting

pr EN 50.020. Draft 3, Intrinsic Safety March 91
CENELEC document for voting

Draft European Code of Practice
CENELEC document about to be issued

Political

Working Document. Proposal for a Council Directive on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres. March 91

A draft Directive with frightening implications available from appropriate government departments or trade associations

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