Advanced diagnostics embedded in a pressure transmitter can detect integrity issues

7 February, 2012Erik Mathiason, Jessica Lo and Natalie Strehlke comments

Pressure transmitters measure pressure, flow, or level and may be used to control or monitor changes in a process. To receive these measurements, an operator relies on successful communication between the transmitter and the host system.

A pressure transmitter with advanced diagnostics technology can detect issues with the integrity of this connection and proactively alert the operator of the possibility of miscommunication

This technology can also provide a means for early detection of abnormal situations in a process environment.

Having comprehensive diagnostic coverage improves the transmitter's overall safety levels to the highest levels seen in the industry. Advanced Diagnostics technology enables the user to respond to changes in both the process and electrical loop, troubleshoot, and proactively prevent future shutdowns.

Electrical Loop Integrity

Most pressure transmitters communicate using the 4-20 mA analog signal. To allow more information to be introduced into traditional automation networks, the HART (Highway Addressable Remote Transducer) Protocol was created as a standard for sending and receiving digital information via existing analog wiring.

HART technology has been used to introduce many new transmitter innovations by utilizing this digital signal. In order to accurately obtain all of the information that is being communicated by the transmitter, an operator relies on the integrity of the electrical loop.

Advanced Diagnostics embedded in the pressure transmitter provide detection capabilities for failure modes that could occur in the electrical loop, such as power supply failures and on-scale measurement failures.

Power Advisory Diagnostics monitor transmitter terminal voltage and sends notifications of unwanted changes on the electrical loop. Characterization of the electrical loop is completed when the diagnostic is enabled.

The transmitter then automatically drives the terminal voltage to its low (20 mA) voltage and high (4 mA) voltage outputs. The characterization constructs a linear line between the two points (similar to Figure 1 below), and sets high and low voltage deviation limits that are parallel to that line.

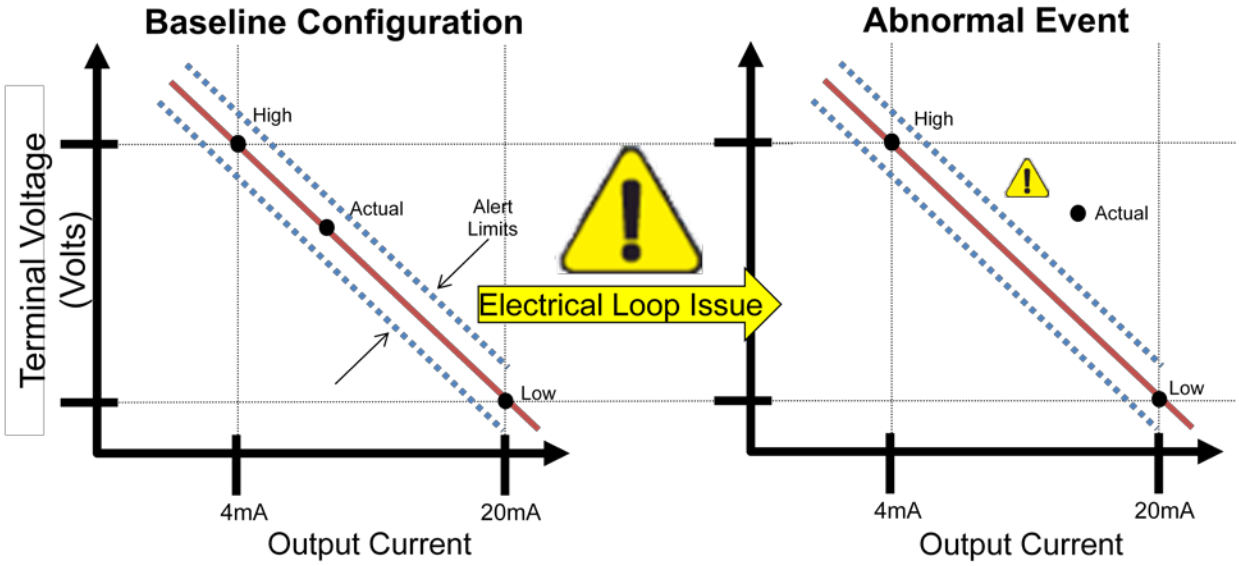

Figure 1: Power Advisory Diagnostic Technology

When a deviation outside the limit occurs a HART alert or analog alarm will be sent to the host system.

