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New breed of electronic threshold detection switch fills gap in safety instrumented systems

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This new type of pressure sensing device may be what you need to satisfy the monitoring criteria of regulatory agencies in mid-level areas, such as Class I, Division 2 hazardous locations.

When selecting instrumentation for pressurized systems, the protection of people, equipment, processes, and the environment must be a top priority. New standards continue to be introduced that drive safety regulations to increasingly higher levels. As a result, greater diligence is required to select and adapt process instruments to meet the reliability and safety goals of today's process systems.

Typically, any time new safety standards are introduced, one of the first thoughts that comes to mind is: How much will it cost to comply? The simple answer is: Far less than the potentially staggering costs and risks of noncompliance.

Standards such as OSHA FR29 CFR 1910.119 and ANSI/ISA S84.01 are driving the need to reexamine the threshold detection instruments that perform alarm and shutdown functions in pressurized systems. Important

provide important health and status indication? More than ever, having a proven, reliable, and documented system in place is essential in order to meet both increasingly stringent regulations and the desired safety integrity levels (SIL) of end-user systems.

The purpose of this article is threefold: to provide an introduction to the latest standards related to threshold detection in pressurized systems; to introduce the main concepts behind the regulations; and to examine cost-effective threshold detection instrument options (both traditional and new) for use in the design or evaluation of a pressurized safety instrumented system (SIS).

The thrust of the new regulatory standards

The relevant standards include OSHA FR-29 CFR 1910.119, ANSI/ISA S84.01, and IEC 61508. OSHA has addressed general process safety management in its regulation, which calls out the need to ensure that systems are properly designed and that a process hazard analysis (PHA) is performed, documented, implemented, audited, and maintained. However, for specific safety system guidelines, it refers users to the ANSI/ISA and IEC regulations.

In order to meet these requirements, you need the following key elements: documented and verifiable proof of enhanced system safety and reliability, achieved through redundancy in control instrumentation and the application of diverse or alternate technology to eliminate or minimize system common mode failures.

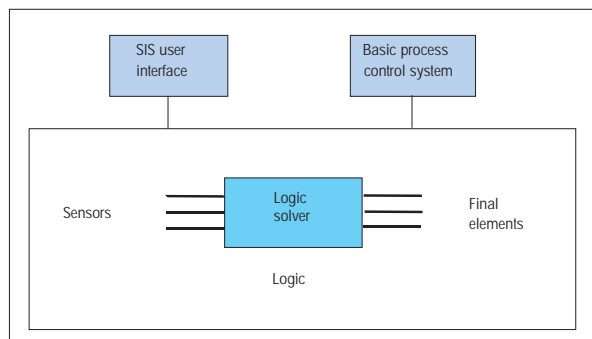


FIG. 1: ANSI/ISA regulations relate to these basic components.

implementation questions include: Is our process system designed for safety? What instrument selection and configuration will meet the needs of our process system? Do the instruments use appropriate technology to satisfy regulations? Is the instrumentation sufficiently reliable and does it



Compliance overview

ANSI/ISA regulations relate to the components shown in Figure 1. The standards address electrical/electronic/programmable electronic systems (E/E/PES) associated with sensors, final elements, and interfaces for process industry SIS. Examples of E/E/PES technologies include electromechanical relays, solid-state logic types, PES (programmable configurable devices, e.g., PLC and SLDC), motor-driven timers, hard-wired logic, and combinations of these technologies.

Important design objectives that must be kept in mind to meet SIS Conceptual Design and Safety Requirement Specifications are:

- General requirements,
- SIS logic solver,
- Field devices,
- Interfaces,
- Energy sources,
- System environment,
- Application logic requirements,
- Maintenance and testing requirements.

Clearly, a process system's health and safe operation are contingent upon the plant's ability to keep variables such as pressure, temperature, flow, level, and vibration within limits. To ensure compliance with new safety regulations, the design of any new or upgraded SIS needs to carefully address the critical issues of reliability, application of diverse technology, and implementation of back-up protection devices.

Which threshold detection equipment?

For years, traditional pressure switches and transmitters have been used to monitor and regulate process media pressure. They are regularly called upon to serve a variety of critical watchdog operations to activate alarms, perform shutdown and restart operations, and initiate backup sequences and systems—often in critical process and environmentally demanding applications such as monitoring and control of valves and pumps.

As safety regulation and validation gain importance, threshold detection instrument performance and reliability become ever more crucial. Well-designed systems should use instruments that incorporate self-diagnostics with status indication to assure reliable operation when called upon.

