Pressure sensor safety requirements in hazardous environments

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Many of us associated hazardous environments with the oil and gas industries where it is common to see mandatory safety requirements for “intrinsically safe” and “explosion proof” (flame proof) equipment. Other industries including nuclear power generation, chemicals, sub-sea, mining, dusty and high temperature environments also fall within the hazardous environment category. Within these environments, hazardous locations can be broken into classes, divisions/zones and groups, along with temperature codes.

In the U.S., the National Electrical Code (NEC) defines hazardous locations as those areas where fire or explosion hazards may exist due to flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers or flying debris. In Canada, the Canadian Electrical Code (CEC) is used to define the hazardous locations similar to NEC. Articles 500 thru 504 of the NEC code drive the classifications.

Oil & gas applications
All electrical equipment for this market must be inscribed with appropriate markings by a certified testing lab. Under NEC Article 501, electrical equipment employed in this market must carry a Class 1 location marking along with the appropriate operating condition as described by Division (Div) or Zones. Div 1/Zone 0 & 1 refers to normal conditions where flammable gases or vapors or liquids are present at all times while Div 2/Zone 2 represents abnormal conditions.

Gases and vapors of Class I locations are categorized into four groups by the Code A, B, C, and D, according to the ignition temperature of the substance, its explosion pressure, and other flammable characteristics. The four groups include:

Group A   Acetylene
Group B   Hydrogen
Group C   Ether
Group D   Hydrocarbons, fuels, solvents

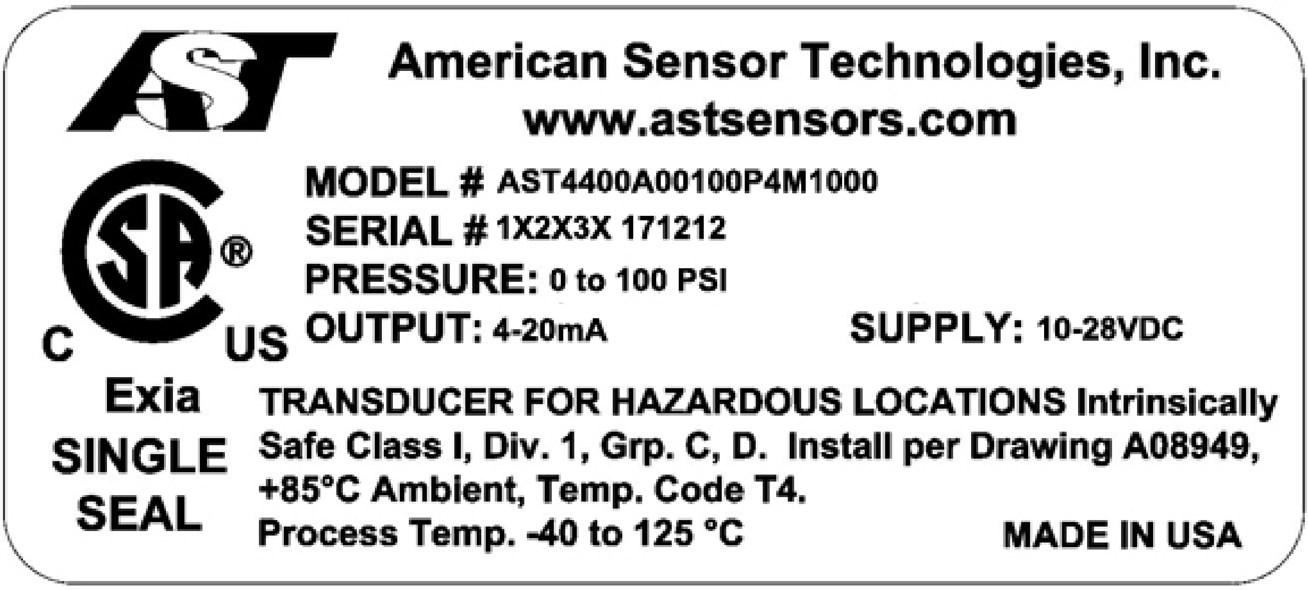
A mixture of hazardous gases and air may ignite in contact with a hot surface. The condition for ignition depends on several factors as surface area, temperature and concentration of gas. The temperature code must also be inscribed on the label as shown below:

