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Technical Article

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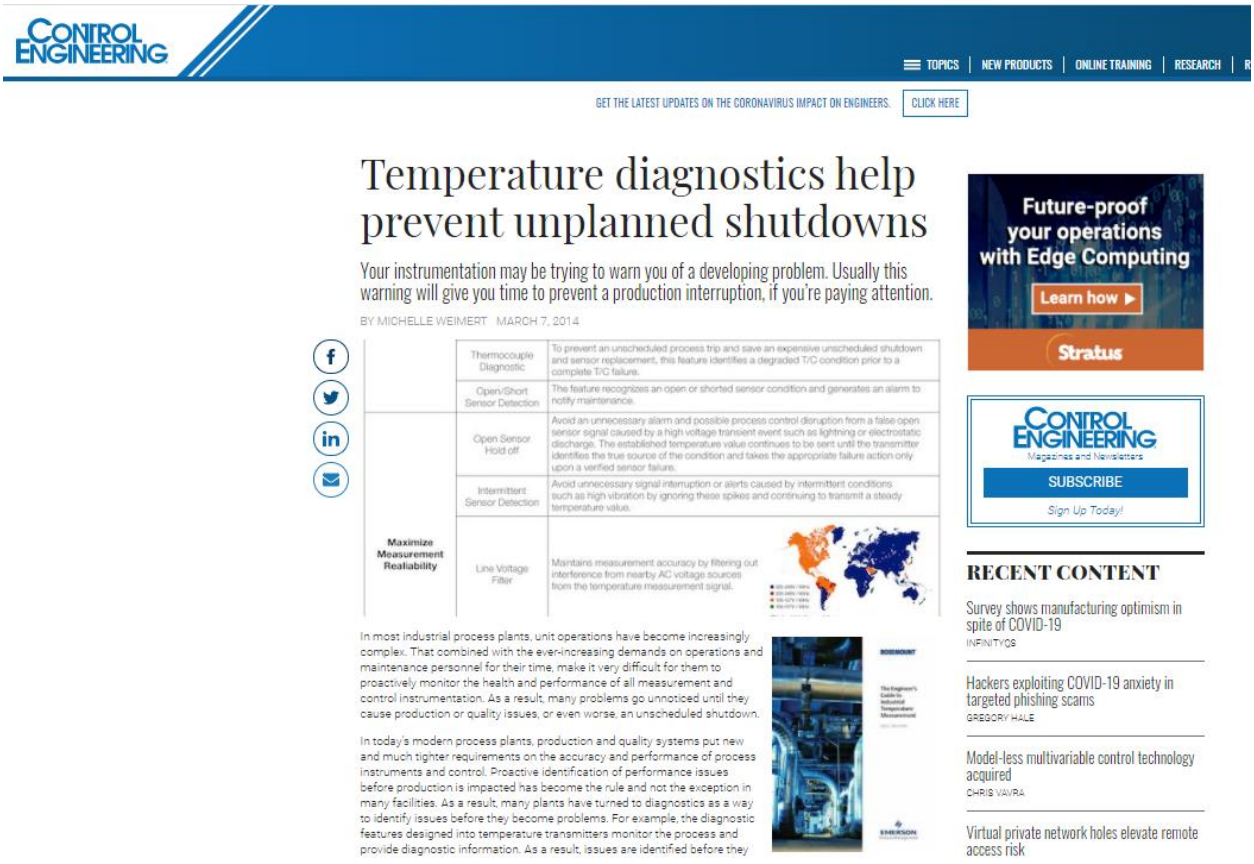

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Temperature diagnostics help prevent unplanned shutdowns

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BY MICHELLE WEIMERT MARCH 7, 2014

	Thermocouple Diagnostic	To prevent an unscheduled process trip and save an expensive unscheduled shutdown and sensor replacement, this feature identifies a degraded T/C condition prior to a complete T/C failure.
	Open/Short Sensor Detection	The feature recognizes an open or shorted sensor condition and generates an alarm to notify maintenance.
Maximize Measurement Realiability	Open Sensor Hold off	Avoid an unnecessary alarm and possible process control disruption from a false open sensor signal caused by a high voltage transient event such as lightning or electrostatic discharge. The established temperature value continues to be sent until the transmitter identifies the true source of the condition and takes the appropriate failure action only upon a verified sensor failure.
	Intermittent Sensor Detection	Avoid unnecessary signal interruption or alerts caused by intermittent conditions such as high vibration by ignoring these spikes and continuing to transmit a steady temperature value.
	Line Voltage Filter	Maintains measurement accuracy by filtering out interference from nearby AC voltage sources from the temperature measurement signal.

In most industrial process plants, unit operations have become increasingly complex. That combined with the ever-increasing demands on operations and maintenance personnel for their time, make it very difficult for them to proactively monitor the health and performance of all measurement and control instrumentation. As a result, many problems go unnoticed until they cause production or quality issues, or even worse, an unscheduled shutdown.

