WHITEPAPER

Advanced Pressure Diagnostics Provide Valuable Insight into Your Process

EMERSON
Process Management

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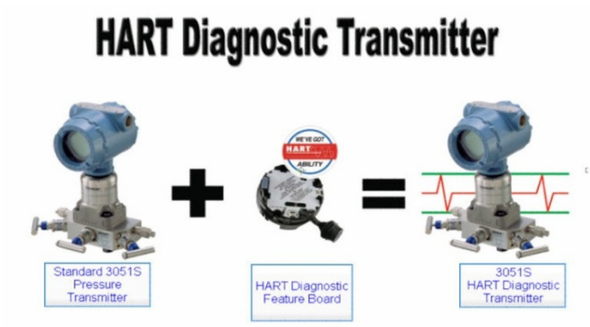
Advanced Diagnostics embedded in a Pressure Transmitter can proactively detect abnormal process conditions

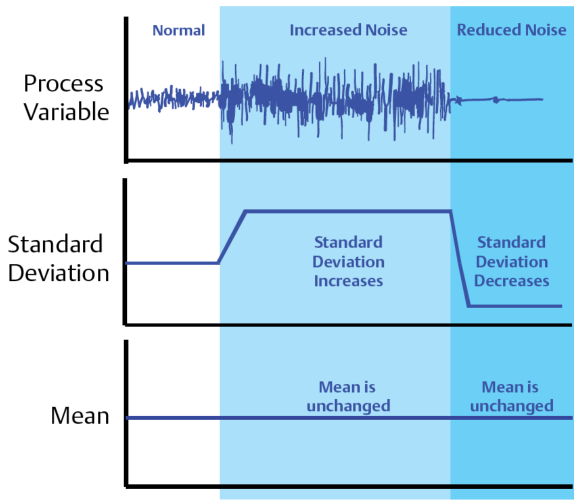
Pressure transmitters measure pressure, flow, or level and may be used to control or monitor changes in a process. Although plants make every effort to instrument and control their process effectively, there may be abnormal conditions that could cause a loss of production, plant shut-down or safety hazard. Advanced Pressure Diagnostic technology provides a means for early detection of abnormal situations in a process environment. This technology can also detect integrity issues in the electrical loop that connects the transmitter to the host system. Advanced Diagnostic technology enables the user to proactively respond to changes in the process, troubleshoot, and prevent future shutdowns.



ADVANCED PRESSURE DIAGNOSTICS

Emerson Process Management has developed a unique patented technology that provides a means for early detection of abnormal situations in a process environment. The technology, called Statistical Process Monitoring (SPM), is based on the premise that virtually all dynamic processes have a unique noise or variation signature under normal operation. Changes in these signatures may signal that a significant change in the process, process equipment, or transmitter installation will occur or has occurred. For example, the noise source may be equipment in the process such as pumps, agitators or the natural variation in the DP value caused by turbulent flow or any combination thereof.

The analysis of the unique signature begins with a high speed sensing device such as the Rosemount 3051S Pressure Transmitter equipped with patented software resident in a HART® Diagnostics or FOUNDATION™ fieldbus Feature Board. This powerful combination has the ability to compute statistical parameters that characterize and quantify the noise or variation and represent the mean and standard deviation of the input pressure. Filtering capability is provided to separate slow changes in the process due to intentional set point changes from inherent process noise which contains the variation of interest.



The transmitter provides the statistical parameters to the host system via HART or FOUNDATION fieldbus communications as non-primary variables. The transmitter also has internal software that can be used to baseline the process noise or signature via a defined learning process. Once the learning process is completed, the device itself can detect changes in process noise and will communicate an alarm via the 4 – 20 mA output or alert via HART or FOUNDATION fieldbus.

DIAGNOSTIC APPLICATIONS

The use of Advanced Diagnostics has many applications including:

