The effect of IEC and CENELEC intrinsic safety standards on the future development of instrumentation

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Introduction

There are a number of factors which affect intrinsic safety which make a review of the European and International situation at the present time very relevant.

The International Standard IEC 79-11 has very recently produced its new edition and the second edition of the CENELEC Standard EN50020 will shortly go out for voting. There is a draft CENELEC code of practice which is at a fairly early stage and an EEC Directive which has recently moved into the political arena. All these factors could be turned into a positive influence to produce a more efficient use of safety knowledge and to reduce the need for repetitive certification.

The Standards Process

The CENELEC intrinsic safety standard has always been closely aligned with the IEC standard and in practice the two standards have interleaved, with each building on, modifying and developing the other. More recently CENELEC and IEC have worked very closely together and now parallel voting on standards in some areas is encouraged. In the particular field of intrinsic safety the major difficulty with both CENELEC and IEC standards is the timescale involved in achieving any change or interpretation. The delay is an almost inevitable consequence of the consultation process and in some cases is beneficial in that it allows a cooling off period. However, within CENELEC it has been found necessary to issue national and CENELEC interpretation sheets quite frequently which has caused considerable administrative problems. The CENELEC intrinsic safety committee has been criticised for the amount of interpretation necessary but this criticism is not well founded. Intrinsically-safe equipment is constantly evolving and the standard must keep pace and if we are to have a consistent level of safety, difficulties will arise and these need to be discussed and amendments made. At the present time some of these decisions are made by the heads of test houses committee [HTOL] which is knowledgeable about testing but does not have the necessary breadth of knowledge to make some of the decisions which it has to make in the absence of a better forum. In practice, interim decisions by small working groups are almost always considered as unrepresentative by those outside the group.

There is a persistent financial problem associated with all standards. The necessary experienced people involved are all senior members of their own organisations and whether they should spend the time and incur the costs involved is a matter of considerable concern. In the last few years the intrinsically-safe CENELEC committee has lost several valuable members because of financial criteria. The need for members to be self supporting does mean that the committee members are not an ideal combination. In particular, the apparatus committee tends not to have adequate user representation. A recent two day CENELEC IS committee with twenty two participants must have cost £25,000 and hence any meeting must be made effective.

International committees are even more expensive to convene, but full committees should not need to meet too frequently if full use of modern communication facilities is made.

The inevitable conclusion of any study of the standards committee system is that (to paraphrase Churchill on democracy) it is "not the ideal system, but is better than all the alternatives". A solution must be found to the problem of interim interpretations or, alternatively, national committees must be free to decide. The ideal solution would be an IEC standard to which everyone could certify, and which was comprehensive and definitive without being restrictive. This is not likely to be achieved.

Interaction Between Standards and the Legislative Process within the EC

The existing European directive relating to flammable atmospheres has worked surprisingly well. The present situation where there is widespread acceptance within the EC of equipment certified by the notified test houses to the CENELEC standards was not anticipated by everyone and certainly has exceeded the author's expectations. In particular, the attitude of the Scandinavian countries outside the EC has been particularly commendable. End users may still have strong preferences for particular suppliers and certifying authorities because of a long history of satisfactory association, a common language and physical proximity but this is commercially reasonable. It is a factor which seems beyond the comprehension of some governments and even some manufacturers who appear to believe that end users should be coerced to buy from any supplier who achieves certification.

It is worth commenting that the requirements of the EC Directive for surveillance are only being rigorously interpreted by the United Kingdom test authorities. The UK interpretation of the quality control requirements is for the manufacturer to have a system as required by ISO 9002 plus some additional requirements as imposed by themselves. This requirement was imposed by the UK authorities largely as a result of representations by end users. The UK manufacturing industry has bowed to the inevitable largely because it was faced with accepting or re-applying for certification by other test houses. Ironically the resultant quality control upheaval enables UK suppliers to claim a higher level of defined quality to justify the increased costs incurred by the end users. It will be interesting to observe whether the end users who brought about the intensification of surveillance will now only purchase from suppliers with adequately approved quality control systems. Present indications are that the presence of these quality control systems has had no appreciable influence on end users purchasing policy. The problems incurred by purchasing from suppliers with products manufactured in different countries and certified by different authorities should cause lots of fascinating problems of conscience to the quality control fanatics.

The new approach directive on flammable atmospheres has completed its consultative phase and is now entering its legislative phase. The new directive embraces both mechanical and electrical safety of equipment for use in flammable atmospheres and contains requirements for surveillance similar to those required by the United Kingdom at the present time. Manufacturers have tried with very limited success to change the directive but it has proceeded with the inevitable blind momentum driven by a number of bureaucrats, irrationally confident in their very limited experience of the subject. The absoluteness of the requirements is a worrying aspect. In the past, codes of practice have been used as guidance for normally occurring circumstance and engineering judgment has been allowed to override the code of practice to achieve the required level of safety if this is thought necessary. This may not be possible in future. Surprisingly, the majority of end users have not reacted against the proposed directive, presumably believing that the document will not be enforceable, but this is a very risky approach. The author's personal view is that if the directive goes through in its present form, it will be widely ignored by end users and spasmodically enforced by the authorities, which is not a desirable situation. One consolation is that although there are problems in the electrical area, the potential difficulties created for designers of mechanical equipment are horrendous. The other interesting result will be that European manufactures will also be subject to surveillance which will give UK manufacturers some considerable if vindictive pleasure.