In some cases, users may over-specify in-

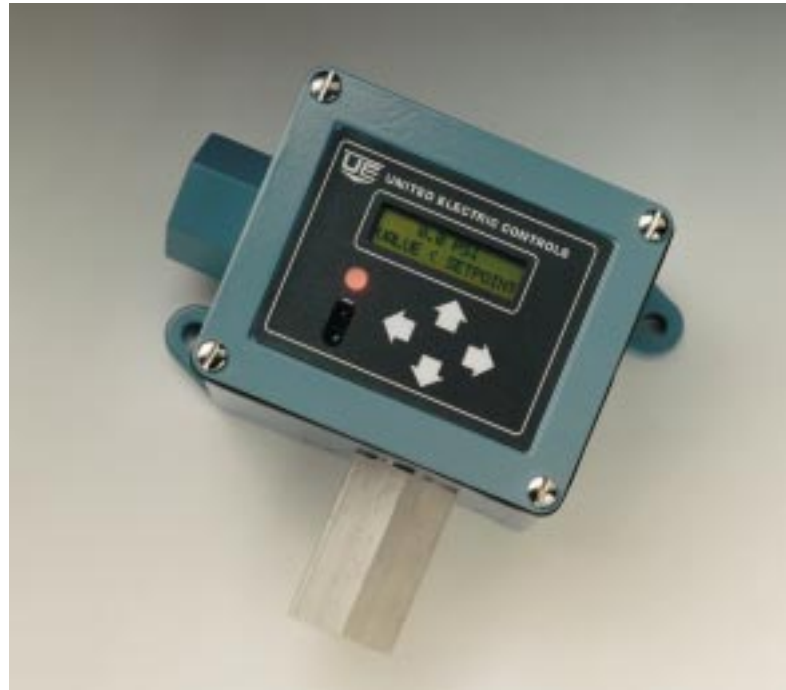


Fig. 2: Threshold detection switch health and switch status (IAW™) output.

strumentation to achieve the ON/OFF threshold detection required. For example, they might opt to use high-end explosion-proof smart transmitters, which will satisfy most requirements, but cost a lot of money. In practice, both cost and performance are important design requirements. By closely matching product features and reliability to the application, viable, safe and cost-effective solutions are possible, and deserve full consideration.

In the material that follows, we'll examine some threshold detection instrument options and review the pros and cons of each. Along with traditional switches and transmitters, we'll introduce a hybrid solution that combines and enhances the features of switches and transmitters to extend the range and quality of reliable, yet cost-effective instrument solutions.

Traditional pressure switches

These well-established devices provide simple, passive ON/OFF operation at a set pressure. With few bells and whistles, they give stand-alone, local control over critical processes and equipment parameters, or can serve as discrete inputs to external logic solvers, such as a PLC or DCS. Their simplicity and low cost often make them excellent candidates for backing up smart, more complex PLC or DCS systems. They are frequent-

ly installed in applications with air compressors, hydraulic pumps, and turbines.

The pros of this technology are:

- Simple, rugged, and well understood,
- Direct, local switching of loads,
- Low cost,
- Simple to install and wire,
- No device power required,
- No complex communication or computer investment necessary,
- Highly useful as a redundant control.

The cons include the following:

- Moving parts which may wear or corrode undetected—unless made of more costly noncorrosive, high-performance materials,
- No self-diagnostics,
- Maintenance checks can require unit removal or installation on isolation manifold,
- Adjustment is limited and requires tools,
- Fairly application specific; no one-size-fits-all solution (increased stocking needs),
- Limited switch life,
- Arcing and sparking components,
- No local or remote read-out of process or setpoint values or status.

Pressure transmitters

The active electronics of both analog and smart digital transmitters enable these instruments to offer remote sensing and process monitoring. The instruments provide various levels of health indication (live zero/active 4 mA signal) and dynamic control of setpoint values. Additional requirements for typical transmitter systems include a more costly analog input channel in the logic solver, or processor, and software to set and determine trip points.

Typical applications for pressure transmitters include those suitable for pressure switches. However, transmitters provide the added ability to perform process monitoring and trending.

The pros of this technology include:

- Solid-state, with no moving parts,
- High accuracy (typically $\pm 0.25\%$ or better),
- Well-established technology,
- Easy to install and wire (analog versions),
- Low power consumption (if the unit is loop powered),
- Can be used for a wide range of applications (low stocking requirements),
- Built-in diagnostics (smart versions),

- Live zero indication—which provides some health status information,
- Full range setpoint control and “on-the-fly” adjustability.

The list of cons (for threshold detection) is as follows:

- Cost is typically two to three times higher than mechanical switches,
- Analog input channel for 4-20 mA signal is more expensive than discrete digital channel,
- Often there is no direct, local control over final control element/device,
- More complex to wire (when completing the control loop from sensor to final control element),
- Poor standardization among smart communication interface devices (which means you may have to stock multiple devices),
- Interoperability issues/problems,
- Not always locally programmable and usually no local display,
- Added expense of logic solvers and control circuits, plus wiring to monitor and implement threshold detection actions,
- Low-cost versions provide no indication of unit health,
- Analog signals susceptible to noise, which can affect accuracy.