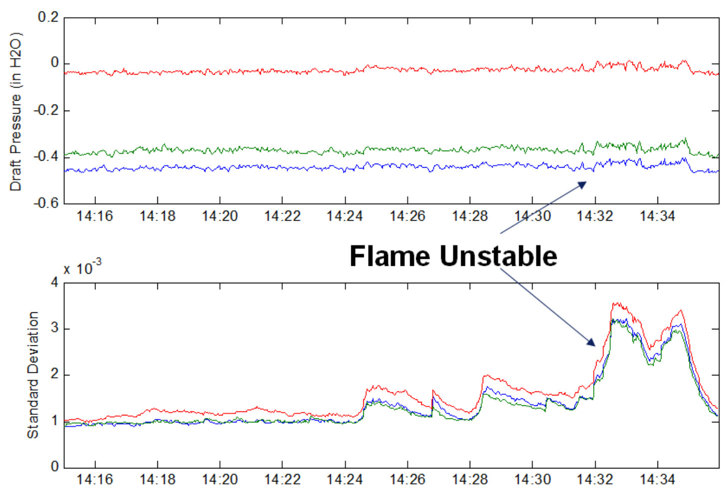
- ***Furnace Flame Instability***
- ***Process Leak Detection***
- ***Pulsation Induced Flow Measurement Error***
- ***Entrained Gas***
- ***Distillation Column Flooding***
- ***Plugged Impulse Lines***
- ***Power Advisory Diagnostics***

FURNACE FLAME INSTABILITY

Furnaces are found throughout many industries including chemical, power, and refining. A large refinery may have dozens of furnaces. One common problem that occurs in furnaces is instability in the burner flames. When a flame goes unstable, it gives a “flickering” appearance. The furnace operator will attempt to bring the burner flames back to stability, normally by adjusting either the air or the fuel into the furnace. If the instability is not immediately corrected, it could lead to a flame-out, a dangerous condition of unburned fuel left in the firebox. This unburned fuel presents a hazard because if it does light up, the uncontrolled combustion could damage equipment, and pose a safety hazard to anyone in the vicinity. If a flame-out does occur, the furnace operator may have to shut the furnace down, taking part of the process offline, and resulting in a costly loss of production to the plant.

Because of the importance of keeping furnace flames healthy, many different technologies have been tried for monitoring burner flames, such as thermal measurement, flame sensors, combustion analysers, and photographic or optical techniques. Another method is simply mounting a camera in the furnace and viewing the burner flames on a monitor in the control room. These technologies all have shortcomings, such as being reactive (detecting only after the flame is out), subject to false alarms, or expensive to install and maintain. However, most furnaces utilize one or more pressure transmitters at the firebox to measure the inlet draft pressure.

Recently, it has been shown that by using a pressure transmitter with Advanced Diagnostics for this measurement, it is possible to gain insight into the health of the burner flames, and to gain an early detection into flame instability. Instability in furnace flames can be detected using advanced pressure diagnostics. During normal operation a burner has a relatively solid and steady flame. But when a burner flame goes unstable, it is evidenced by a flickering in the flame, producing pressure fluctuations that can be seen by a pressure transmitter measuring the inlet draft of the furnace. A pressure transmitter with advanced diagnostics can detect this flickering as an increase in the standard deviation.



PROCESS LEAK DETECTION

The use of impulse lines, manifolds and bleed valves in measurement instrumentation process connections is a universal practice. Over time these connections may degrade due to vibration, temperature changes, wear, damage or neglect resulting in process leaks. Traditionally, identifying these leaks requires specialized and expensive equipment or frequent and costly visual inspections. In many installations, transmitters are located in remote or restricted areas where a leak could go undetected for extended periods of time. This, in turn, translates into higher operating costs, lost product, negative impact to the environment and also places personnel at risk of injury.

Providing the end user with an accurate and reliable PV along with a real-time indication of the integrity of the process measurement is a very powerful combination. A pressure transmitter with Advanced Diagnostics is capable of detecting process leaks at the bleed valves, at the manifold and along the impulse lines. A leak at any of these points changes the level of process dynamics as measured by the pressure transmitter. This change in dynamics is reflected to the user as a drift or a shift in standard deviation.

Secondary or supporting evidence of a process leak is also available by monitoring the pressure mean (average) variable. A leak, having gone undetected and worsening with time, will directly affect the pressure mean value. In a LP application, mean will always decrease with the presence of a leak as line pressure is no longer being completely contained. In a DP application with fixed flow rate, mean will increase or decrease depending on which side (high or low) the leak has occurred.

Using the standard deviation and mean process variables in tandem makes for a clear method for process leak detection. The instantaneous feedback from the transmitter allows for quick maintenance response, reducing lost product and improving safety.

PULSATION INDUCED FLOW MEASUREMENT ERROR

When using DP to determine flow rate, the square root of the DP is proportional to flow and is considered to be a very accurate measurement when operating under steady state conditions. When the process is unstable, for this example due to pulsations caused by pumps, compressors or control valves, the output will indicate a higher than actual flow rate.