Another interesting side effect of the directive will be the necessary qualifications of certifying authorities. At present, certifying authorities are appointed by their national governments on the basis of different acceptance criteria but most frequently because they have been around for some time. It will be interesting to see how many survive a more rigorous examination of their procedures and manufacturers could be forgiven for enjoying their discomfort at having to establish "uncertainties of measurement" for how long is a piece of string. So many strange stories abound about ridiculous requirements imposed upon certifying authorities that some must be true.

Certainly "approved" certifying authorities seem even more reluctant to make common sense decisions than they were previously. It would all be very amusing if it was not such an expensive waste of time.

It would however be generally beneficial if certification was in the hands of a few competent authorities providing certification services on an economic unsubsidised basis to meet manufacturer's needs. The author's opinion is however that HOTL will emerge as the Commission's official arbiter on all matters arising and, confident in their own infallibility, the present cosy status quo will remain.

An ideal solution would be to certify to an international standard by certifying authorities who themselves met certain requirements and were internationally approved. The regulatory and insurance authorities of each country could then accept equipment regardless of origin and certifying body. This is a very ambitious thought and the possibility may be readily dismissed. However many people, including the author, thought the CENELEC and EC procedures would not work but the end result while not perfect is quite effective. So ultimately it may be possible. The primary argument against accepting international certification is the quality of some certifying authorities and manufacturers. There are other vested interest arguments, in particular, manufacturers defending their established markets and certifying authorities concerned to defend their authority and work load.

The majority of manufacturers of intrinsically-safe products do aim for international markets because for those working in a relatively narrow market area, an international capability is necessary to achieve an economic level of sales and also to reduce the effects of economic problems in a particular country. Fortunately, intrinsic safety is the only technique which does permit a single design to meet the requirements of all countries, but it is still necessary to obtain certification in an infinite number of countries. The resulting collection of largely meaningless marking is adequately illustrated by figure 1 which omits the Japanese requirement for the sake of clarity.

The petrochemical industry is one of the most international and hence it is desirable to be able to use identical equipment regardless of location. Fundamentally the risk is the same and hence the precautions to be taken should be identical.

Comparison of the IEC and CENELEC Intrinsic Safety Standard

Intrinsic Safety is fortunate in that the international standard is relatively up to date and contains almost sufficient detail to enable certification to be possible. The standard also covers the design of intrinsically safe systems which are covered in EN50039 in the CENELEC standards. In practice there are only infrequent references to systems and hence a comparison is not difficult, and the principal differences are listed in the sequence that the subjects are raised in the IEC standard. The second edition of EN50020 has not been voted upon and may not appear until late 1993 but the voting document has been widely discussed and is largely a consensus document.

In particular the IEC clause on mains transformers is not very easy to interpret, allowing a very wide range of interpretation. The CENELEC standard quite specifically sets out the European position requiring both insulation thickness and voltage test. This clause is fundamental to the whole subject of intrinsic safety, and there have been extensive developments in transformer technology which is one of the reasons the CENELEC standard gives more detail on other types of transformer. Possibly the small high frequency coupling transformer is an area where some original thought should be given since the standards are really written with larger devices in mind and the restricted energy transfer associated with small cores and the desirable isolation between circuits should be more effectively exploited.

The clause on temperature classification of small components has been modified to permit the 1.3 watt temperature relaxation to be applied to surface areas greater than 10cm^2 and also to permit the relaxations to be applied to Group 1 situations where

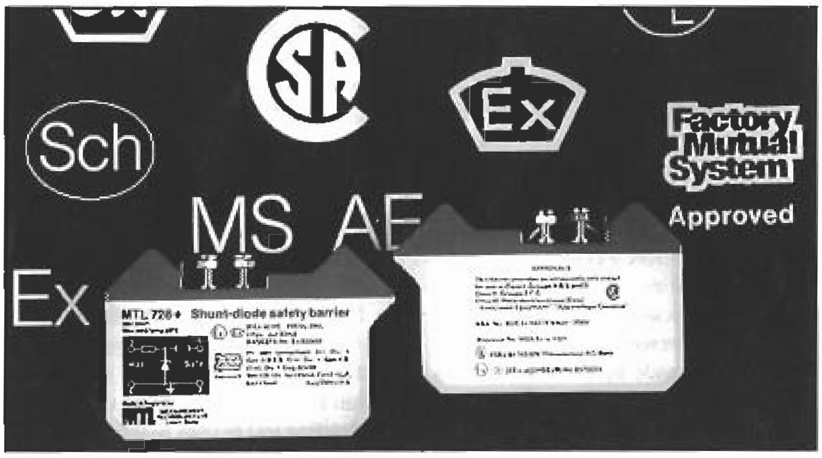


Fig 1. Illustration of product marking

there is no risk of dust layering. This is almost an editorial change.

