Is it time to switch switches?

Electromechanical switches have their place in the modern plant, but a digital upgrade could pay off in many applications

By Wil Chin and Rick Frauton

A typical process plant might have anywhere from 100 to 1000 mechanical switches installed, performing functions ranging from controlling hard alarms, permissive and interlock circuits, blowers, and fans to emergency shutdown. Some of these switches, however, may be nearing the end of their useful lives or taking up operating space that might be filled by more productive contributors to plant control, process efficiency, and safety. Here are eight criteria to consider when determining whether it is time to upgrade switching assets.

Fast Forward

- How much visibility do you need into the operation of your switches?
- If operation off the power grid is essential, mechanical switches may be your only option.
- Hybrid transmitters provide switching functionality through SIL-certified integration of a logic solver, 4–20 mA output, and process sensor.

1. Operational visibility

Electromechanical switches are a low-cost alternative for process and safety applications, but are essentially blind. Unless tested on a regular basis, there is no way to determine when problems exist, and given their age and number of moving parts, there could be many. Sensors crack, pistons stick, and microswitch contacts wear out without warning. The only way to diagnose such problems is to remove the switch from service for bench testing, which leaves the control or safety function unprotected. Some plant operators tried to add visibility by integrating gauges into the design, but these can add unnecessary leak paths.

Newer digital switch designs incorporate liquid crystal displays (LCDs), presenting local process variable measurements and integrated internal diagnostics, monitoring the health of the device. The addition of LCDs and device diagnostics increases uptime and improves overall plant safety. At a glance, operators can see what is happening. Upgrading to these smart switches reduces the number of installed components and fittings, resulting in more dependable process monitoring.

The comprehensive diagnostic coverage of safety-integrity-level- (SIL) certified digital switches can identify 98.8 percent of all the potential failures of the device. This allows maintenance to reduce or completely forgo routine inspection rounds that can leave devices inoperable due to human error, and it reduces cost.

2. Adjustability

Mechanical switches require delicate adjustments to achieve desired set points. Deadband adjustments are either limited or nonexistent in mechanical designs. Adjustability varies significantly, depending on the control’s design, making these adjustments across different switch models and vendors difficult and cumbersome. Even after careful adjustment, set point and deadband settings are prone to drift due to ambient and process temperature changes. Maintaining instruments requires removal from service and bench calibration, often without installation and instruction documentation. Tracking down such documentation from the manufacturer can be frustrating and time consuming, and the whole process is subject to human error. Premature failure has been linked to mishandling by inexperienced technicians.

Today’s generation of electronic switches offers digital adjustability, which can reduce setup and programming time to seconds. A local keypad and LCD provide a user interface for programming switch set points instantly and easily, without a calibrated pressure source or having to remove the instrument from the process. Deadband and set point are now 100 percent adjustable, allowing these digital switches to provide precise on-off control in a number of applications where mechanical switches would not be suitable. High cycle rates are not an issue for digital switches that have no moving parts. With the increased reliability and easy adjustability, operators are no longer required to stock redundant devices in case one fails in the field. Users now have the flexibility of programming one switch to match many different process requirements.

Figure 1. Mechanical switches remain prevalent in the modern plant, but digital alternatives are emerging to offer additional value.

3. Safety

Industrial process plants are pushing pressure and temperature limits to new boundaries in an effort to stay competitive in a global market. Many of the systems designed 20 years ago were not intended to run at the current process extremes, and it is only a matter of time before some of their systems fail. In response to this reality, manufacturers are implementing safety instrumented systems (SISs) to protect the process, people, and environment. An SIS includes sensors that detect changes in process variables that indicate potential danger, computational logic solvers (including safety programmable logic controllers [PLCs] and trip alarm/amplifiers that interpret the level of the danger), and switches that activate valves, blowers, and other elements that must be run in proper sequence to mitigate any disaster.

A modern SIS requires a switching functionality that matches the required system performance level while also being fault tolerant. These must be evaluated by third-party agencies to verify the level of safety integrity. These new SIS implementations do not deploy mechanical switches due to the lack of proven-in-use data and valid failure modes and effects diagnostics analysis data.

One cost-effective alternative is a hybrid transmitter that integrates the functionality of a switch, a transmitter, and a logic solver in one unit. The switch portion provides a direct digital output (relay output) to a final element, which instantly brings a process to a safe state in a critically abnormal situation. And the analog transmitter signal can be used for trending to determine the health of the device and the process. A hybrid transmitter-switch can be certified as an integrated unit, eliminating any reliability issues introduced by connecting independent transmitters, logic solvers, and switches on site.

4. Uptime

Mechanical switches are also used in critical control applications such as compressors and turbines. These applications may not have safety requirements, but SIL reliability is still valuable for maintaining uptime. Depending on the scope and complexity of the application, the hybrid transmitter-switches mentioned above could also be a valuable upgrade in these situations. Because the sensing, logic solving, and switching functionality are integrated into one pretested unit, they deliver the higher reliability required and are less susceptible to human error.

5. Protection in hazardous environments

Many critical control applications are in tough environments that include high levels of mechanical shock, vibration, heat, and pressure. Vibration, for example, is one of the leading causes of electromechanical switch failure. Most mechanical switch designs have a plunger to activate a microswitch. High shock and vibration conditions can cause fluctuation in the plunger position, which can lead to false trips.

Figure 2. The One Series safety transmitter from United Electric Controls integrates the functionality of a switch, a transmitter, and a logic solver in one unit.