Prior work on identifying Percent Square Root Error (%SRE) has taken the form of methods to significantly increase the rate at which DP is sampled to achieve a virtual instantaneous DP reading. This technique effectively eliminates the square root error through its ability to report the average of the instantaneous square root of the DP, considered by industry to be an accurate representation of true flow rate. Previously no device was available to provide both a reliable and accurate pressure measurement as well as offer an indication of the presence of process pulsation until now. The 3051S equipped with an Advance Diagnostics feature board satisfies both of these needs.

Pulsation induced errors are related to an increase in noise relative to the fundamental pressure signal (the coefficient of variation) and have been demonstrated to be an excellent tool to represent pulsation induced errors. A pressure transmitter with Advanced Diagnostics can provide early warning of process, equipment and installation problems related to process pulsation.

ENTRAINED GAS

Issues with entrained gas in process fluids impact nearly every aspect of industrial applications. Negative effects due to entrained gas can be divided into three categories; measurement error, equipment risk and efficiency loss.

Measurement precision, the ability to make consistent repeatable readings of a process fluid containing entrained gas, becomes increasingly difficult as the gas content rises. For example, the density variation of two-phase flow will be translated into an increase in noise on the differential pressure (DP) output. This noise will reduce the probability of routinely achieving a repeatable process measurement. Adverse effects on equipment include an increased likelihood of pipeline vibration, higher susceptibility to cavitation and an undesirable level of ambient noise around the process loop.

Two-phase flow, in this instance liquid and gas, can escalate into a situation where fluid sections of significantly varying densities interact with the process infrastructure creating strong vibration forces. The results of this flow condition range from an increase in ambient process noise to fitting and seal leaks and finally structural failure of the system. Entrained gas will lower heating and cooling efficiencies, decrease system response times, cause process fluid foaming and inadvertent process fluid aeration. As one example, closed loop boilers frequently include a deaerator in the feedwater line to minimize entrained gas in the steam system due to the detrimental effect of trapped gasses on heat transfer. Another common problem consists of pipe, valve, fitting or pump leaks leading to the unexpected introduction of air to the process.

Advanced Diagnostics provide the user with an indication of changes to the gas content of a process fluid across a wide spectrum of flow rates by monitoring the coefficient of variation. This diagnostic is particularly effective when operating in the Plug or Slug flow regimes. Flow conditions in the Bubble regime, a result of higher liquid flow rates, are shown to influence the ability of the transmitter to distinguish changes to Gas Volume Fraction (GVF). Advanced diagnostics can calculate and communicate the required statistical parameters via HART or FOUNDATION fieldbus digital communication protocols, readily providing users with additional insight into their process conditions. With this capability, operators can have an indication of significant changes in GVF that affect the measurement repeatability, equipment health and process efficiency.

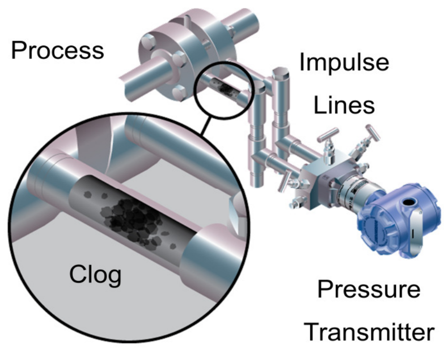
DISTILLATION COLUM FLOODING

Distillation is a common unit operation, which is used to separate or purify components in a feed stream. Flooding is a common abnormal process condition wherein the distillation column stops generating a separation, thus causing the quality of the top and/or bottom products to go off specification.

The Rosemount 3051S Pressure Transmitter with Advanced Diagnostics can be used to detect incipient flooding in real time, and provide an early warning. The onset of distillation column flooding is associated with a change in the flow regimes of the gas and liquids flowing inside the column. The flow regime associated with flooding generates more high frequency white noise, which can be detected in the DP signal across the column. Advanced Diagnostics available on both the Rosemount 3051S HART transmitter and the 3051S Fieldbus transmitter are able to use this phenomenon to generate an Incipient Flooding alert. When an operator is made aware that the column is approaching flooding, adjustments can be made to prevent the column from becoming completed flooded.

PLUGGED IMPULSE LINES

In many instances pressure transmitters are installed with impulse piping that can become plugged with solids or frozen in cold environments. Figure 3 shows common examples of causes of plugged impulse lines. The user typically has no idea that this has occurred because the pressure is effectively trapped between the plug and the transmitter, resulting in the pressure measurement not responding to changes in the process.
The trapped pressure causes a change in the process noise, which can be seen by the SPM technology and can be used to detect plugging in either one or both impulse lines. Using SPM technology to detect impulse line plugging may increase the Safe Failure Fraction and safety rating of the measurement point.



