Automation & Safety Solutions

Know Safety – No Pain

Intrinsic Safety (IS)

www.adico.co
info@adico.co

Table Of Contents

1. Introduction

The concept of Intrinsic Safety (IS) is completely different from any of the other recognized methods of protection, and, as a starting point, it is worth considering why it has its name. If something is intrinsically safe, this means that is safe by its own nature, without any help from outside. So to make use of this valuable quality we have to be sure to use it properly, and not to do anything which will interfere with its inherent safety. So the protection technique is not a matter of creating intrinsic safety, but instead it is a matter of preserving the intrinsic safety which the device or apparatus already possesses.

2. The Basics of Intrinsic Safety

The term Intrinsically Safe is frequently used to describe any product destined for an explosive area. In reality, IS is a protection concept based around limiting the available electrical energy to nonincendive levels so that sparks cannot occur from short circuit or failures which could cause an explosive atmosphere to ignite. A typical fixed IS circuit would comprise a device such as a temperature sensor permanently located within the explosive area, which is in turn protected by a safety barrier located in the safe area. These barriers usually incorporate a series of diodes, resistors and fuses arranged and sized in such a manner that they limit the energy provided to the device in the field. Interestingly, the inclusion of a barrier in the control loop does not allow any device to be connected downstream. Even though the power may be limited, the device located within the explosive area itself must also be designed to comply with the requirements of various regulatory standards depending upon the geographical locale of the plant.

2.1 Definition

The following abbreviated definitions are typical:

Intrinsic Safety: A protection technique based upon the restriction of electrical energy to a level below that which can cause ignition by either sparking or heating effects.

Intrinsically Safe Circuit: A circuit in which any spark or thermal effect produced in normal operation and specified fault conditions is not capable of causing ignition.

2.2 Illustrations

To help the reader to understand the basic underlying principle, we will quote some examples.
A switch on its own is intrinsically safe. You can carry one in your pocket into the hazardous area and, providing it is not connected to anything else, you may operate its contacts as many times as you like without causing an explosion. However, if you connect it into a circuit in which 40 amps are flowing at 200 volts dc, you will ruin its intrinsic safety, and when you operate the big spark would most probably ignite any hazardous mixture.
Again, a resistance thermometer element (e.g. Pt100) on its own is intrinsically safe because it is not capable of self-heating nor is it able to create any sparks. However, if you were to connect the 100ohm element directly across a 24-volt supply you would destroy its intrinsic safety because it would now get dangerously hot and might ignite a hazardous gas or vapor.

2.3 Preserving intrinsic safety

So the preservation of intrinsic safety depends entirely on the strict control of energy in a circuit so that incendive sparks or hot surfaces cannot possibly arise. This includes restricting voltage and current to low values, and ensuring that no parts of the circuit can store or generate excessive levels of energy.
So we have to consider the whole circuit, not just the field apparatus in isolation.

3. Certification standards

Across the world, there are differing regulations and requirements which dictate how products are designed, developed, certified and manufactured in order to be sold to a customer as IS certified.
Some examples of IS standards are:

- Europe:- EN60079-1:2007
- United States:- Factory Mutual - FM3610
- Canada:- CSA C22.2 NO 157.92-CAN/CSA

Although each of these standards defines the requirements for a device to be certified as IS, the requirements of each are different.
These differences range from the effects of static build-up on non-metallic casings to the assessment of cells, even the test parameters themselves may be different.
The bottom line is that it is not possible to claim a product certified as intrinsically safe in Europe to EN60079-XX (ATEX) can be deemed as intrinsically safe certified in the United States or Canada and vice versa. For each country, the device should be tested in accordance with the local requirements. Once tested and certified, products are marked as part of their manufacture.

3.1 U.S. and Canadian Standards

CSA C & US Mark: United States and Canada Safety Standards

An electrical, mechanical or electro-mechanical product bearing the North American CSA Listing mark signified that it was tested and meets the minimum requirements of prescribed safety standards. Moreover, the mark indicates that the manufacturer's production site conforms to a range of compliance measures and is subject to periodic follow-up inspections to verify continued compliance. A CSA Listed device with both "US" and "C" labels at the lower left and lower right of the CSA mark respectively, signifies that the product bearing the mark complies with both U.S. and Canadian product safety standards.

