Whitepaper

# How to Select an Intrinsically Safe Pressure Transducer

## Understanding Intrinsic Safety

### OVERVIEW

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 circuits. The National Electrical Code defines an intrinsically safe 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, and/or fibers.

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

Sections in this whitepaper include:

- Intrinsically Safe Applications
- What to Look for in an Intrinsically Safe Pressure Sensor
- Zener Safety Barriers
- Certifying Organizations
- Hazardous Areas—Class, Division, and Groups

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# 1. Intrinsically Safe Applications

Sixty percent of all manufacturers require intrinsically safe (I.S.) electrical devices. Obvious industries include chemical manufacturing, pharmaceutical processing, energy production, and the transportation of hazardous chemicals.

Chemical manufacturing, by its very nature, is 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. Consider, for example, the manufacture of titanium powder for powder metallurgy. It is highly flammable dust when dry and will explode when combined with an energy source. That's what happened at the A.L. Solutions titanium plant in New Cumberland, WV in 2010 that fatally injured three 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.

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 intrinsically safe.

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, intrinsically safe radios are used instead of untested radios that could cause ignition in a highly volatile environment.

While munitions manufacturing might be another obvious example of a potentially explosive environment, others are not so evident. The cosmetics industry is one example. Surprisingly, it too requires intrinsic safety 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 intrinsically safe 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, among others.

## 2. What to Look for in an I.S. Sensor

When selecting intrinsically safe pressure transducers there are a number of things to look for. First, be assured that the pressure transducer has been significantly modified for intrinsically safe applications—the printed circuit board has been simplified to use low voltage and current, capacitors and inductors have been minimized, etc. Intrinsically safe pressure transducers typically operate on low voltage DC 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 intrinsically safe.

Select small sputtered thin film units—less than 1 inch 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 intrinsically safe 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 deposited onto the back of the sensing diaphragm, which is in direct contact with the media. Find a design that provides +/-0.25 percent full-scale accuracy over its full temperature range. In addition, it should have long-term stability of better than +/-0.1 percent full scale per year, enhanced sensitivity, and 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 from 75 to 32,000 PSI. It should have no oil that could cause thermal instability and/or leakage. Verify 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 intrinsically safe 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 components. Collectively, these measures ensure current is lower than the threshold required for the intrinsically safe rating. The Zener safety barrier must be installed in a "safe area" outside the "hazardous area" so any fault that is generated is not 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 transmitter 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." Furthermore, it will list parameters, for example:

*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 by way of the Zener barrier. Pressure transducers are certified for use with a specific cable length, 10 meters, for example.

The next step is to select the pressure transducers by Class, Division, and Group to address the specific hazardous application.

## 5. Certifying Organizations

Here's where it gets a bit tricky. There are a number 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 (National Electrical Code) 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, 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, which makes understanding and selecting an intrinsically safe 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, intrinsic safety 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.

# 6. Hazardous Areas—Class, Division, and Groups

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 intrinsically safe 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.

Intrinsically safe 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 intrinsically safe 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 intrinsically safe, 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 intrinsically safe ratings. The CSA and ATEX codes and classifications are explained below.

Many applications and manufacturers require intrinsically safe (I.S.) 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 Intrinsically Safe 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)

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About the Authors:

John Sullivan is a business owner representing sensing products used in process control, test & measurement, and the automation technology. He has been working with engineers in a variety of process and other applications for over 30 years in New England.

Melanie Cavalieri is the Product Planner for Industrial Products at Setra Systems, Inc. She is responsible for new product development and marketing for Industrial, Refrigeration and Medical markets. Melanie has experience in Quality and Manufacturing Engineering for a variety of industrial and medical products. She has a Bachelor of Science in Mechanical Engineering from Purdue University.

For more information on Setra's intrinsically safe pressure transducers, please contact Mike Turner, Industrial Product Manager, at mike.turner@setra.com.

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