There are only detailed differences in the creepage and clearance requirements. The IEC standard applies r.m.s. voltages when assessing clearance whereas the CENELEC standard uses peak values. The CENELEC standard does not require a CTI value for insulation used below 10 volts whereas the IEC standards requires a value of 90. The reasons for this is doubt over whether CTI is a relevant parameter for failure of insulation at low voltages and the problems of acquiring data on components such as batteries. A positive decision was made not to align the requirements of intrinsic safety with those of the increased safety technique although it was recognised that in the long term alignment is more logical if not necessarily desirable.

The CENELEC standard when considering infallible components attempts to explain the fault mechanisms against which the components are infallible which is useful in overcoming some of the misunderstandings which arise when test houses fail infallible components. Apart from the omission of protective chokes which have no practical use the CENELEC standard more closely specifies infallible components.

The IEC standard has no specific clause on shunt diode safety barriers, however the CENELEC standard retains a short clause with many of the original requirements being transferred to a clause on shunt voltage limiters. The IEC standard permits the design of shunt diode barriers with replaceable fuses whereas the CENELEC standard, while not requiring barriers to be encapsulated, requires all the components to be non-replaceable. The CENELEC standard also contains a useful simplification for the determination of zener voltage.

The draft CENELEC standard clarifies some aspects of simple apparatus which was previously inadequately defined in EN50014. The proposed clause increases the acceptable voltage to 1.5 volts and replaces the stored energy restriction of 20 microjoules with a need for well defined inductance and capacitance to be taken into consideration when assessing overall system safety. This change is much more logical and permits significant inductance or capacitance to be used, particularly in the less sensitive gas groups. Quite how far this clause can be exploited will be determined by what is acceptable to the end users who in general tend to prefer the assurance provided by a certified and marked product. The wording of the new clause does allow considerable scope for manufacturers and users with adequate knowledge of the principles of intrinsic safety to avoid certification in exploiting new ideas. The system standard and code of practice will also need to clarify some aspects of the use of simple apparatus in intrinsically safe systems, in particular where certified apparatus has input terminals with simple apparatus parameters.

Fig 2. Instruments having input terminals equivalent to 'simple apparatus'

Perhaps the most significant long term change will be the adoption of the new design curves for capacitive circuits. For many years there has been an IEC working group considering the capacitive curves incorporated in the standard and it has been accepted that more sensitive results than those previously used could be consistently achieved. There has been a long discussion about whether the test apparatus is representative of actual circumstances and eventually a compromise set of curves emerged which are shown in figure 3 with the current IIC curve superimposed upon them. After some debate it was decided to adopt these curves for the next edition of EN50020 and also to retain the original safety factors.

The significance of this is best illustrated by considering the permitted cable capacitance with a 28 volt barrier. Currently the permitted capacitance is 0.13 microfarads but with these curves it will become 0.08 microfarads, hence if an instrument screened twisted pair has a capacitance of 200 picofarads/metre the acceptance cable length in IIC is reduced from 650 metres to 400 metres. The significance of this change will depend on how the system standard defines that cable parameters should be measured. Interestingly enough a method of measurement has never been defined, which perhaps reflects how widely this requirement has previously been ignored. In practice there are very few occasions when cable parameters do matter and it is very desirable that when the European Code of Practice emerges it should state something like "only if you have leads longer than 200 metres and the gas risk is IIC need capacitive cable parameters be considered". If this could be combined with a statement that "if the permitted system L/R ratio is greater than 40μH/Ω the inductive cable parameters can be ignored" then thousands of man hours would be saved by not pursuing what is really a non problem.

The benefit which emerges from the change is that capacitive curves for IIB and IIA gases are now available. Previously, multiply factors of 3 and 8 on capacitance values derived from the IIC curves were used. The relaxation for IIB gases offered by the new curves can be illustrated by once more considering the 28 volt barrier which presently permits a capacitance of 0.39 microfarads and this will rise to 0.5 microfarads which completely removes any concern about cable capacitance in IIB gases.

Code of Practice

There is a draft CENELEC Code of Practice which includes a section on intrinsic safety which has been put together without too much difficulty. Many of the apparent differences have tended to be removed by closer examination.