Examples of Plugging Methods by Fluid Type

Fluid	Residue [1]	Freezing [2]	Crystallization
Steam	X	X	
Caustic		X	X
Hydrocarbon	X	X	

[1] Residue can be any type of junk / rust / debris that gets into the process, such as from some upstream source, or from corrosion in the pipes

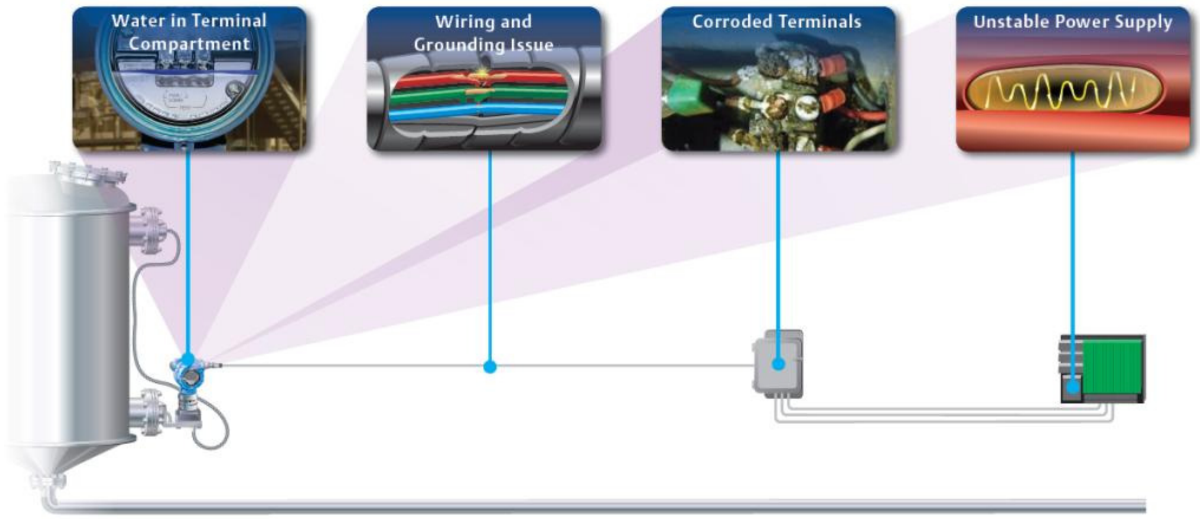
[2] Survey in Europe estimated that 60% of heat trace systems are not working properly. (Daiber and Hughes, cited in NEL Flow Programme Paper: Guide to Impulse Lines for DP Flowmeters.)

POWER ADVISORY DIAGNOSTICS

The integrity of the electrical loop from the transmitter to the host system is critical for communicating process information from the field.

The Rosemount 3051S provides loop diagnostic monitoring to help detect conditions that may jeopardize plant operations. These diagnostics can advise of changing electrical loop conditions such as water in the housing, ground loop issues, or an unstable power supply. If undiagnosed, these conditions may lead to unreliable measurements and unsafe operating conditions.

This diagnostic works by first determining the baseline conditions of the electrical loop. During configuration, the transmitter drives the output current to 4mA and 20mA to record the resistance and power supply values. This draws a linear relationship for the terminal voltage and output current. This relationship is linear because in the ideal installation, loop resistance and power supply values should never degrade or change. Thresholds can then be configured by the user to provide an alert if the value of the output current is outside of the baseline. When this happens, we know two things: 1. the loop resistance has changed or 2. the power supply has changed. For example, a change in the loop resistance usually means that there's water or corrosion on the terminals.



DIAGNOSTIC INTELLEGENCE YOU CAN USE

The insight provided by these diagnostics has the most value, when they are presented in a form that that is highly intuitive and provides knowledge about the process rather than just data.

Emerson Process Management provides Device Dashboards which have been developed using a Human Centred Design methodology that focuses on understanding and meeting human needs rather than on technology and features. These Device Dashboards are focused on reducing complexity and removing unnecessary work to improve productivity.

CONCLUSION

Advanced Diagnostics embedded in the Rosemount 3051S Pressure Transmitter turn noise into intelligent process information to help process units predict abnormal situations in their applications and use that information to enable preventative maintenance practices to better improve quality control, improve productivity and efficiency and increase operational safety.

To learn more or to organise an onsite demonstration of how Advanced Diagnostics can help you prevent abnormal situations in your plant, please contact;

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