3.2 United Kingdom and Europe

The "Ex Hexagon" mark: United Kingdom and Europe Safety Standards

Similar to the CSA mark described above, a product bearing the Ex Hexagon has not only been designed and tested to meet the minimum requirements of the relevant ATEX safety standard but also the production facility has sufficient controls to ensure safe manufacture of the device itself. Annual audits are carried out by safety bodies to ensure that these standards are being adhered to and products designed are safe.

4. The Classification of Hazardous Location for Divisions

In the United States, the classification of hazardous locations is based on the National Electrical Code, NFPA 70, articles 500 through 504. Article 505 includes the Zone Method and is discussed later.

In Canada, C22.1, Part I of the Canadian Electrical Code applies. Similar to the United States, Canada has adopted the zone method for identifying hazardous locations; however, Canada has been much more aggressive in its pursuit to harmonize to international requirement.

In both countries, hazardous locations are categorized into the following three classes, depending on the type of flammable substances present:

Class I	Hazardous due to the presence of flammable substances such as gases or vapors.
Class II	Hazardous due to the presence of flammable substances such as dusts or powders.
Class III	Hazardous due to the presence of flammable substances in a fiber or flying state.

Each classification is further divided according to the level of risk present. In general, the divisions are as follows:

Division 1	Danger can be present during normal functioning, during repair or maintenance, or where a fault may cause the simultaneous failure of electrical equipment.
Division 2	Combustible material is present but confined to a closed container or system, is normally vented or is in an area adjacent to a Division 1 location.

4.1 Class I (Gases or Vapors)

Class I hazardous locations are subdivided into the following four groups, depending on the type of flammable gases or vapors present:

Group A	Atmospheres containing acetylene
Group B	Atmospheres containing hydrogen, fuel and combustible process gases containing more than 30 percent hydrogen by volume, or gases or vapors of equivalent hazard such as butadiene, ethylene oxide, propelling oxide and, acrolein
Group C	Atmospheres such as, ethyl ether, ethylene, or gases or vapors equivalent in hazard
Group D	Atmospheres such as acetone, ethanol, ammonia, benzene, butane, cyclopropane, gasoline, hexane, methanol, methane, naphtha, natural Gas, propane, or gases or vapors equivalent in hazard

4.2 Class II (Combustible Dusts or Powders)

Class II hazardous locations are subdivided into the following three groups, depending on the type of combustible dusts or powders present:

Group E	Atmospheres containing combustible metal dusts, including aluminum, magnesium and their commercial alloys, or other combustible dusts whose particle size, abrasiveness and conductivity present similar hazards in the use of electrical equipment
Group F	Atmospheres containing combustible carbonaceous dusts, including carbon black, charcoal, coal, or coke dusts that have more than 8 percent total entrapped volatiles, or dusts that have been sensitized by other materials so that they present an explosion hazards
Group G	Atmospheres containing combustible dusts not included in Group E or Group F, including flour, grain, wood, plastic, and chemicals

4.3 Class III (Easily Ignitable Fibers or Flyings)

Class III hazardous locations are those that are hazardous because of the presence of easily ignitable fibers or flyings, but in which such fibers or flyings are not likely to be in suspension in the air in quantities sufficient to produce ignitable mixtures.

Class III, Division 1 locations are those in which easily ignitable fibers or materials producing combustible flyings are handled, manufactured, or used.

Class III, Division 2 locations are those in which easily ignitable fibers are stored or handled.

Locations belonging in this class usually include parts of textile mills, cotton gins, flax-processing plants, clothing manufacturing plants, woodworking plants, etc.

Easily ignitable fibers and flyings include rayon, cotton, sisal, hemp, cocoa fiber, kapok, Spanish moss, excelsior, etc.

Class III locations are not further subdivided.

5. The Classification of Apparatus for Divisions

Intrinsically Safe Apparatus

According to Article 504 of United States, National Electrical Code, apparatus can be classified as intrinsically safe; i.e., containing circuits in which any spark or thermal effect is incapable of causing ignition of mixture of flammable or combustible material in air under prescribed test conditions.

Pressure, temperature and flow transmitters, solenoid valves, I/P converters, and other instrumentation are typical of intrinsically safe apparatus.

Associated Apparatus

Associated apparatus can be defined as apparatus in which the "circuits are not necessarily intrinsically safe themselves, but that affect the energy in the intrinsically safe circuits and are relied on to maintain intrinsic safety." Associated apparatus is classified as either:

1. Electrical apparatus having an alternative type protection for use in the appropriate hazardous location; or
2. Electrical apparatus not protected and therefore must not be used within a hazardous location.