In today's modern process plants, production and quality systems put new and much tighter requirements on the accuracy and performance of process instruments and control. Proactive identification of performance issues before production is impacted has become the rule and not the exception in many facilities. As a result, many plants have turned to diagnostics as a way to identify issues before they become problems. For example, the diagnostic features designed into temperature transmitters monitor the process and provide diagnostic information. As a result, issues are identified before they

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In today's modern process plants, production and quality systems put new and much tighter requirements on the accuracy and performance of process instruments and control. Proactive identification of performance issues before production is impacted has become the rule and not the exception in many facilities. As a result, many plants have turned to diagnostics as a way to identify issues before they become problems. For example, the diagnostic features designed into temperature transmitters monitor the process and provide diagnostic information. As a result, issues are identified before they cause process upsets, dangerous conditions, or measurement failure.

Temperature transmitters have an enormous capability to run full-time diagnostics. Many offer a vast array of options and features to assure that an accurate and stable measurement is reported to the control system. Many of these alerts can prioritize maintenance scheduling for more efficient use of available maintenance resources.

Understanding temperature transmitters and diagnostics

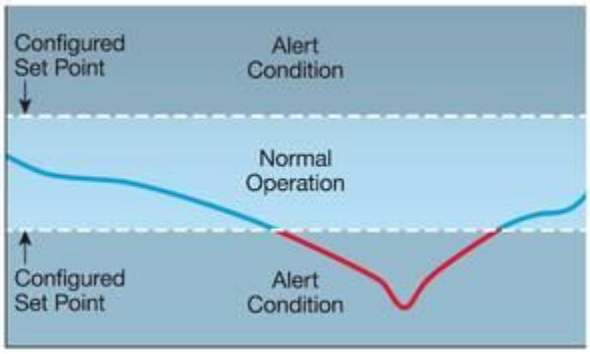
While all smart temperature transmitters have diagnostics, some are considerably more extensive than others. There are normally internal diagnostics that monitor transmitter functionality and output validity. Also, there is a wide range of external diagnostic functions that monitor the measurement signal for drift, degradation, measurement validity, and broken or damaged leads. Of all transmitters that are available, those that use HART, Foundation fieldbus, or Profibus protocols offer a high level of sophistication.

Transmitters initiate either alerts or alarms based upon these diagnostic processes. Alerts cover diagnostics that are determined not to affect the transmitter's ability to output the correct measurement signal reflecting the process variable (PV) and therefore will not interrupt the 4-20 mA or digital fieldbus output. A typical example of an alert could be "PV out-of-range."

Alarms cover diagnostics that are determined to affect the transmitter's ability to output an accurate PV value of the measurement. Detected alarms will drive the transmitter output either high or low depending on the user's configuration choice. Alerts and alarms can be sent to the control system, read on a local indicator, on a field communicator, or on a HART-compliant monitoring system.

Accessing diagnostic information

At a basic level, transmitters with display options will present certain diagnostic messages. Typically, the field operator will routinely check these displays and report any diagnostic conditions to the control system technician group.



The most frequently deployed transmitters communicate using 4-20 mA with HART. This allows them to send a large amount of operational and diagnostic data via the HART signal that is superimposed on the analog output signal of the transmitter. Any or all data may be accessed via:

- A hand-held field communicator
- A HART-enabled capability in the DCS I/O systems to extract and monitor the HART data, and
- A HART-enabled asset management system.

As with traditional wired HART transmitters described above, that same information can be sent using a WirelessHART transmitter or one using ISA100.11a. For Foundation fieldbus and Profibus systems, the operational and diagnostic information available is also very extensive.

The operations-maintenance relationship

Close coordination between operators and technicians to review diagnostic information routinely enables quick identification and resolution of problem situations before they can adversely impact production. One example is in relation to a dual sensor redundant measurement. If an operator gets a diagnostic message that the secondary sensor has been initiated for a transmitter, he or she knows that the primary sensor has failed, and that the measurement is now coming from the secondary sensor. By alerting the maintenance technician, the failed sensor can be replaced, thus restoring the measurement redundancy capability.

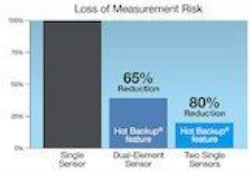
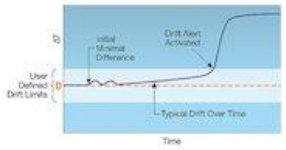
Another example is regarding when the PV is out of limits. An operator receives a "PV out of limits" alert where the HART transmitter is reporting that the primary variable read by the transmitter is outside of the 4-20 mA range. This signal could focus the technician on troubleshooting open or short circuits in the transmitter wiring. Yet another example is regarding analog-digital mismatch. The HART transmitter is reporting a difference between the analog 4-20 mA signal and the digital primary PV signal. This functionality can be used to determine a small ground leakage in the home-run cable to the instrument or an intermittent device. If a small ground leakage exists in the loop, any alarm trip limit of the loop may never be reached, even under trip conditions, due to earth leakage from the signal.