Perhaps the outstanding problem is that of earthing or bonding. This is a subject which, despite being a basic part of all

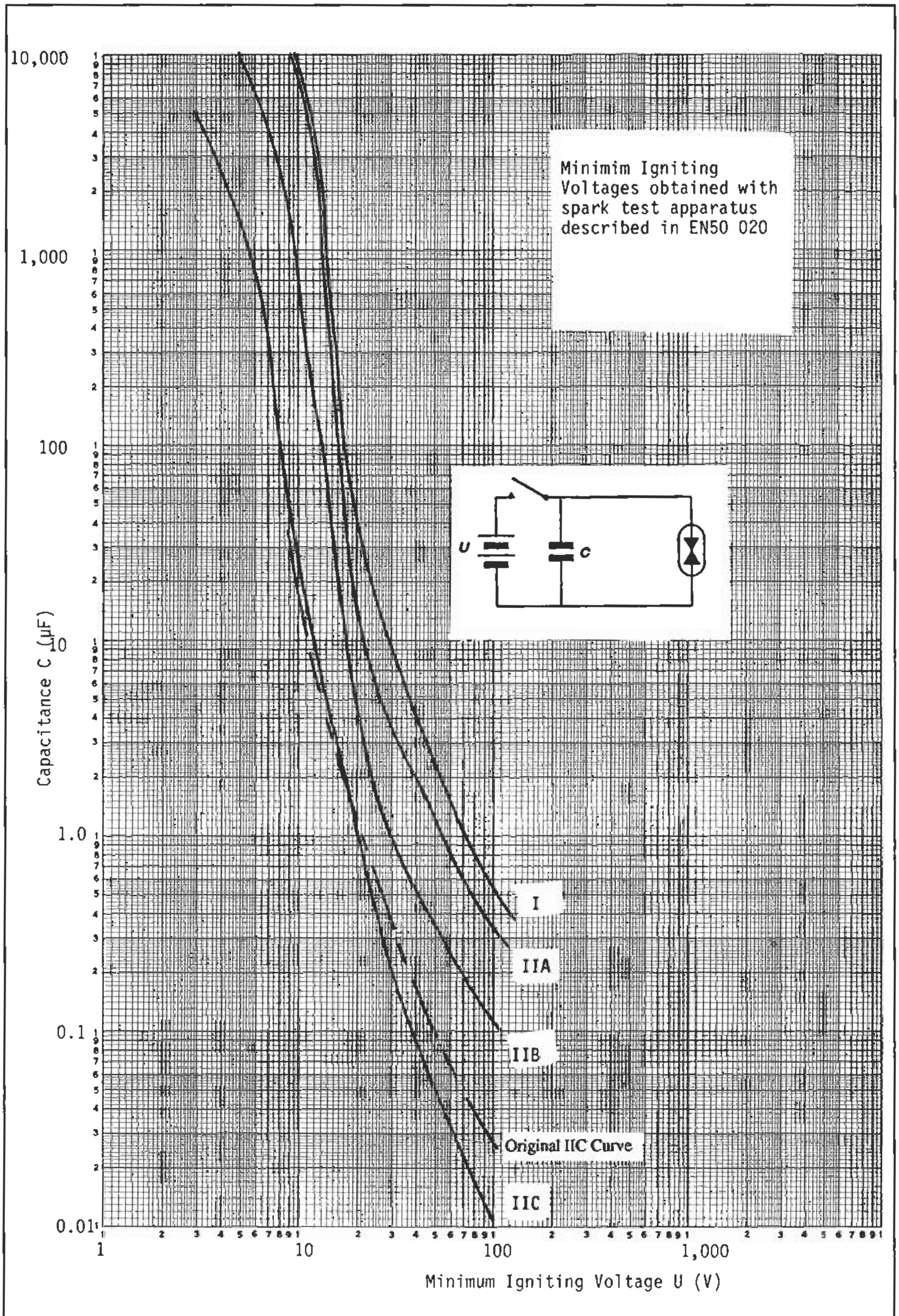


Fig 3. Capacitive circuits

instrumentation, causes more argument than any other. The fundamental requirement of the bonding system is that it should provide a return path for fault and parasitically induced currents and that potential differences between "earths" within a circuit should not cause unacceptable circulating currents. For a European code of practice to emerge then the differences of approach need to be examined and some effective compromise reached.

The primary source of disagreement has been the need for galvanic isolation in Zone 0. Galvanic isolation is difficult to define but fortunately not too difficult to recognise. It is the type of isolation provided by a transformer, hence it prevents the passage of appreciable direct current, rejects common mode alternating signals but permits a prescribed transfer of series energy.

The major difference between the United Kingdom and Germany is the level of concern over transient differences in potential which can occur across a well bonded plant. In the United Kingdom, a well bonded plant is achieved by deliberate cross bonding of metalwork where appropriate and the provision of fault return earth paths. The German technique of equipotential bonding achieves the same purpose in a more systematic manner. In both cases the desired result of an equipotential bond capable of carrying significant fault currents is achieved. A reference potential for the plant to which protective conductors should be connected emerges in both cases. In the United Kingdom it is usually, but not always, the neutral star point earth mat bond and in Germany the equipotential bond. Provided the code of practice is concerned with the necessity for adequate bonding and the provision of fault paths which do not generate significant voltage differences within the hazardous area, a safe and acceptable compromise will be achieved. Figures 4 and 5 show the basic bonding systems used in the United Kingdom and Germany and illustrate that they are fundamentally identical.

