HOW TO SELECT AN INTRINSICALLY SAFE PRESSURE TRANSDUCER

WHITEPAPER

Engineers selecting pressure transducers in hazardous industries must make one more significant consideration beyond performance, reliability and stability, they must specify units with intrinsically safe (IS) circuits. The National Electrical Code (NEC) defines an IS circuit as, "A circuit in which any spark or thermal effect is incapable of causing ignition of a mixture of flammable or combustible material in air under prescribed conditions." In addition, intrinsically safe products are incapable of storing large amounts of energy that might spark an explosion when discharged. These circuits must be used wherever there are combustible gases, vapors, liquids, dust or fibers.

This paper discusses what industries and applications require IS systems and the technical considerations for specifying an IS pressure transducer.

1. Intrinsically Safe Applications

Sixty percent of all manufacturers require IS electrical devices. Obvious industries include chemical manufacturing, pharmaceutical processing, energy production, and the transportation of hazardous chemicals.

Chemical manufacturing applications are considered inherently dangerous. Improper mixtures, incorrect handling, the introduction of extreme heat to the process or an unintended spark from an electrical device are possible fire and explosion risks. For example, the manufacturing of titanium powder for powder metallurgy, which is a highly flammable dust when dry and can explode when combined with an energy source. This combination occured at the A.L. Solutions titanium plant in New Cumberland, WV in 2010 that fatally injured 3 workers.

Pharmaceutical manufacturing shares the same risks. Flammable solvents such as acetone, isopropyl alcohol, and methanol used in tablet coating can create explosive atmospheres. Similarly, the food industry uses products such as cornstarch, organic pigments, and cellulose that are combustible in powder form.

What's Inside

Oil refineries, petrochemical manufacturing, power plants and underground mines are energy applications that routinely handle large amounts of fuel or have dangerous concentrations of flammable gases or dust. Consequently, all electronics inside production areas are required to be IS.

The same safety precautions are followed for the transportation of these fuels as well as volatile and hazardous chemicals. Carriers must use non-sparking breaching tools to prevent the ignition of a hazardous material resulting from a spark. Also, IS radios are used instead of untested radios that could cause ignition in a highly volatile environment.

While ammunitions manufacturing might be another obvious example of a potentially explosive environment, others are not so evident, such as the cosmetics industry. Surprisingly, it too requires IS measures because toner dust is a combustible powder. U.S. Cosmetics Corporation's Dayville, Connecticut plant was cited in February 2013 by the Occupational Safety and Health Administration (OSHA) for failing to create and execute electrical safety programs. OSHA claimed that employees were exposed to the hazards of electrocution, arc blasts, lacerations and falls.

Other industries that require IS products such as pressure transducers, mobile phones, scanners, keyboards, sensors, actuators, solenoid valves, etc., include automotive, aerospace, grain, fertilizer, tobacco, plastics, wood, paper & pulp, furniture, textile,and water/wastewater treatment and handling.

2. What to Look For in an Intrinsically Safe Sensor

When selecting IS pressure transducers there are a number of things to look for. First, make sure the pressure transducer has been significantly modified for IS applications, the printed circuit board has been simplified to use low voltage and current, capacitors and inductors have been minimized, etc. IS pressure transducers typically operate on low voltage DC (VDC) and consume less than 1 watt of power. If a capacitance type pressure transducers is desired for an application, it also can be certified as IS.

Select small sputtered thin film units, less than 1" in diameter, made of all stainless steel wetted parts. They should come with a broad selection of electrical and pressure connections, and a wide choice of electrical outputs ready for installation. Heavy-duty applications will feature a thicker diaphragm and a pressure resistor designed to withstand the rigors of cavitation and extreme pressure spikes.

State-of-the-art IS pressure transducers use the well-proven Wheatstone bridge principle. Molecular layers are sputtered onto a 17-4 PH stainless steel diaphragm and the circuit is etched to provide excellent resistor definition and uniformity. Sputtered thin film technology allows the design of simple, highly accurate and compact strain gauges. This is deposited onto the back of the sensing diaphragm, which is in direct contact with the media. Find a design that provides ±0.25% FS accuracy over its full temperature range. In addition, it should have long-term stability of better than ±0.1% FS/YR enhanced sensitivity and has virtually no drift.

Construction should be all welded stainless steel with no internal elastomers, RTV silicon adhesive sealant or epoxies. The unit should offer a wide pressure range, such as 75 to 32,000 PSI. It shouldn't have oil that could cause thermal instability or leakage. Verify that the unit is CE and RoHS compliant.[1]

Engineers may consider using a capacitor transducer design to minimize orientation and vibration issues by using a stretched stainless steel diaphragm that is not fluid filled. The only gravity effect it has is the weight of the diaphragm, which is not insignificant, but very small and is easily compensated for in the field.

3. Zener Safety Barriers

Some pressure transducers require a Zener safety barrier to achieve the IS rating. This barrier limits the amount of energy in electrical cables running in a hazardous area. Zener barriers control voltage to ground through Zener diodes in shunt mode and use resistors to limit current. In addition, they have a series fuse to protect internal components. Collectively, these measures ensure the current is lower than the threshold required for the IS rating. The Zener safety barrier must be installed in a safe area outside the hazardous area so any generated fault isn't carried to the hazardous area.

