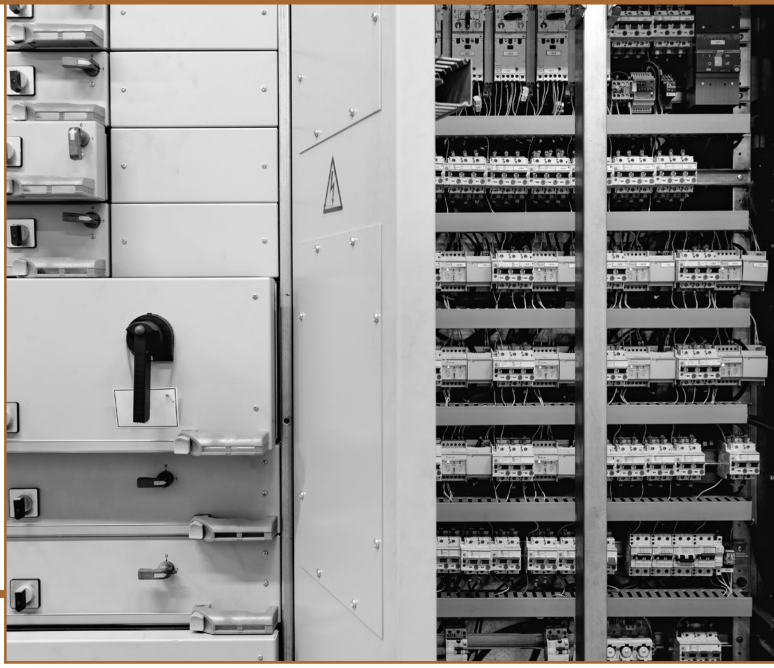
MOORE INDUSTRIES WORLDWIDE



Associated Apparatus: The Safe and Most Affordable IS Solution

Overview

Significant savings, both initial installation and ongoing maintenance costs, for your intrinsically-safe (IS) facility or project can be achieved by selecting associated apparatus as the IS barrier in your system.

Preventing explosions and fires in hazardous areas caused by process measurement and control instrumentation has historically followed either the path of containing the explosion within the device enclosure or preventing the device from having enough energy to cause a spark or thermal ignition. In North America the predominant choice has been to use explosion-proof equipment while the rest of the world typically employs energy limiting Intrinsic Safety devices.

Although there has been some resistance to change from the familiar explosion-proof approach in North America, engineers have recognized the cost savings and advantages of an IS design, leading to wider acceptance of IS. Additionally, globalization of many corporate structures often leads to standardization of plant designs that are the best economic fit on a global basis and these designs frequently require use of IS technology.

This whitepaper provides a brief introduction to intrinsic safety, the different components in an intrinsically-safe system and the two different types of barriers. Additionally this paper outlines why selecting an associated apparatus as the IS barrier provides the most economic and effective use of IS technology. The techniques outlined in this paper are most applicable to the industrial process control sector including such industries as oil and gas production, oil refining, petrochemical, chemical, pharmaceuticals, food & beverage, and pulp & paper.

The Concept of Intrinsic Safety

Instead of using explosion-proof techniques to contain a possible explosion, the IS approach limits the electrical and thermal energy that could reach any device in the hazardous area. This ensures that the energy level remains below threshold levels that would ignite an explosive atmosphere. The vast majority of field instrumentation devices, such as transmitters and solenoid valves, typically operate on 24Vdc or less with low current signal levels which are well within typical IS system limits.

There are a number of approval agencies that certify IS devices including FM, CSA International, SIRA, LCIE, Testsafe and many others who offer North American, ATEX and IECEx based certifications for gas, dust and fiber hazardous environments. These certifications are accepted by OSHA in the US and other agencies throughout the world.

An IS system includes the field devices, the barriers and/or the associated IS devices, and the interconnecting cable. *(Figure 1)*

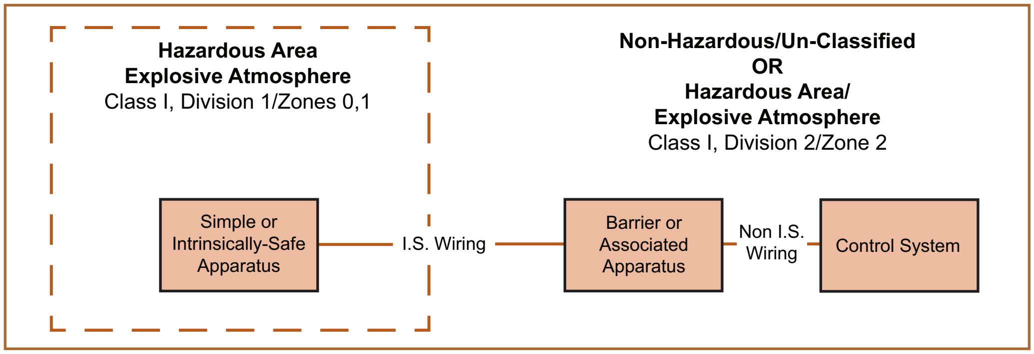


Figure 1. *Components of a typical intrinsically-safe system.*

Field Device IS Classifications

Simple Apparatus include devices such as RTDs, T/Cs, switches, LEDs, potentiometers and switches. They are electrical components which do not generate or store more than 1.5V, 100mA and 25mW or a passive component which does not dissipate more than 1.3W. Simple devices can be freely used without any agency certifications but do require an assessment for their maximum surface temperature and assigned a temperature classification (referred to as a T code).