T6   85°C (185°F)
T5   100°C (212°F)
T4A   120°C (248°F)
T4   135°C (275°F)

T3C 160°C (320°F)
T3B 165°C (329°F)
T3A 180 deg C (356 deg F)
T3 200 deg C (392 deg F)

Intrinsic safety (IS)
IS is a protection technique, developed by Europeans for offshore oil platforms, to ensure safe operation of electronic equipment in explosive atmospheres and under irregular operating conditions. Developed for safe operation of process control instrumentation in hazardous areas, IS is an application of inherent safety in instrumentation. There are two groups within this scheme: Exia (two fault) for Zone 0 and Exib (one fault) for Zone 1

IS ensures that the available electrical and thermal energy in the system is always low enough that the hazardous atmosphere cannot ignite, by warranting that only low voltages and currents enter the hazardous area and that all electric supply and signal wires are protected by Zener safety barriers. Figure 1 shows a typical IS label for a pressure sensor intended for use with a safety barrier that must include key parameters and manufacturer details.



Explosion proof (flame proof)
The National Fire Protection Association (NFPA) began publishing the NEC Code in 1897 that defines criteria necessary for all components installed in hazardous (classified) locations. To meet the criteria for the explosion proof rating, an enclosure must be able to contain any explosion originating within its housing and prevent sparks from within its housing from igniting vapors, gases, dust, or fibers in the air surrounding it. Therefore, explosion proof, when referring to electrical enclosures, does not mean that it is able to withstand an exterior explosion. Instead, it is the enclosures ability to prevent an internal spark or explosion from causing a much larger blast.

Additionally, the NEC states that equipment must meet temperature requirements of the specific application in which it is to be installed. This means that the operating temperature of the pressure sensor (and its enclosure) cannot be greater than the lowest ignition/combustion temperature of the gases or dusts in the atmosphere where the component is to be installed. The electrical connections must be via some sort of rigid conduit connections with the ability to withstand 6000PSI (400Bar) of pressure between the wires and sensor. The pressure sensor information along with the markings, manufacturer's model number and pressure ratings must be engraved or etched to withstand the heat, in case of fire, as shown in Fig 3.

Mining and dusty environments
According to NEC Article 502, all electrical equipment used in these areas must comply to Class II approvals. Here are the predominant groups:

Group E   Metal dusts (conductive, explosive)
Group F   Carbon dusts(conductive and explosive)
Group G   Flour, starch, grain, combustible plastics, chemical dust

For textiles and wood dust, Article 503 of NEC applies and falls under Class III Fibres and flyings.

Chemicals and process gases
Chemicals and process gases are widely used in the food and beverage, pharmaceuticals, waster water treatment, desalination, refineries, natural gas fracking, paper and pulp, alternative energy, fuel cells and chemical injection plants. While some areas within these applications are subject to the same safety requirements in hazardous location as the oil & gas industry, most are subject to spill or leakage against corrosive liquids and gases that may be deadly.

The rise in use of hydrogen as process gas is challenging to pressure sensor suppliers who must develop new materials and testing to contain hydrogen permeation and embrittlement. Traditional sensor materials traditionally included large grain steels such as 13-8PH, 15-5PH and 17-4PH. While these are good spring materials with high strength, they suffer from extreme embrittlement and loss of strength, resulting in leak of media. Oil-filled sensors tend to fail from permeation since the isolation diaphragm is very thin. Unless the diaphragm is gold plated, it will leak hydrogen ions, causing the sensor to fail. Corrosion-resistance materials, such high strength high nickel 316L steel for hydrogen and nickel alloys such as Hastelloy C 276 for aggressive chemicals, must be employed to maintain the media and offer trouble-free operation for years.

There are chemicals that even the best corrosion resistance metals are not suitable. Here, engineered plastics offer economical solutions and full media compatibility. Figure 4 shows a pressure sensor constructed from engineered non-metallic parts for use in level measurement of chemical tanks.

Summary
Pressure sensors users must be fully aware of the specifications of the operating environment when selecting a specific pressure sensor, especially in hazardous environments. Media compatibility, along with or without agency approvals, if needed, ensures reliable and trouble- free operation, as well as compliance, for

many years. If in doubt, ask the pressure sensor manufacturer - in writing - for clarification if the product data sheet is confusing.