Intrinsic safety barriers are typical of associated apparatus. These barriers must be placed in nonhazardous locations (unless protected by other suitable methods, i.e., nonincendive techniques for Div. 2) and must be certified as intrinsically safe.

Simple Apparatus

Simple apparatus is defined as " a device that will neither generate nor store more than 1.5 V, 0.1 A or 25 mW."

Examples include switches, thermocouples, LEDs, connectors, and RTDs. Simple apparatus themselves do not have to be approved, but must be used with an approved barrier and installed in accordance with the control drawing.

Installation Requirements for Intrinsically Safe and Associated Apparatus

Intrinsically safe and associated electrical equipment or apparatus must be installed subject to the following two conditions:

Control Drawing: The manufacturer must provide a control drawing of the intrinsically safe associated apparatus that details the allowed interconnections between the intrinsically safe and associated apparatus. The control drawing identification must be marked on the apparatus.

Location: Intrinsically safe and associated apparatus can be installed in any hazardous location for which it has been approved. Equipment rated for use in Division 1 may also be used in Division 2 for the same gas group and temperature class.

Intrinsically Safe System

An intrinsically safe system is defined as "an assembly of interconnected intrinsically safe apparatus, associated apparatus and interconnecting cables in that those parts of the system that may be used in hazardous (classified) locations are intrinsically safe circuits."

6. Surface Temperature Classification for Divisions

An apparatus directly located in a hazardous location must also be classified for the maximum surface temperature that can be generated by the instrument, either during normal functioning or under a fault condition.

The maximum surface temperature must be lower than the minimum ignition temperature of the gas present.

In the United States and Canada, temperature classifications are divided into six classes- T1 through T6. Classes T2, T3 and T4 are further subdivided, as shown in the following table.

Maximum Temperature		**North American Temperature Classification**
Degrees C	Degrees F	
450	842	T1
300	572	T2
280	536	T2 A
260	500	T2 B
230	446	T2 C
215	419	T2 D
200	392	T3
180	356	T3 A
165	329	T3 B
160	320	T3 C
135	275	T4
120	248	T4 A
100	212	T5
85	185	T6

Each gas is associated with a temperature class based on its ignition temperature. It is important to note that there is no correlation, for any specific mixture, between ignition energy and ignition temperature.

For example, hydrogen has a minimum ignition energy of 20 µJ and an ignition temperature of 1040 °F (560 °C), while acetaldehyde has an ignition energy greater than 180 µJ and an ignition temperature of 284 °F (140 °C).

Maximum surface temperature, calculated or measured under the worst conditions, is not to be confused with the maximum working temperature of the apparatus. For example, an electrical apparatus designed to work with a maximum ambient temperature of 158 °F (70 °C), even under the worst conditions of the expected temperature range, must not have a temperature rise greater than the safety margin specified by the applicable standards.

An apparatus classified for a specific temperature class can be used in the presence of all the gases with an ignition temperature higher than the temperature class of the specific instrument. For example, an apparatus classified as T5 can be used with all gases having an ignition temperature greater than 212 °F (100 °C).

7. The Classification of Hazardous Location for Zones

In the United States and Canada, the zone classification method is recognized and applied; however, it is generally considered the secondary method used versus the division method. For simplification, we will identify the division method for North America and the zone method for Europe.

In Europe, the tendency is to follow the recommendations of IEC 60079-10, based on which any place where the probability of the presence of a flammable gas exists must be classified according to the subdivision in one of the following zones:

Zone 0	An area in which an explosive air/gas mixture is continuously present or present for long periods
Zone 1	An area in which an explosive air/gas mixture is likely to occur in normal operation
Zone 2	An area in which an explosive air/gas mixture is unlikely to occur; but, if it does, only for short periods of time
Zone 20	An area in which a combustible dust cloud is part of the air permanently, over long periods of time or frequently
Zone 21	An area in which a combustible dust cloud in air is likely to occur in normal operation
Zone 22	An area in which a combustible dust cloud in air may occur briefly or during abnormal operation

Any other plant location that is not classified as a hazardous location is to be considered a nonhazardous locations.

8. The Classification of Apparatus for Zones

European standard EN60079-0:2006 requires that apparatus be subdivided into two groups:

Group I	Apparatus to be used in mines where the danger is represented by methane gas and coal dust
Group II	Apparatus to be used in surface industries where the danger is represented by gas and vapor that has been subdivided into three groups: A, B and C. These subdivisions are based on the maximum experimental safe gap (MESG) for an explosion-proof enclosure or the minimum ignition current (MIC) for intrinsically safe electrical apparatus.