Electronic pressure switches

Historically, pressure switches and transmitters have done a good job of providing solutions for either simple, low-end applications or high-end, hi-rel applications. This has left some process system design engineers a choice of either under- or over-designing systems for middle areas such as Class I, Division 2 hazardous locations.

In more recent years, electronic pressure switches have entered the industry. These typically are solid-state versions of the traditional pressure switch with additional features and cost. The extra features include displays of the process variable, various device settings, and the output switch status. Analog 4-20 mA outputs may also be available.

Electronic pressure switches often are used in applications similar to those using conventional switches and transmitters. However, these devices usually will provide only low-level (100 to 200 mA) switching, and are constructed for use in nonhazardous areas.

The pros of this technology include:



- Solid state, no moving parts,
- Local analog and/or digital display,
- Local programmability,
- Full range of set point selection,
- Visual displays simplify field calibrating and testing,
- Direct, local control of final control element/device (however, usually low power),
- Optional 4-20 mA analog output signal provides remote process variable measurement.

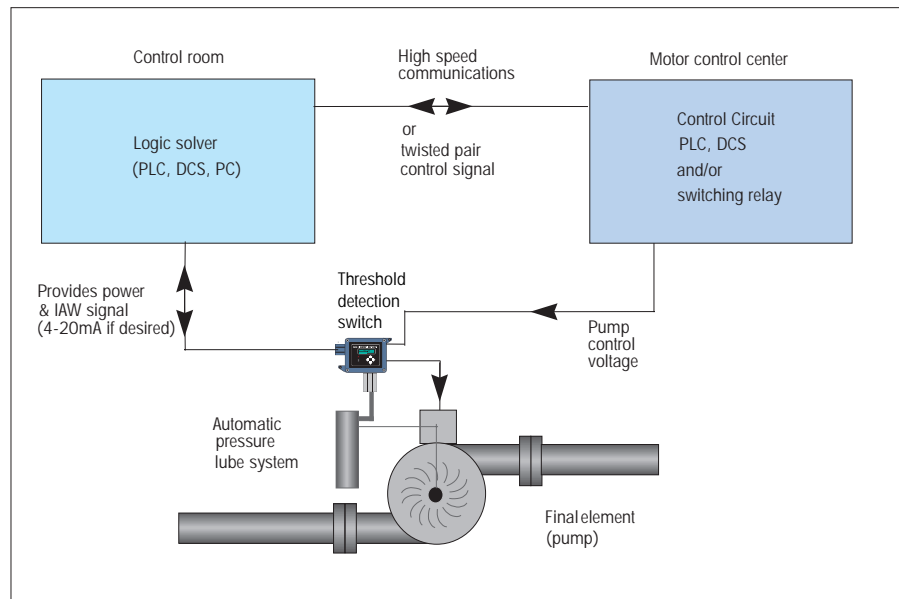
The cons are as follows:

- Output switch often is a low-power dc device not capable of direct V ac switching,
- Generally available in either low-end or high-end types with no middle ground for applications such as Class I Division 2 hazardous locations,
- The typical industrial electronic switch is much more expensive than a traditional mechanical switch.

Enter electronic threshold detection switches

Electronic threshold detection switches expand the features currently available on electronic switches. This type of switch fills the gap between traditional switches and high-end smart digital transmitters, but at a cost comparable to traditional mechanical switches. These devices perform the basic functions of the others, but typically include enhanced built-in diagnostics, device health and switch status indication (locally and over a simple discrete digital signal), direct solid-state high level switching, and rugged packaging for Class I Division 2 hazardous areas. In addition, they often include selectable alarm and shutdown operating modes, full-range setpoint and deadband programmability, and options that make possible tamper-proof or alphanumeric display and touch pad models.

Electronic threshold detection switches can meet the redundancy and diverse technology requirements of SIS, while reducing cost. They can be used for the same types of threshold detection applications in which you will typically find switches and transmitters. However, they are particularly suited to applications that call for added versatil-



ity, high reliability, direct high level (15 A) switching, and rugged construction for Class I Division 2 hazardous areas (See Fig. 2 for photo, Fig. 3 for schematic).

The pros of this technology include:

- All solid state design,
- Local indication of process variable, switch status, and unit health,
- Built-in diagnostics that provide continuous critical real-time information on properly functioning and switching status (both local and remote), loss of power, microprocessor and software watchdog status, and integrity of primary sensor,
- Discrete digital connection to local or remote system, visual or audible indicators, or other devices,
- Easy field configuring, programming and testing with tamperproof options available,
- Full-range setpoint and deadband programmability,
- Direct, local control of final process control elements/devices,
- Available 4-20 mA analog output signal,
- Multiple operating modes for high or low alarm/shutdown operation,
- Can function in stand-alone mode (i.e., without a PLC or host intervention),
- Rugged design and packaging for Class I Division 2 hazardous locations,
- Can be used in a wide range of applications (reducing stocking requirements),
- Unit costs are comparable to those of traditional switches.