To consider the Zone 0 situation in detail. In the United Kingdom the situation illustrated in figure 6 is regarded as acceptable, since the fault current within the combined protective conductor and structural bond is not capable of generating a significant voltage and with close circuit protection of the power circuit this should only exist for a short length of time. In a well maintained installation, transient voltages in excess of 40 volts would not be expected and the thermocouple is isolated

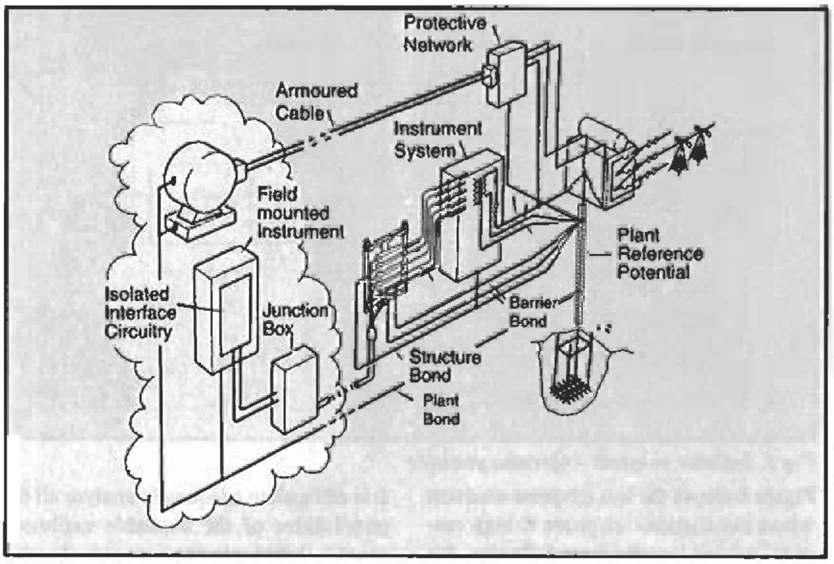


Fig 4. United Kingdom bonding practice

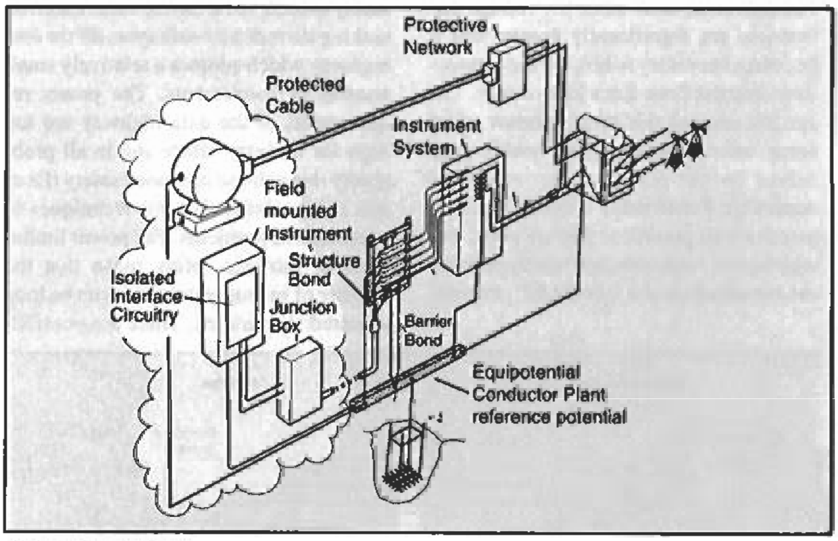


Fig 5. German bonding practice

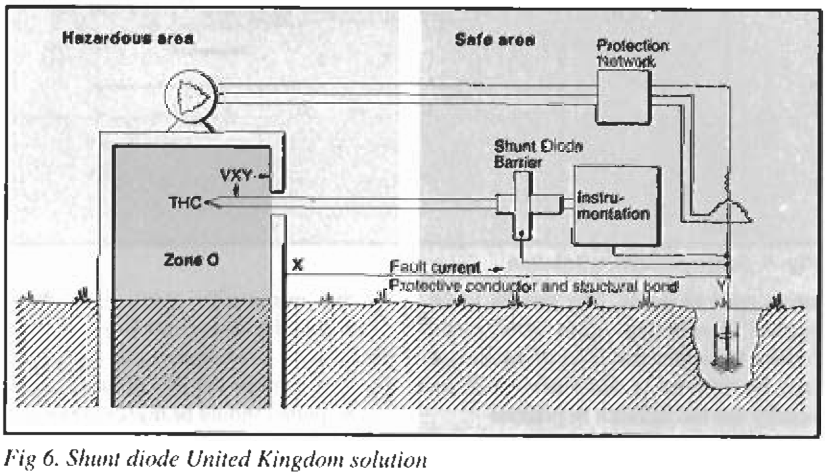


Fig 6. Shunt diode United Kingdom solution

to a 500 volt level and hence arguably no spark will occur.