Avoiding the biggest issues

The three biggest issues that diagnostics help you to avoid are measurement failure, poor measurement reliability, and suboptimal process control.

Measurement failure occurs when any of the components of the overall temperature system fail. Temperature sensors are relatively delicate and are exposed to the harsh process environment, making them more susceptible to failure than the other components. The use of redundancy, drift detection, and monitoring of the measurement instrument's diagnostics all help to identify and address sensor degradation or failure.

Measurement reliability is key to minimizing disruptions to the process. The temperature measurement system should be designed to minimize or eliminate the problems caused by sensor degradation, electrically noisy environments, or instrument failure to ensure a reliable

Solution	Capability	Benefit
Avoid Measurement Failure	Hot Backup® Feature	The feature improves process availability by preventing a failure of the primary sensor. It prevents disrupting process control by switching to a secondary sensor and setting an alert. 
	Sensor Drift Alert	Before a sensor failure can adversely affect the process this feature detects degradation or drifting of the sensor and generates an alert. 
	Thermocouple Diagnostic	To prevent an unscheduled process trip and save an expensive unscheduled shutdown and sensor replacement, this feature identifies a degraded T/C condition prior to a complete T/C failure.
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Maximize Measurement Realiability	Open Sensor Hold off	Avoid an unnecessary alarm and possible process control disruption from a false open sensor signal caused by a high voltage transient event such as lightning or electrostatic discharge. The established temperature value continues to be sent until the transmitter identifies the true source of the condition and takes the appropriate failure action only upon a verified sensor failure.
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	Line Voltage Filter	Maintains measurement accuracy by filtering out interference from nearby AC voltage sources from the temperature measurement signal. 
	EMF Compensation	Improves RTD measurement accuracy by monitoring RTD sensor leads and filtering out the small voltages that can be induced on these leads.
	Recall Factory Trim	When calibration issues cannot be resolved, the sensor calibration information originally stored in the device may be recalled.
Optimize Process Control	Diagnostic Log	For better records and easier troubleshooting this feature keeps a history of the device alerts and alarms that have occurred.
	Min/Max Tracking	Facilitates troubleshooting of quality or performance issues by tracking minimum and maximum values of the process and ambient temperatures.
	Transmitter-Sensor Matching	Improve measurement accuracy by at least 7:1 by matching the transmitter to the actual RTD curve vs. the standard curve thus minimizing the offset error.
	Configurable Process Alerts	Configure alerts that are customized to your application for critical temperatures and/or diagnostic conditions.
	Ambient Compensation	The feature improves measurement accuracy by compensating for ambient temperature variations within the transmitter.
	Measurement Validation	Enduring visibility of measurement and process abnormalities before a sensor failure occurs by monitoring and validating temperature measurement data.

measurement. The design should use such features as noise filtering, measurement validation, drifting sensor identification, and alerts for broken or loose sensor leads.

The ultimate goal of providing an accurate and reliable measurement signal is to ensure process control reliably keeps the process within its predetermined limits. The diligent use of transmitter diagnostic features can identify situations where these limits are violated and identify and quantify the deviations. They can identify intermittent sensor failures, record minimum and maximum process temperatures, and log failures and their causes. Using this information can support rapid response to address identified issues, to ensure optimal process control is maintained.

Each approach has its own benefits

Many benefits can be gained by using diagnostics in a manufacturing process. A few have been outlined in Chart 1. For example, measurement failure is related to sensor failure. As mentioned earlier, sensors are relatively delicate, but for the sake of getting the most accurate readings, they must be exposed to the often-harsh process environment, making them more susceptible to failure than the other components. Without an accurate and reliable measurement signal, control will be sub-optimal, and the system will be unable to keep the process within predetermined limits.

The bottom line

Judicious use of the diagnostics available in almost every temperature measurement system provides a return on this investment (ROI) in proportion to the criticality of the measurement. The investment is mostly in time spent, and the ROI may be measured in increased throughput, higher product quality, less downtime, less product waste, lower energy costs, or more subjectively, prevention of an explosion.

Your instrumentation provides the means to look into the process. Using diagnostics provides a way to keep that window clean.

Key concepts:

- Diagnostic information from smart transmitters can warn of problems developing with a process sensor.
- The physical delicacy of temperature sensors makes them particularly susceptible to damage or degradation.
- Your ability to control a process depends on the accuracy and reliability of your instrumentation. Diagnostics help ensure that reliability.