Many abnormal events can compromise the integrity of an electrical loop. From rainstorms to faulty power supplies to corroded terminals, each one of these events can cause the control system to receive an incorrect 4-20 mA signal from the transmitter.

An issue that can occur is condensation accumulating in the terminal compartment, a result of poor conduit sealing. With enough water in the compartment a short may occur, causing an incorrect output signal (see example in Figure 2 below).

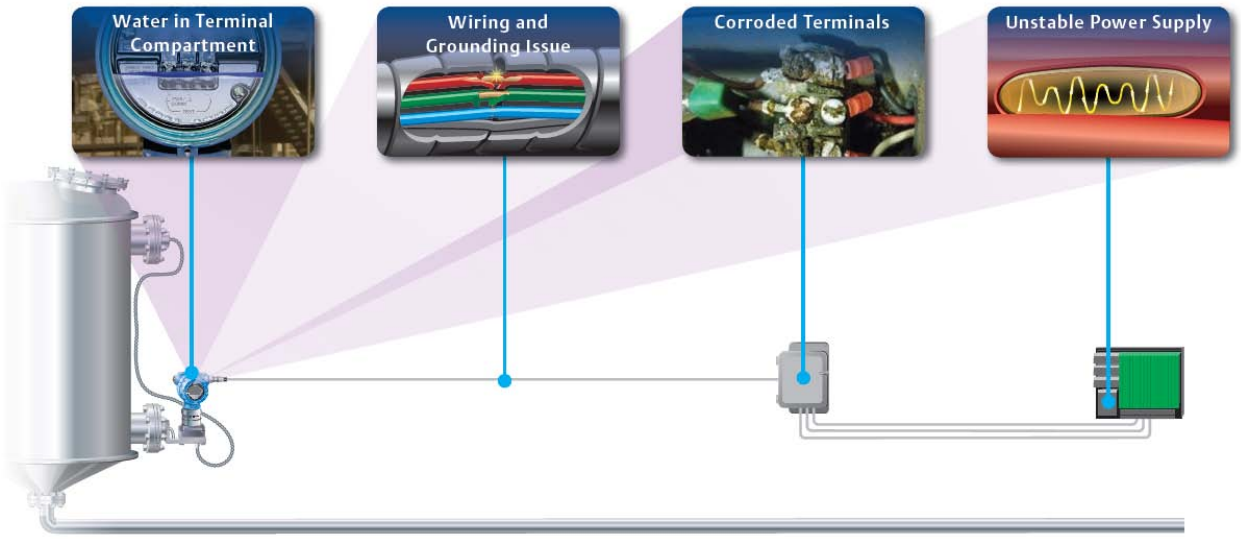

Figure 2: Examples of Electrical Loop Issues Detectable by Power Advisory Diagnostics

Spike in Output

Another issue that Power Advisory Diagnostics can detect is an unstable power supply. Power supplies that drift or spike in output often indicate that the power supply is faulty and unreliable.

Also, if the supply voltage decreases the transmitter may not have enough power to reach a high alarm value.

Power Advisory Diagnostics calculates the power supply input and compares it against the characterization that was recorded during setup.

This ensures that the varying power supply is not compromising the electrical loop. Advanced Diagnostics can detect certain types of on-scale failures by monitoring the transmitter power consumption and the 4-20 mA output.

Monitoring the transmitter power consumption is critical to ensure that it can drive the appropriate alarm action when required. The transmitter should not consume more than 3.6 mA of current so it can drive to low alarm.

Additional diagnostics verify that the analog 4-20 mA loop accurately reflects the pressure value.

The conditions described above could result in an analog on-scale failure or even a loss of HART communication.

Safety Coverage

One measure of safety coverage, as defined per IEC 61511 “Functional Safety: Safety Instrumented Systems for the Process Industry Sector,” is the Probability of Failure on Demand or PFD.