The groups indicate the types of danger for which the apparatus has been designed. Since Group I is intended foe mines, this subject will not be addressed in this paper.
The apparatus in Group II can be used in an area where gases or vapors are present (Class I hazardous location).

9. Surface Temperature Classification for Zones

European standard EN60079-0:2006 requires that the maximum surface temperature be subdivided into six classes from T1 to T6, assuming a reference ambient temperature of 40 °C. Should the reference temperature be different, this temperature must be specified on the respective instrument.

<table>
<tr><th>Maximum Surface Temperature (°C)</th><th>European Temperature Classification</th></tr>
<tr><td>450</td><td>T1</td></tr>
<tr><td>300</td><td rowspan="5">T2</td></tr>
<tr><td>280</td></tr>
<tr><td>260</td></tr>
<tr><td>230</td></tr>
<tr><td>215</td></tr>
<tr><td>200</td><td rowspan="4">T3</td></tr>
<tr><td>180</td></tr>
<tr><td>165</td></tr>
<tr><td>160</td></tr>
<tr><td>135</td><td rowspan="2">T4</td></tr>
<tr><td>120</td></tr>
<tr><td>100</td><td>T5</td></tr>
<tr><td>85</td><td>T6</td></tr>
</table>

10. ATEX Summary

For hazardous area products, the following chart applies:

Device Group	Device Category	Type of Atmosphere	Protection to Be Ensured	Hazardous Area Characteristics	Zone Comparison
I (mining)	M1	-	Very High	Present continuously-equipment cannot be de-energized	-
	M2		High	Present continuously-equipment can be de-energized	-
II (all areas expect mining)	1	G (Gas, Vapor, mist) D (dust)	Very High	Present continuously, for long periods or frequently	Zone 0 Zone 20
	2		High	Likely to occur in normal operation and for short periods of time	Zone 1 Zone 21
	3		Normal	Not likely to occur in normal operation or infrequently	Zone 2 Zone 22

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 opposite) 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.

The following example identifies the key elements of the equipment marking:

II (1) G D [Ex ia] IIC PTB 00 ATEX 2080

		Symbol identifies the product for hazardous locations
ATEX Portion	II	Device Group – Non-mining application
	1	Device Category –Can be used in Zone 0 and/or 20
	G	Atmosphere type – Can be used in/for areas with flammable gas
	D	Atmosphere type – Can be used in/for areas with flammable dust
CENELEC/IEC Portion	[…]	Associated apparatus that supplies safety into the hazardous area
	Ex	Product Type – Explosion protection
	ia	Protection Type – Intrinsic safety
	IIC	Equipment Group – IIC is most hazardous area
Certificate Details	PTB	Certifying Test Agency
	00	Test Year
	ATEX	Compliance With Directive 94/9/EC
	2080	Running Number

11. Differences between Division and Zone Practices

The following table shows the difference between the North American and European practices, regarding the classification of hazardous locations.

Method	Continuous Hazards	Intermittent Hazards	Abnormal-condition Hazard
Division	Division 1		Division 2
Zone	Zone 0/20	Zone 1/21	Zone 2/22

It is evident from the above table that Zone 2/22 (IEC/Europe) and Division 2 (North America) are almost equivalent, while Division 1 includes the corresponding Zones 0/20 and 1/21. An instrument designed for Zone 1/21 cannot necessarily be directly used in Division 1. In the stated definition from the cited standard, no quantification of the expressions "long period of time" for Zone 0/20, "can be present" for Zone 1/21 and Division 1, and "not normally present" for Zone 2/22, is given.

The main difference between the North American and the European classification of hazardous locations is that there is currently no direct equivalent to the European Zone 0 in the North American system.

Zone 0 is, therefore, the most dangerous. An instrument designed for Zone 0 must be incapable of generating or accumulating sufficient energy to ignite the fuel mixture.

References

1. Process Automation, Interface technology, Engineer's Guide. Edition 2.0, Published by Pepperl+Fuchs.
2. Intrinsically Safe or Explosion-proof. Copyright, CorDEX Instruments Ltd. 2010. Document Ref: ID1002 Rev.A.
3. The Basics of Intrinsic Safety, By RTK.
4. Intrinsic Safety and Hazardous Locations. Technical Note TN-161. RAE systems by Honeywell.
5. Intrinsic Safety, By Omega.
6. AN9003- A Users Guide to Intrinsic Safety, By COOPER Crouse-Hinds.