In some cases, a sensor manufacturer may use galvanic isolation instead of the Zener diode barrier. This is an alternative method of providing energy limitations to circuits in hazardous locations.

To determine if a pressure transducer requires a Zener or galvanic barrier, contact your sensor supplier and request the parameters for that unit or review the specifications sheet for the transducer being considered. If it does require a Zener barrier, the specification sheet will make a clear statement such as: "The unit is CSA certified Intrinsically Safe for use in Class 1, Division 1, Groups C & D, when used in conjunction with a Zener safety circuit."

The Zener Barrier Parameters:

Voltage Ui = 30VDC
Current Li = 100mA
Power Pi = 0.7W

During installation, the pressure transducer is connected using approved wiring back to a system in the non-hazardous area through the Zener barrier. Pressure transducers are certified for use with a specific cable length, such as 10 meters. The next step is to select the pressure transducers by Class, Division and Group to address the specific hazardous application.

4. Certifying Organizations

There are a large amount of domestic and international testing and certifying organizations around the world. The Factory Mutual Research Corporation Approvals Division, for instance, determines the safety and reliability of equipment, materials, or services utilized in hazardous locations in the United States and elsewhere. Factory Mutual certifies to NEC standards for hazardous locations, NEC Standard 500 (Division classification) and also to the new NEC Standard 505 (Zone classification), which attempts to harmonize American and European classifications[2].

In Canada, the Canadian Standards Association generates standard requirements that demonstrate product quality, enhance market acceptability, and improve quality and safety control procedures in manufacturing and construction for the Canadian marketplace.[3] Other countries around the world follow the IECEx scheme certified by Sira Test & Certification Ltd.

Additional international certifying agencies include Underwriters Laboratories, the American National Standards Institute (ANSI), International Electrotechnical Commission, and International ATEX.

One major difference between the rating agencies is how hazardous areas are classified. The United States and Canada use the Class/Division system, whereas the rest of the world uses the Zone system. This makes understanding and selecting an IS pressure transducer a little more difficult.

A bigger problem, of course, is that a product may be considered flammable or toxic by one agency or country, but not by another. However, despite different geographic locations and standards developed by several different organizations, IS ratings easily transition between the United States, Europe and the rest of the world. For simplicity, consider how three U.S. rating agencies classify hazardous environments.

5. Hazardous Areas - Class, Division and Group

Underwriters Laboratories, Factory Mutual Research, and the American National Standards Institute adhere to the same definitions of what constitutes a hazardous area. These areas are defined as Class I (combustible gas and liquids), Class II (combustible dust), and Class III (combustible fibers). Class I is subdivided into Groups A (acetylene), B (Hydrogen and butadiene), C (diethyl ether, ethylene, isoprene, and UDMH), and D (acetone, gasoline, lacquer solvent, styrene, propane, and natural gas). Class II is divided into Groups E (metal dust), F (carbon black, coal, and coke), and G (flour, starch, and grain dust).

All Classes include two Divisions. Division I covers electrical equipment directly exposed in an explosion atmosphere of the material of a specific Group. Division II covers electrical equipment in an explosive atmosphere only when accident or fallout occurs, or in a properly vented direct exposure.

Qualification for a rating automatically includes the equipment for a lower Class and Group. For example: Class I equipment can be used in Class II and Class III applications with no restrictions.

A single piece of equipment, a system, or parts of a system can receive an IS rating for a Class, Group and Division. The rating agencies usually test the equipment as a system, and all parts of the system receive the highest Class and Group reached by the system regardless of any previous explosion-proof rating. The entire system also receives a collective rating, which will generally be that of the lowest rated piece within the system.

IS products receive their classification because their electrical power usage is below the level of power required to set off an explosion within a given hazardous area. Each IS device can only be used in the specific hazardous location for which it is certified. The end user must install the equipment as supplied. A certified product should never be opened or modified because this may risk worker safety. The product will lose its rating if modified by the end user.

Once the accredited agencies rate the sensor as IS, the approvals are labeled on the unit. Typically, there will be multiple approvals, such as from FM, ATEX and CSA. These multiple approvals provide global recognition and acceptance of the IS ratings. The CSA and ATEX codes and classifications are explained below.

Many applications and manufacturers require IS electrical systems and devices. It is important for an engineer selecting pressure transducers in hazardous industries to understand their system requirements as well as the specifications of the pressure transducer. One must

consider the application, pressure transducer, Zener safety barriers, certifying organizations and hazardous areas classifications. Understanding and selecting the right pressure transducer will help ensure proper and safe operation.

[1]Standard & Heavy-Duty IS CSA Rated Pressure Transducers (http://www.setra.com/content.aspx?id=681&terms=31cs)
[2,3] Intrinsic Safety Approvals for Radio Communications Equipment (http://www.ameradio.com/systems/intrinsic_safety.html)

About Setra:
Founded by former professors of Engineering at Massachusetts Institute of Technology (M.I.T.), Setra has been designing and manufacturing sensor products since 1967. Our specialty is in the pressure and sensing in a wide range of markets including HVAC/R building automation, pharmaceutical, energy, medical sterilization, industrial OEM, test & measurement, meteorology and semiconductor.

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