2 An Introduction to Intrinsic Safety

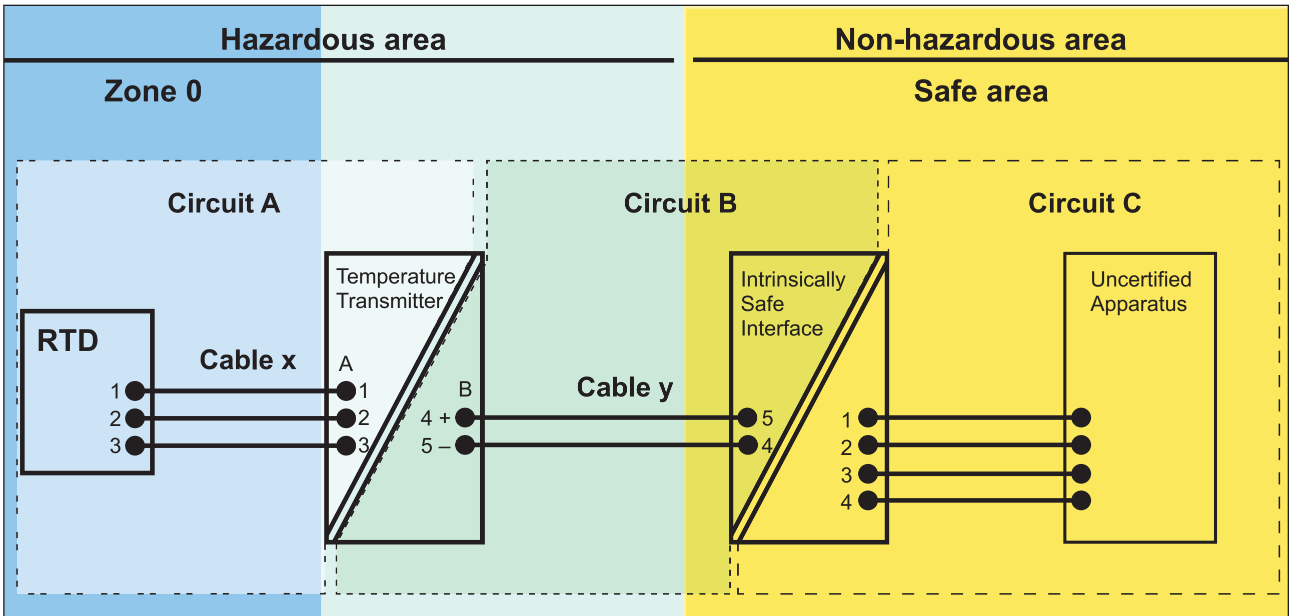

Figure 2.1 - Typical IS system

2.1 Definition of Intrinsic Safety

The definition of intrinsic safety used in the relevant IEC apparatus standard IEC 60079-11 is a 'type of protection based on the restriction of electrical energy within apparatus and of interconnecting wiring exposed to the potentially explosive atmosphere to a level below that which can cause ignition by either sparking or heating effects'. This is a concise statement of intent to introduce a multi-faceted subject.

2.2 Typical intrinsically safe system

Figure 2.1 illustrates a typical intrinsically safe (IS) system where the safe performance of each piece of apparatus is dependent on the integrity of all the equipment in the system. For example, the safety of the Temperature Transmitter (Tx) depends upon the amount of energy supplied by the IS Interface.

In most process control applications, each piece of apparatus in a system is individually certified. A document that confirms the safety of the whole system is then produced using the information from the individual apparatus certificates, in accordance with the system standard IEC 60079-25. This system document also includes details of cable types and simple apparatus used in the system.

It is important to recognise that where pieces of intrinsically safe apparatus are interconnected, it is the safety of the system that must be established. There are however some examples of apparatus which stand alone, such as mobile radios and portable gas detectors, where the system approach is not relevant.

2.3 Levels of protection

Intrinsic safety utilises three levels of protection, 'ia', 'ib' and 'ic' which attempt to balance the probability of an explosive atmosphere being present against the probability of an ignition capable situation occurring.

'ia'

This offers the highest level of protection and is generally considered as being adequately safe for use in the most hazardous locations (Zone 0) because the possibility of two 'faults' (see below) and a factor of safety of 1.5 is considered in the assessment of safety.

'ib'

'ib' apparatus, which is adequately safe with one fault and a factor of safety of 1.5 is considered safe for use in less frequently hazardous areas (Zone 1).

'ic'

'ic' apparatus which is assessed in 'normal operation' with a unity factor of safety is generally acceptable in infrequently hazardous areas (Zone 2). The 'ic' concept is relatively new (2005) and will replace the 'energy-limited' (nL) of the type 'n' standard IEC 60079-15 and possibly the 'non-incendive' concept of North American standards.

It is usual for a system to be allocated a level of protection as a whole, depending on the level of protection of the apparatus in the system. However it is possible for different parts of a system to have different levels of protection where suitable segregation exists. This must be made clear in the system documentation.

2.4 Faults

If a fault can adversely affect the safety of the equipment it is called a 'countable' fault.

The situation is further complicated because the apparatus standard permits some specially designed components to be regarded as infallible and some inadequately designed features to be failed in normal operation. Consequently there are faults that are not considered to happen, faults, which are counted, and faults, which are imposed but not counted.

One of the major advantages of intrinsic safety is that 'live maintenance' on equipment is permitted without the necessity of obtaining 'gas clearance' certificates. A consequence of this is that during the safety analysis the possibility of open circuiting and short-circuiting any field wiring is regarded as normal operation.

Fortunately understanding the apparatus standard and faults is only necessary for apparatus designers and certifying authorities. The apparatus certificates remove the necessity to consider faults, except for field wiring faults, in system design.