Intrinsically-Safe Apparatus are devices that can store electrical energy such as transmitters, I/P converters and solenoid valves. They may also be connected to simple apparatus in the hazardous field location. These devices must be certified as intrinsically safe apparatus and classified based on allowable hazardous locations, gas group and T code. Entity parameters for the device must also be provided and include the maximum voltage, current and power limits as well as the internal capacitance and inductance parameters of the device. These parameters are used in conjunction with the connecting cable parameters to calculate the maximum allowable cable lengths, loop voltage and current values for the system.

Barrier or Associated Apparatus

An IS system installation requires a barrier or associated apparatus interface between the field device and the control room equipment. Its function is to limit the energy to the hazardous area such that, even under a fault condition, there cannot be enough electrical or thermal energy released by the device to ignite an explosive atmosphere. They are designed for connection to simple or IS apparatus, and must be certified. There are two types of barriers that are most commonly used and a hybrid method where the barrier is integrated into the receiving device.

Zener Diode Barriers are simple passive devices comprised of Zener diodes, resistors and fuses that serve to limit the voltage, current, and power available to the hazardous area device. The design requires the use of a dedicated IS earth ground connection maintained at less than 1Ω and allows no grounding connections at the field devices. A common downside of using this approach is that the required earth ground has low noise rejection capability. This electrical interference can introduce stray and unwanted electrical noise components into the measurement circuit creating potentially significant measurement errors.

Isolated Barriers are active devices that incorporate galvanic isolation thus eliminating the requirement for an earth ground and the restriction for grounding of field devices. They also provide a higher voltage to the field and devices. These barriers require operating power and are application specific with different models required for different applications (RTD, T/C, 4-20mA etc.)

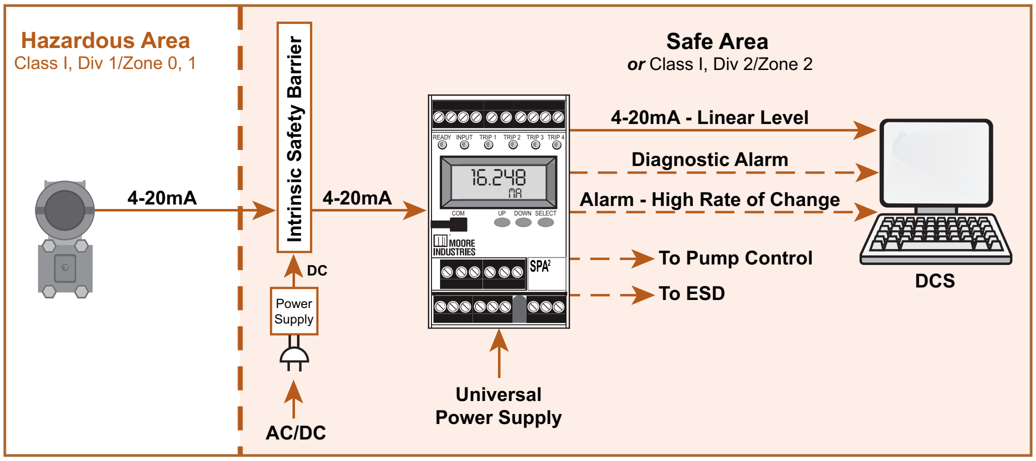


__Figure 2.__ A system using a safe area device with an external barrier and power supply.

Associated Apparatus incorporate a barrier into the safe area mounted receiving device or the control room equipment. The Moore Industries SPA²IS is an example of such a device that provides an isolating barrier within the alarm trip. This dramatically reduces the cost of purchase, installation and maintenance versus more traditional approaches that require a separate zener or isolating barrier. *(Figures 3 and 4)*