PFD is defined as the probability that the SIS loop or device (transmitter) will have a failure or be in a failure mode upon demand when needed during a hazardous situation. This is undesirable as it impacts the ability for the SIS loop to function properly and prevent a catastrophic event from occurring.

The Probability of Failure on Demand of a transmitter is heavily influenced by the transmitter's dangerous undetected failures. Dangerous undetected failures are identified during a Failure Modes, Effects and Diagnostics Analysis (FMEDA), conducted by a third party.

During this activity the circuitry is analyzed component by component and each assigned failure modes. Each failure mode is classified as safe detected, safe undetected, dangerous detected and dangerous undetected and then assigned a probability.

The numbers are based on the type of component and a large database of historical failure rates. Dangerous undetected failures are the most concerning as they may result in the transmitter not being able to perform properly during a safety shutdown event.

A typical example of a failure that can occur within an electrical loop is a brown out. This is where there is enough power for the transmitter to operate but not enough power for the transmitter to reach 20 mA or to go to high alarm.

Process noise

Process diagnostics is where the transmitter uses Statistical Process Monitoring to look at process noise and detect an abnormal process condition.

The transmitter first generates a process noise baseline and will tell you if it has changed outside the limits you configure. A typical example of a failure in this area is plugged impulse lines (see Figure 3 below).

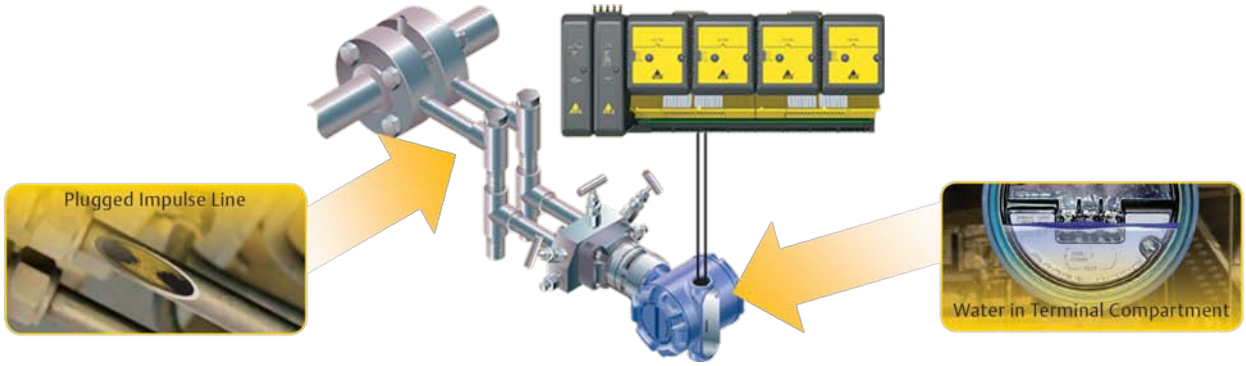

Figure 3: Comprehensive Protection from the Process to the Host

Many other failures can be detected as well including loss of agitation, change in aeration or solids, and pump cavitations.

When you factor in the internally focused diagnostics, as well as electrical loop and process diagnostics, you can achieve the safest, most reliable transmitter for use in an SIS system.

In conclusion, Advanced Diagnostics embedded in a Rosemount 3051S Pressure Transmitter can provide a means to ensure the operator is receiving the correct data values from the transmitter.

This comprehensive detection coverage increases the pressure transmitter’s overall safety levels to the highest in the industry.

Advanced Diagnostics technology enables the user to proactively respond to changes in both the process and electrical loop, troubleshoot, and prevent future shutdowns.

Tech Specs

The Rosemount 3051S Pressure Transmitter with advanced diagnostics technology claims to have the industry's highest diagnostic coverage with a Safe Failure Fraction of 96.7 percent and the lowest dangerous undetected failures, resulting in the lowest PFD transmitter on the market. To achieve this rating, a number of internal transmitter focused diagnostics were added, such as power consumption and mA output. This transmitter can detect external failures that occur in the electrical loop and process that may otherwise go undetected. Electrical loop diagnostics is where the transmitter learns the voltage characteristics of the loop and alerts the operator if something changes.

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