2.5 Simple apparatus

In general, intrinsically safe apparatus is certified; usually by an independent body such as an Accredited Certification Body (ACB) under the IEC Ex scheme. Self-certification by the manufacturer of 'ic' equipment is also quite commonly accepted.

The exception to the rule is 'simple apparatus', which is considered not to appreciably affect the intrinsic safety of the system. This apparatus is exempted from the requirement for certification. The simple requirements are clearly specified in the apparatus standard.

'Simple apparatus' should always be readily demonstrable to be adequately safe. The usual examples are switches, thermocouples, RTDs and junction boxes.

2.6 Cables

Because cables have inductance and capacitance, and hence energy storage capabilities, they can affect system safety. Consequently the system design imposes restrictions on the amount of each of these parameters. A great deal has been written on this subject but only rarely is there a serious limitation placed on the available cable.

As cable faults are taken into account during the system analysis, the type of cable in individual installations is not closely specified in the system standard. The choice is therefore determined by the need for reliable system operation.

Where intrinsically safe systems are combined in a multi-core, then there are special requirements. These determine which additional faults have to be considered.

2.7 Gas classification

The amount of energy required to ignite a particular gas/air mixture varies for each gas.

Industrial gases capable of being ignited are divided, in the UK, into three classes, IIA, IIB and IIC.

Typical Gas	Gas Group	Ignition energy
Methane	IIA	160μJ
Ethylene	IIB	80μJ
Hydrogen	IIC	20μJ

Table 2.1: Typical gases, their classification & ignition energies

The table above shows a representative gas for each group and the minimum energy required to ignite it. IIC is clearly the most sensitive.

Apparatus can be designed to be acceptably safe in any of these groups. Usually apparatus is designed to be safe in IIC, because it can then be used in any gas atmosphere. Sometimes a IIB classification is used as this permits slightly higher powers to be available. Only very rarely however is apparatus designed for the IIA classification because this restricts its use to this group alone.

Apparatus is usually assessed using the curves and tables included in the apparatus standard which lists acceptable levels of current and voltage. More complex circuits are checked with 'spark test' apparatus; normally the preserve of certifying authorities.

2.8 Temperature classification

The second method of causing an explosion is normally considered to be ignition by a hot surface. When a gas is heated above its ignition temperature it may spontaneously ignite. The ignition temperature varies with the gas and is not correlated to ignition energy. Consequently, when selecting apparatus, both properties of the explosive gas have to be considered.

Apparatus is classified into temperature ('T') classes depending on its maximum permitted surface temperature.

T1	T2	T3	T4	T5	T6
450°C	300°C	200°C	135°C	100°C	80°C

Table 2.2 The 'T' classes

The standard enables almost all apparatus, dissipating not more than 1.3W, to be allocated a temperature classification of T4 (135°C). Almost all intrinsically safe field mounted apparatus meets the requirements of T4 temperature classification, which permits its use in all industrial gas atmospheres except in those comprising carbon disulfide (CS_2) and air. These require a T6 classification, which is difficult to achieve at high ambient temperatures. There are also toxicity problems associated with carbon disulfide.

The other temperature that needs to be considered for each piece of apparatus is its ambient temperature rating, which does directly affect the safety of the apparatus in several ways.

Apparatus normally mounted in the safe area but which affects the safety of the intrinsically safe system (such as the intrinsically safe interface in Figure 2.1) is called 'associated apparatus'. Such apparatus does not need to be temperature classified but must be used within its specified ambient temperature range.

2.9 Categories and equipment safety levels

When the European Directive (ATEX) for apparatus for use in hazardous areas (94/9/EC) was created, it introduced the concept of categories, which was intended to clarify the Zone(s) in which apparatus could safely be used. Unfortunately, and for nothing more than pedantic reasons, it was decided that a category 0 would not be used and the result was the confusing situation illustrated in Table 2.1, where the category and Zone numbers differ.

More recently (2004) the IEC took up the concept of identifying the level of protection offered by a piece of apparatus and also paid a little more attention to risk analysis as a method of determining the acceptable use of equipment. The result was the creation of equipment protection levels (EPLs), which are similar to ATEX categories but have numbers that align with their normal Zones of use.

In practice both categories and EPLs align with the levels of protection 'ia', 'ib' and 'ic' as indicated in Table 2.1 and, as far as intrinsic safety is concerned, they can largely be ignored, as the level of protection is already defined as 'ia', 'ib' or 'ic'. They do however appear on apparatus marking and certificates and consequently need to be explained.

2.10 Summary

Intrinsic safety offers an acceptable level of safety in all hazardous locations. Arguably it is safer and less prone to accidental errors than other methods of protection. This combined with its flexible use of available apparatus and the ability to do 'live working' means that it is the natural choice for instrumentation systems in hazardous areas. For example it is the only technique which is readily applicable to Zone 0 locations. The introduction of the 'ic' concept completes the picture.

The essential requirements of an intrinsically safe system are:

- ✦ The system must work.
- ✦ The apparatus in the system must be 'certified' or 'simple'.
- ✦ The compatibility of the apparatus must be established.
- ✦ The level of protection of the system established.
- ✦ The temperature classification and ambient temperature rating of each piece of apparatus established.
- ✦ The requirements of the cable established.

This extract is part of MTL Application Note AN9003 as published on the MTL web site.

http://www.mtl-inst.com/appnotes/an9003/

Level of Protection	Countable Faults	ATEX Category	IEC EPL	Normal Zone of Use
ia	2	1	0	0
ib	1	2	1	1
ic	0	3	2	2

Table 2.3 Relationships between different methods of assessing safety levels