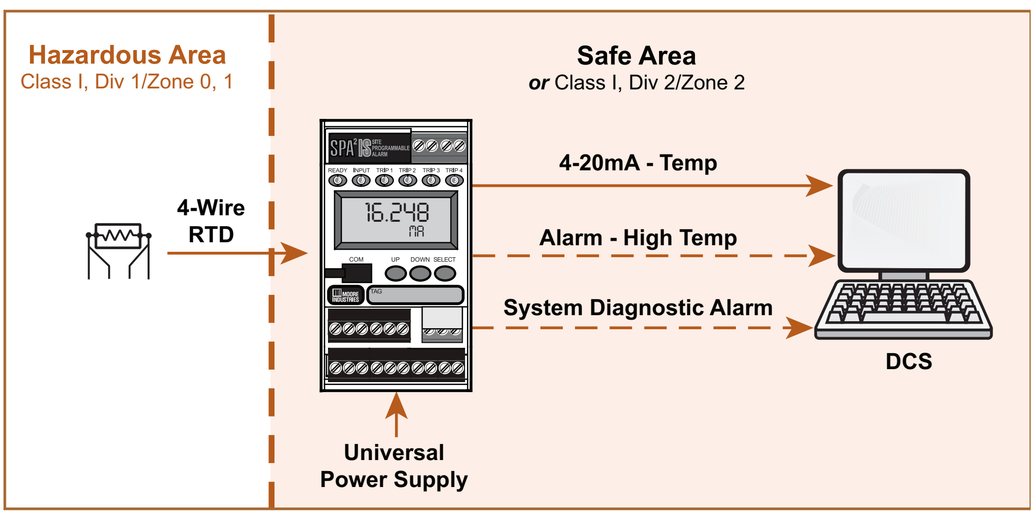


__Figure 3.__ A Moore Industries SPA²IS associated apparatus incorporating the isolating barrier, temperature transmitter, temperature alarm and diagnostic alarming functions in a single device.

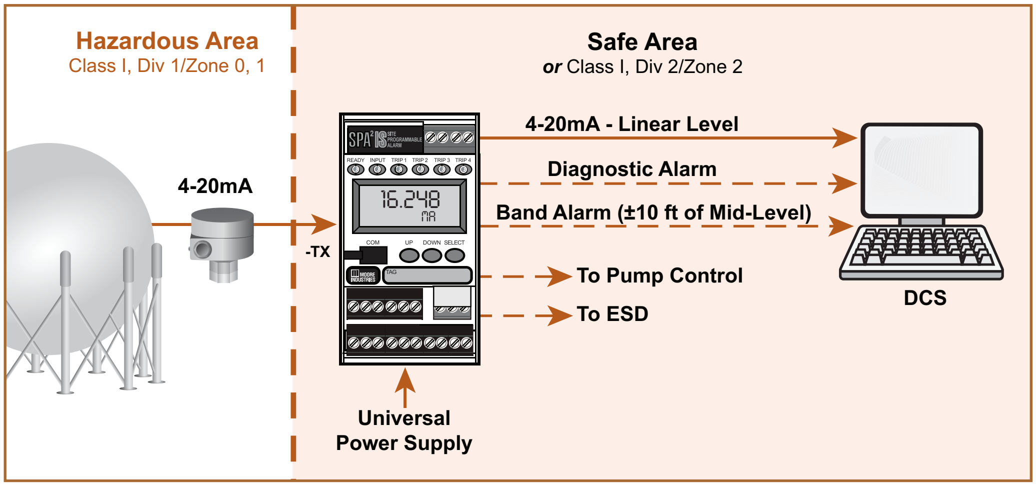


Figure 3. *A Moore Industries SPA²IS associated apparatus incorporating a spherical tank linearization measurement function, local pump control, Hi-Hi ESD, local indication, self diagnostics, and quad relay outputs for control and alarming.*

Design Considerations

As discussed, the premise of an Intrinsically-Safe system is that there is no component or combination of components that can release enough electrical or thermal energy to ignite an explosion in the hazardous area either under normal or fault conditions. In order to accomplish this goal the energy storage and release characteristics of all components must be defined and incorporated into the system design.

While this may sound like a daunting task, it is relatively simple in practice. The manufacturer of each component must provide a certification document (or data sheet) that lists the definitive voltage, current, power, inductive and capacitive values appropriate to the application. These are called ***entity parameters***. As an example, the capacitance of the field mounted transmitter and its output cable must not exceed the allowable value specified by the associated device (barrier) in the safe area. This is a simple A + B ≤ C calculation for the capacitance (C) and the inductance (L) of the transmitter and the cable. And further, the output voltage of the barrier must be less than the maximum allowed by the transmitter and similarly the output current of the barrier must be less than that allowed by the transmitter.

The combined values of capacitance and inductance for a typical transmitter and 400 meters of cable are far less than the maximum allowable by a typical barrier or associated IS device. The voltage, current and power specification of a typical associated IS device (barrier) is limited by vendor design to acceptable numbers for the intended application. For a transmitter barrier for example, the maximum voltage is typically less than 30Vdc, and the maximum current is less than 110mA.

Figure 5. *Design constraints associated with Entity Parameters.*

NOTE: A simple apparatus has no entity parameters and only the cable parameters need to be considered to determine maximum cable length for intrinsically-safe installation.