Figure 7 shows a possible galvanic isolation solution normally adopted in Germany. If the circuit remains fully floating then the distribution of voltages is determined by stray capacitance and inductance. If a bond is imposed as shown then the voltage difference occurs across the isolator and the wiring within the less hazardous area. The isolator technique is undoubtedly safer and since the economics and accuracy of isolation has improved recently [reduced by a factor of 60 since 1960] it seems desirable that the change should be made to prevent the code of practice becoming too complex. Unfortunately the United Kingdom is likely to oppose the change.

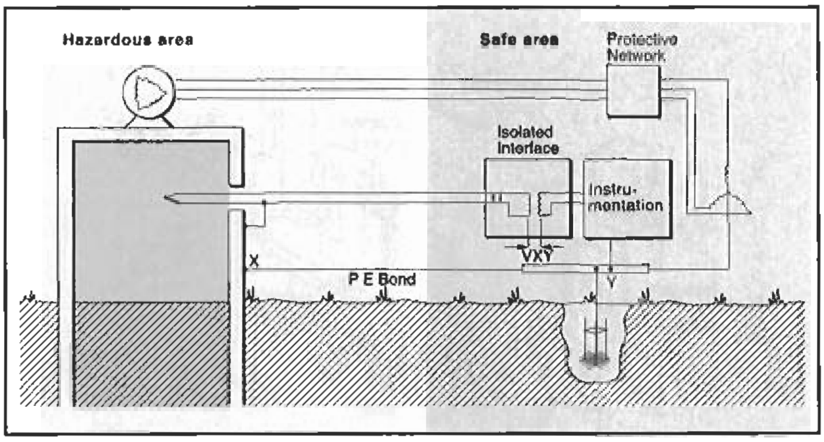


Fig 7. Isolator solution – German practice

Figure 8 shows the less frequent situation where installations are prone to high currents, arising usually from lightning, but occasionally from high voltage electrical equipment. In these cases the voltage differences are significantly greater and it becomes necessary to hold all the connections into the Zone 0 at a low voltage. The specification of this surge arrestor raises some interesting questions which may reflect on the design of the connected apparatus. Presumably existing German practice will provide a starting point, but whether this will withstand the hypercritical examination of a CENELEC committee is open to doubt. The criteria to be applied in selecting which installations require the additional level of protection may be difficult to write down but are usually not too difficult in practice

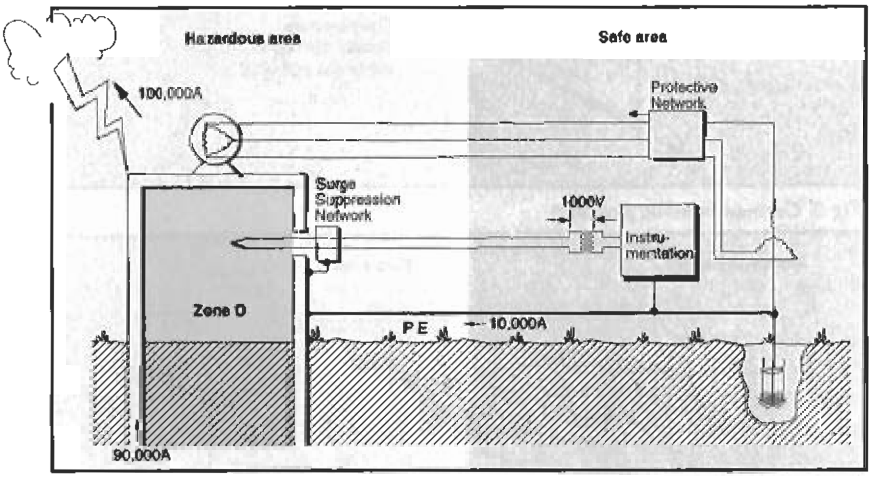


Fig 8. Surge protection solution

International Fieldbus

There is an international committee attempting to specify a system for digital communication with process control measurement and control instrumentation. The provisional IEC standard will shortly emerge but the final acceptance may be delayed by the usual repetitive quibbles about detail and the 100% perfection syndrome.

It is difficult to adequately analyse all the possibilities of the available explosion proof techniques in a review paper but this summary may be helpful. The intrinsic safety aspects so far have concentrated on making intrinsically-safe spurs off the data highway which address a relatively small number of instruments. The power requirements of the data highway are too high for intrinsic safety and in all probability this will use increased safety (Ex e) and encapsulation (Ex m) techniques to overcome its problems. The power limitations of intrinsic safety mean that the number of instruments which can be loop powered is restricted. There is a possibility that instruments, particularly those which require considerable amounts of power such as analysers, will be locally powered and the number of these which can be polled should be higher. There are some interesting operational problems which require that the interfaces present matching impedances, but must also meet the current limiting resistance requirements associated with the circuit voltages.