The schematic shows a threshold detection switch installed on a pressurized lubrication system where it is performing several important functions:

1. Provides unit health status and switch status to the logic solver;
2. Provides 4-20 mA signal that can be used for motor speed control;
3. Provides local shut down control of the pump's motor.

The advantage of using a threshold detection switch as an input to the logic solver is that the "I Am Working" (IAW) signal uses a single wire connected to a discrete, digital channel. Typical 4-20 mA signals require an analog input channel, which can cost twice the price of a digital channel. Using the instrument's analog output can potentially eliminate the need for an additional invasive port into the process. At the other end of the control loop, the threshold detection switch can perform local shut down of the pump's motor, providing immediate protection for critical pumps.



There are basically two cons:

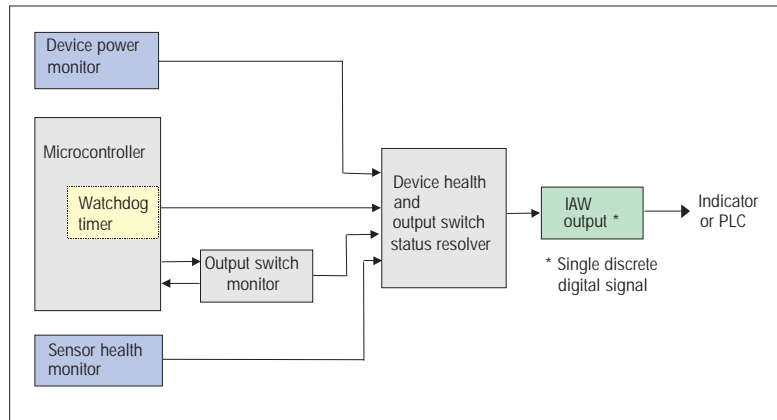
- The units require dc power,
- More wiring is required than for mechanical pressure switches, which will increase installed costs.

Summary

Traditional pressure switches and transmitters are now joined by a new breed of electronic threshold detection switch. This new type of switch provides lower cost with full functionality, diverse technology, reliability, and the ruggedness necessary to satisfy a broad range of demanding applications in today's safety instrumented systems. **I**

About the author

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University and has more than 20 years of experience developing industrial measurement and control instruments.

Fig. 3: Schematic of threshold detection switch.

For more information...

The author, Dennis Lonigro, will be available to answer any questions you may have about this article. He can be reached at (617) 926-1000 during normal business hours.

Electronic threshold detector combines functions of pressure switch and transmitter



Pressure switches don't have many functions, but they're inexpensive and easy to use, and can directly operate final control elements such as valves and motor controls—with no other logic devices required. Pressure transmitters, on the other hand, have plenty of functionality with their solid-state circuitry, but they're more expensive than simple pressure switches. Despite this, many transmitters are installed just as threshold detectors because users have the perception that conventional pressure switches are unreliable—because they have moving parts, and don't provide any indication that they're working until they either do or don't.

United Electric Controls has addressed this problem with a new threshold detection switch that combines the features of both a transmitter and a pressure switch. It's an electronic pressure switch with no moving parts developed for the redundancy and diversity requirements of such standards as ASNSI/ISA S 84.1 and IEC 1508.



The device combines functions traditionally performed by transmitters, switches, and gauges with a single pressure connection, and can switch on both rising and falling pressures. It continuously monitors its own health and status, signaling "I Am Working" (IAW) and "I Have Switched" both locally by a visual indicator and remotely, via a single discrete connection. This reassures the operator that the switch will work properly when pressure thresholds are exceeded. The front-panel digital readout shows a real-time indication of process pressure in both digital and bargraph formats, as well as setpoint,

deadband, operating mode, and certain diagnostic parameters. A four-key keypad with plain English display prompts allows easy field adjustment of set point and deadband. Bench set versions are available at lower cost.

The IAW and switch state outputs are reported via a standard single two-wire connection, which saves the cost of an analog channel; a 4-20 mA trending output is available as an option. The solid state main switch output is rated for 100 mA dc or 15 A.

The switch is rated for Class I, Div. 2 hazardous locations, and is UL listed for U.S. and Canadian installations. Pressure ranges are from 0-25 psi to 5500 psi, and setpoint and deadband can be set over the entire operating range. Accuracy is ±1% of range, maximum, and repeatability is ±0.1% of range, maximum. The price is less than \$350.—United Electric Controls, P.O. Box 9143, Watertown, MA 02272-9143, (617) 926-1000.