[1] Symbols shown are the IEC and ISA markings. ISA markings are shown 2nd if they differ from IEC.

Intrinsically-Safe Apparatus (maximum)	Barrier or Associated Apparatus (maximum)	Design Constraints
Input Voltage (U_i or V_{max})[1]	Output Voltage (U_o or V_{oc})	Maximum Output Voltage must be less than or equal to Maximum Input Voltage ($U_o \leq U_i$)[1]
Input Current (I_i or I_{max})	Output Current (I_o or I_{sc})	Maximum Output Current must be less than or equal to Maximum Input Current ($I_o \leq I_i$)
Input Power (P_i)	Output Power (P_o or P_t)	Maximum Output Power must be less than or equal to Maximum Input Power ($P_o \leq P_i$)
Internal Capacitance (C_i)	Allowed Capacitance (C_o or C_a)	The Total Capacitance of the connecting cable plus the device must be less than or equal to the Allowed Capacitance ($C_o \geq C_i + C_{cable}$)
Internal Inductance (L_i)	Allowed Inductance (L_o or L_a)	The Total Inductance of the connecting cable plus the device must be less than or equal to the Allowed Inductance ($L_o \geq L_i + L_{cable}$)
OR		
Internal Inductance to Resistance Ratio (L_i/R_i)	External Inductance to Resistance Ratio (L_o/R_o or L_a/R_a)	Inductance to Resistance Ratio can be used as an alternative to the Allowed Inductance ie. The cable length restrictions due to cable inductance can be ignored if the following conditions are met: $L_o/R_o \geq L_i/R_i$ AND $L_o/R_o \geq L_{cable}/R_{cable}$)

To certify the installation, a system assessment document is created based on the entity parameters of each component and a verification performed to ensure that all values of the system are within the allowable limits.

Installation and Maintenance Considerations

One advantage of IS installations is that, due to the low power, ordinary instrument cables can be used for IS circuits. Maintenance and calibration of field equipment can also be carried out while the plant is in operation and the circuit is “live” in the hazardous area.

A key design decision which can have a significant effect on the IS system installation and maintenance costs is the choice of barriers. While zener barriers are less expensive than active isolated barriers they require a separate, clean, high integrity ground which has high maintenance costs and potential for electrical noise issues. An isolated barrier is often the better choice but cost, maintenance and cabinet space of barrier power supplies needs to be included. This may also involve redundant systems, since power supplies usually have the highest failure rate and can significantly reduce system reliability. This further adds to required cabinet space and heat dissipation or cooling considerations in your barrier marshalling cabinets. Often the additional cost of the isolated barriers and power supplies are more than the field mount instruments themselves.

An often overlooked consideration is the use of associated apparatus. These offer the dual role of transmitter/isolated barrier combination in one package which can provide significant cost savings by reducing the number of components, power supply requirements, cabinet space, wiring terminations, installation labor and stocking requirements. Cost savings are ongoing with reduced spares inventory, maintenance-related downtime and consequent process restart issues.

Conclusion

Intrinsically safe systems are becoming more prevalent in the process control industry and offer some advantages over explosion proof systems when used for field instrumentation. Since the energy is limited, general purpose wiring methods can be used (no rigid conduit, pouring of seals or special housings are needed). Also equipment can be replaced and maintained without having to un-power loops or shutdown the process.

However, a disadvantage is the installation and maintenance costs of the required IS barriers. Many, but of course not all, of these costs can be drastically reduced if an associated apparatus like the SPA^{2}IS is used. Since the associated apparatus includes the barrier in the receiving device there is no need for the additional cost of the barrier, cabinet space, a high integrity clean ground connection, separate power supply or custom vendor backplane.

The associated apparatus provides an integral solution that is the most affordable and safe IS solution available.

Relevant Standards and Further Reading

- SPA^{2}IS Data Sheet
- THZ^3/TDZ^3 Data Sheet
- STZ Data Sheet
- NEC 2017 National Electrical Code ANSI/NFPA 70 Articles 500-505
- ANSI/ISA-RP12.06.01-2003 Recommended Practice for Wiring Methods for Hazardous (Classified) Locations Instrumentation Part 1: Intrinsic Safety
- ANSI/ISA 60079-11 (12.02.01)-2014 Explosive Atmospheres – Part 11: Equipment Protection by Intrinsic Safety "i"
- IEC 60079-10-1 Ed 2.0 2015 Explosive Atmospheres – Part 10-1: Classification of Areas – Explosive Gas Atmospheres
- IEC 60079-11 Ed 6.0 2011-07 Explosive Atmospheres – Part 11: Equipment Protection by Intrinsic Safety "i"
- FM 3610 2015 Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I,II and III, Division 1, Hazardous (Classified) Locations