Design Tips: Ten Recommendations to Help Design for Intrinsic Safety

Flammable gases or vapors and airborne dusts, fibers, and filings pose serious explosive hazards if sources of sparks or excess heat are present in the environment. Over the years, these hazards have led to some catastrophic losses of life and property. In response to this hazardous potential, regulatory bodies around the world have worked to establish and refine Intrinsic Safety (IS) standards that will minimize the risk of explosion in working environments. An IS certified device or product is one that’s designed so that it’s incapable of generating sufficient heat or spark energy to trigger an explosion.

The following tips may be helpful when designing circuitry for electrically powered products intended for use in a wide range of potentially hazardous work environments, including energy production (such as oil/gas production/refining/storage/transportation, mining, etc.), materials processing (chemicals manufacturing, semiconductor fabrication, tank farms, etc.), food production (grain milling, baking, brewing, distilling, etc.), and many others (pharmaceutical or cosmetics manufacturing, pumping stations for gas, oil, sewage, etc.).

1. Select batteries thoughtfully.

Batteries can pack a lot of energy, especially those based on high-density lithium-ion battery technology. Batteries present significant design challenges, not only due to the energy they contain but because of their sensitivity to environmental stresses. When selecting cells or batteries for use in intrinsically safe devices, take care to ensure that the cells and batteries are robust enough to withstand the expected environmental conditions, as well as to contain or minimize the amount of electrolyte leakage that can occur under severe short-circuit conditions.

2. Be aware of multiple power sources.

It’s quite easy to overlook the implications of having one or more facilities for connection to other devices. Most often, circuits for low-voltage communication ports are not given proper attention because designers are so focused on transmission and reception of data on those ports. However, each of these ports has the potential to be connected to equipment that wasn’t designed or evaluated for intrinsic safety protection. This could result in a condition where an excess amount of fault energy and/or power is available within the intrinsically safe device. Even when such ports are designed only for connection to associated apparatus or intrinsically devices evaluated under the “entity concept,” take care to ensure that the entire system maintains intrinsic safety protection.

3. Beware of Published Electrical ratings for semiconductor devices.

The datasheets for many semiconductor components (e.g., zener diodes) will specify an absolute maximum power dissipation rating for the component. However, this rating is often based on very specific temperature and mounting conditions. Often, the given ratings in the component datasheet do not adequately reflect the conditions the component will be exposed to in the end-use application. Always take the time to understand and evaluate the effects that the end-use application will have on the component’s power rating, thermal rise characteristics, etc. This is essential when using semiconductor components as shunt voltage limiters.

4. Know the thermal rise characteristics of power-dissipating components.

The maximum surface temperature of components under fault conditions must be assessed for determining the appropriate temperature class of an intrinsically safe device. To determine the maximum surface temperature of these components analytically, you’ll need information on the components’ temperature rise characteristics. In particular, a component’s case-to-ambient thermal resistance is required to compute the maximum case temperature of the component when dissipating a given amount of power at a specified ambient temperature. Unfortunately, most component datasheets do not specify this value; instead, they specify a junction-to-ambient thermal resistance. In the absence of such information, tests can be performed to determine the required values experimentally.

5. Be mindful of voltage-enhancing circuits.

Although switching regulators, charge pumps, and other voltage-regulating and -enhancing circuits can be useful in designing an efficient power supply, the same circuits pose challenges if not provided with adequate voltage limitation. Enhanced voltage levels present at the output of such ICs can be faulted to propagate to other circuits tied to the same IC if they aren’t adequately protected with voltage limiters. This can cause issues for separation of circuits (which is based on the peak available fault voltage) and for the spark ignition assessment of other circuits.
6. Limit the amount of energy-storing components.

Although energy-storing components like inductors, ferrite beads, and capacitors are useful as filtering components, they pose challenges for compliance with spark ignition requirements. The energy available and stored in inductive, capacitive, and combination LC circuits must be limited such that there is insufficient energy to cause ignition of an explosive atmosphere. When coupled with the safety factors applied to the available fault voltage and/or current in the circuit, the inductance and capacitance limitations can be quite challenging. To help alleviate these challenges, encapsulation may be used to protect circuits against spark ignition.

7. Limit the power available in separate circuits.

Although one of the main goals of intrinsic safety protection is to limit the available power in a device, it can be quite challenging to meet the industry demands for the same products. With the need for more powerful electronics to be provided in smaller packages, the functional needs of the circuit need to be balanced with the safety needs. Quite often, the strategy of splitting the total available power to various “separate circuits” within an intrinsically safe device is used to provide the maximum amount of power required to drive those portions of the circuit that need the power without compromising safety.

8. Be mindful of separation distances.

One of the most important keys to preserving intrinsic safety, especially when considering the application of faults, is providing and maintaining the required separation distances between separate circuits. When it comes to separation distances, the requirements for intrinsic safety equipment must take into account the environments in which such devices may be installed. These environments can contain a wide array of pollutants that can affect the insulation provided between conductive parts of circuits. It’s essential to design in sufficient space to maintain the separation of circuits necessary to preserve intrinsic safety protection.

9. Derate your protective components.

The components that are selected as safety-critical or “infallible” must meet certain construction requirements; however, they must also be rated such that they do not experience stresses that could be detrimental to the reliability they provide. Intrinsic safety standards require that infallible components be used at no more than two-thirds of their rated voltage, current, and power when subjected to normal operating conditions and fault conditions (commonly referred to as “two-thirds derated.”) This often requires selecting components that are overrated for the application but not so overrated that they fail to provide the needed protection.

10. Select protective components wisely.

The fundamentals of intrinsic safety, where circuits are designed to limit the amount of energy for protection against spark ignition and to limit the amount of power for protection against thermal ignition, depend heavily on the reliable operation and “failure” of protective or “infallible” components. Because these components are being relied upon to function in well-defined ways when subjected to normal operating and fault conditions within a circuit, these components must be selected wisely. Although the intrinsic safety standards do not necessarily force the use of specific components, there are requirements for some widely used components that have well-known operating and failure characteristics. Fuses, current-limiting resistors, and zener diodes are commonly used to design robust voltage and current limiting circuits that can be relied on to maintain the energy and power limitation needed for intrinsic safety.