There are three parallel experiments being carried out which are known to the author. There is a Norwegian venture sponsored by BP called ISI bus which uses a form of transformer coupling from a constant current 14kHz bus. This has the advantage of providing galvanic isolation to the spur and uses separate power and signal isolation. The available information on the intrinsic safety aspects does not clearly define entity parameter aspects of the coupler and hence it is difficult to see how separately certified transmitters can be designed to be compatible with the system. The available information appears confusing but the system has been evaluated by NEMKO and hence it should comply with CENELEC requirements.

There is another German consortium which is using PTB as its source of intrinsic safety expertise. Again the author's access to information is restricted to published documents but the key to this solution seems to rely on a form of constant current limitation to achieve higher levels of hazardous area power thus permitting a larger number of instruments on each spur. There is no internationally accepted set of design curves for the particular form of voltage and current limitation used but the figures derived appear to conflict with figures used within the United Kingdom for similar devices. Where the 1.3 watt matched power limit is exceeded the temperature classification of certified apparatus becomes more difficult and the use of the simple apparatus clause almost impossible.

The other difficulty with constant current sources is that the entity concept rules are not readily applicable and hence a special set of system rules has to be generated. Theoretically these problems can be resolved but the timescale involved for the resolution of international problems is very long and it is yet another problem among all the problems of creating a fieldbus standard.

A more conservative approach based on existing technology is the zener barrier approach under field trials in the United Kingdom and the USA in which MTL Instruments is participating. The techniques used are known to be acceptable internationally but do result in a lower number of transmitters which can be line powered on each spur. (In most cases three or four as opposed to seven or eight). The use of conventional current limiting will permit clear specification of output parameters and conventional entity concept rules to apply. This route may be criticised as being too restrictive but many years of bitter international experience suggests that the fieldbus will have enough difficulty in becoming accepted internationally without adding another layer of controversy about intrinsically-safe aspects.

Conclusion

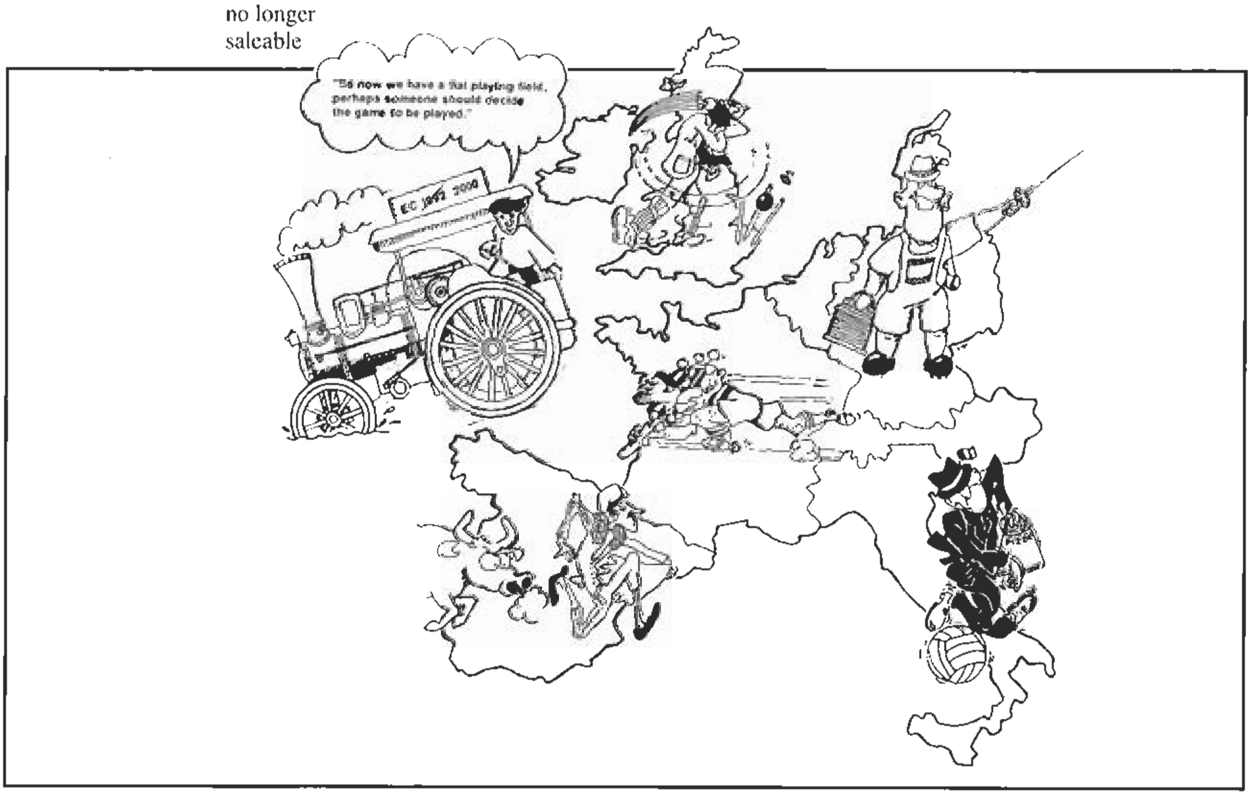
The European standards situation is proceeding slowly in the right direction and when the European code of practice emerges the key elements on which to build will be in place. The Directive may or may not prove a disaster depending on whether it improves in the final format and how it is enforced. Predicting the timescales is difficult; the draft EC directive proposes the following timescale.