New solid-state, digital switches have no moving parts. They can be mounted directly to the equipment or process without adverse effects from vibration. Industry-leading turbine manufacturers and end users operating large compressors in petrochemical plants have better reliability and fewer false trips with digital switches compared to the old mechanical switch designs.

6. Power utilization

Most pressure switches sold over the past 80 years were designed to operate without electric power. They did this by incorporating a sensor that measures pressure by placing force on a plunger that actuates a microswitch. In areas where shock and vibration are limited and ambient temperatures remain constant, mechanical switches are a simple method of monitoring process pressures and temperatures. During their initial installation—plant wiring did not include provisions to power field instruments because it was not required—two wires connected to a distributed control system, PLC, or annunciator panel were all that was needed to provide an on-off signal. Modern digital switching technology can now use the same two wires by using a small amount of leakage current obtained from a host device, such as a PLC. This allows electronic switches to be drop-in replacements for the old mechanical switches, providing a cost-effective upgrade path.

7. Response time

Without question, electromechanical switches are faster than process transmitters in their response time to a process upset. Transmitters must perform numerous conversions, computations, compensations, and other tasks to get an accurate signal. Even today's high-speed processors cannot match the instantaneous reactions from a mechanical device, which can exceed 5 milliseconds, compared with the fastest process transmitters, which have typically ranged between 300–500 milliseconds. Adding a digital protocol such as HART only exacerbates this issue.

New transmitters are getting faster, however, and could be fast enough for most applications. Transmitters designed for safety functions, for example, can be faster than 250 milliseconds. Newer hybrid transmitter-switches can react in 100 milliseconds or less. If your application requires fast response, such as in positive displacement pumps and turbine trip for over-speed protection, consider hybrid transmitter-switches over process transmitters.

8. Modernization

To meet the higher performance demands of modern process plants, some manufacturers routinely replace mechanical switches with process transmitters. They do so because of perceived advantages such as access to solid-state digital electronics, programmability, elimination of moving parts, self-diagnostics, digital display, no drift, and set-and-forget capabilities. Process transmitters do not provide the switching function directly, however. The PLC must be programmed to interpret the transmitter's analog signal to provide the switching function.

In addition to requiring additional PLC programming and new analog I/O to replace the discrete I/O, replacing the mechanical switches with conventional process transmitters can get expensive. The average process transmitter, for example, can cost more than $2000. So for a hypothetical process plant with 100 to 1000 switches installed, upgrading all switches to conventional transmitters could cost up to $1.5 million. More importantly, the designing, planning, purchasing, rewiring, and reprogramming necessary when upgrading to transmitters can take more time than a routine shutdown turnaround would allow. Subsequently, old legacy systems remain in place beyond their useful lives, leaving plants vulnerable to accidents.

Such investment may be warranted if some of the smart capabilities of the new transmitters are required. However, if the intention is to replace mechanical switches with the latest in process and safety monitoring, an $800 hybrid transmitter—in which the sensing device, logic solver, and relay are factory integrated into a single, safety-certified chassis—would be much more economical and better suited for the task. In addition to the lower price, hybrid transmitters require no wiring or programming or control logic changes at the PLC and use the same two wires from the old mechanical switch, reducing the amount of downtime required for switch replacement.

Switch strategy

Where wiring, speed of response, and cost are primary drivers for a plant upgrade, mechanical switches may still be a good solution. Mechanical switch technology has improved as a response to some of the issues outlined in this article. Piston, Belleville washer, and bellows designs have been optimized for the needs of high-vibration applications. And do not forget that mechanical switches still perform their function even when power is completely lost. For example, a diesel pump removing damaging flood waters from an overflowing canal is expected to continue running after the lights go out. Mechanical switches employed to monitor functions such as lubrication oil pressure and temperature can still provide emergency shut down protection for the pump without power.

But if you are looking for greater visibility, adjustability, safety, uptime, and integration, it is time to switch mechanical switches for digital switches. In doing so, one consideration is whether you need SIL reliability for safety or critical control applications. Another is whether you need the diagnostic and other capabilities of a smart transmitter, requiring complex I/O connections and PLC programming, or whether you just need basic switching functionality. If diagnostics and multiple outputs are essential, you may want to deploy a smart transmitter running HART, FOUNDATION Fieldbus, or other smart protocol and pay the freight. If, however, you only want the transmitter for simple safety or critical control sensing and switching, you can save thousands of dollars by implementing a SIL 2 approved hybrid transmitter, which functions as a sensor, a logic solver, and a switch for the final element.

In the end, you may conclude that your mechanical switches are just fine as they are. But advances in switching might warrant another look. It requires thinking about switches and industrial switching in a different way, but it could pay off in cost savings, performance, and safety functionality.

About the Authors

Wil Chin is vice president of marketing and business development at United Electric Controls in Watertown, Mass. Prior to that he was a research director for the ARC Advisory Group, covering asset performance management, condition monitoring, plant asset management, field devices, control valves, communication protocols, and wireless technology. He has also held technical and marketing positions at Krohne and Foxboro (now part of Schneider Electric). He has a bachelor’s degree in mechanical engineering from Northeastern University and a master’s degree in business administration from Bryant College.

Rick Frauton is senior product marketing manager at United Electric Controls, where he is responsible for the One Series safety transmitter product line. Previously he held technical marketing positions at Polaroid Corporation. He has an associate’s degree in electromechanical technology/electromechanical engineering technology from North Shore Community College and a bachelor’s degree in marketing from Northeastern University.