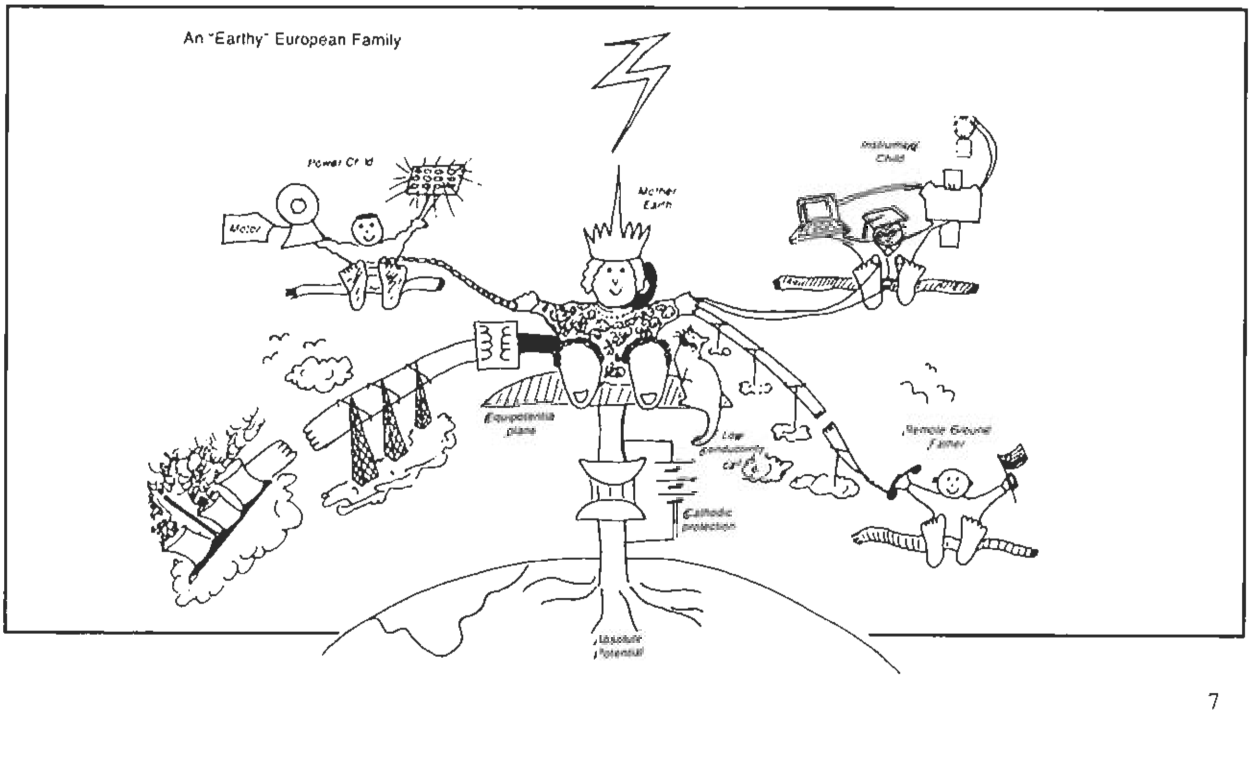
31st December 1992	New Directive adopted
1st July 1996	Existing Directive repealed
31st December 2002	Equipment to old Directive no longer saleable

The impact of this timetable is significant both for the standards writing timetable and the need for re-certification. It means that equipment being certified at the present time has a predicted usable life of ten years without re-certification. This is dramatically less than some existing designs have enjoyed.

Internationally there appears to be a growing realisation of how international the oil and petrochemical business is. Even within the United States there have been noticeable movements in attitudes towards area classification and eventually they may move toward the IEC standards particularly in the area of intrinsic safety. Certainly Japan, Australia and the Singapore area of activity would welcome the abandoning of different parochial requirements by different organisations.

It is in the author's opinion a good time for Europe to get its act together and then expand those views internationally. Competition can then be based on normal commercial criteria of quality, price and service and not on who holds the correct piece of dubious certification.





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