

White Paper

Tips to Address Temperature Measurement Reliability Challenges



Executive Summary

Temperature is one of the most common yet critical measurements in any process industrial plant. While the technology employed in measuring temperature has remained the same over the years, many methods have emerged to counter the challenges that impact measurement reliability.

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Measurement Challenges

Temperature is one of the most common yet critical measurements in any process industrial plant. While the technology employed in measuring temperature has remained the same over the years, many methods have emerged to counter the challenges that impact measurement reliability. These challenges include:

- Measurement variation due to drift in the device
- Noise interference
- Degradation of sensor performance
- Ambient temperature variation

These challenges can be overcome by choosing a temperature transmitter with the right features and functions.

Measurement variation due to drift in the device

Drift of zero or span in temperature transmitters is a major source of measurement variation. It is impossible to trust the reliability of a device that is not stable. While calibration is a proven solution to eliminate drift, this cannot be done frequently enough considering there can be thousands of installed devices that are often located in remote and difficult to reach areas.

This becomes even more critical when temperature measurements are used for fiscal metering in gas pipelines. Imagine a pipeline transferring hundreds of million dollars of energy. If there is a variation of 0.1 Deg C in a temperature measurement, this can create a variation of 0.02% in flow measurement resulting in losing several thousand dollars.

In several instances like this, measurement stability is much more important than measurement accuracy.

Noise interference

Process and power plant environments inherently have electrically 'noisy' environments. This noise comes from sources such as rotating high voltage equipment like motors and generators which cause electrical surges. Since temperature transmitters employ low voltage sensors like thermocouples and are often connected by compensating cables, the entire installation from sensing to the actual temperature device is susceptible to interference from electrical surges.

This is compounded when grounded sensors are used. Grounded sensors create ground loops when subjected to electrical transients or lightning strikes. These transients can cause a difference in ground voltages which range from a few hundred volts up to a few thousand volts.



Grounded Thermocouple



Ungrounded Thermocouple

The difference in ground potential between the sensor and the device leads to interference in the measurement loop. These issues are very prevalent in non-ferrous metal processing plants, like aluminum and zinc since the smelters in these industries operate at high voltage. In addition, coal-based power and cement plants have high voltage environments as a result of their material handling sections.

Galvanic isolation in the temperature transmitter is a proven solution to eliminate noise and ground loops. Galvanic isolation separates signal currents from noise currents and will eliminate interference. Galvanic isolation is now available for up to 2000volts as opposed to few hundred volts.

Another source of noise is caused by thermocouples when they are attached to a conductive material such as steel or are submerged in conductive liquids such as water. When they come into contact with any conductive material, thermocouples are susceptible to common-mode noise. Isolation can dramatically improve the rejection of common-mode noise. With conductive materials that have a large common-mode voltage, isolation is required. In the absence of isolation, amplifiers cannot measure signals with large common-mode voltages.

In addition, all plants have electromagnetic interference (EMI) and radio frequency interference (RFI). They interfere with the low level signals generated by temperature sensors and carried through extension wires. It is very important that the temperature sensors are immune to these interferences. EMC compliance to IEC61326 is mandatory for use in noisy environments.

Degradation of sensor performance

Temperature measurement reliability is directly linked with temperature sensor health. Sensors start degrading the moment they are manufactured. They are made by combining dissimilar metals and are prone to corrosion and degradation. When sensors are installed in tough industrial process environments, sensor degradation accelerates.

There are thousands of temperature sensors in difficult to reach locations in a process facility. This makes it critical to keep a continuous watch on their health. Operating the plant based on temperature readings with a poor sensor will result in faulty measurements leading to poor yield, and in extreme conditions, a plant shutdown.

Current temperature transmitters have the intelligence to learn the resistance characteristics of all their thermocouple sensors. This intelligence can be customized based on the unique baseline determined for every installation. This gives the users a real-time view of sensor health instead of just sensor status information such as “good” or “bad”.

The table below represents the resistance per unit length for various types of thermocouples. The resistance varies based on the type of thermocouple, thermocouple element size and the size of the cable.

TC - Loop Resistance Chart - Ohms per Foot - 3/16" Probes (20 awg wire)	
Type J	0.367
Type K	0.589
Type T	0.304
Type E	0.709
Type N	0.783
1/4" Probes (18 Awg wire)	
Type J	0.234
Type K	0.376
Type T	0.194
Type E	0.453
Type N	0.5

An alert can be generated when the loop resistance crosses the trigger level. It can be made available locally in the device display as well as in the instrument asset management system to identify and implement necessary thermocouple maintenance or replacement.

The sensor health trend can also be shown in the local display on a continuous basis, just like the process temperature display. This helps not only avoid bad PV measurements, but also optimizes sensor health to minimize the risk of a plant shutdown.

Although several manufacturers provide sensor diagnostics, the level of visibility is limited to just a static status of the sensor health. In some cases, the user can only depend upon the instrument asset management system in the control room. This is due to the limitations of the transmitter display which are typically only preformatted or segment-type liquid crystal displays that can only show basic process variable information. Advanced display technology based on graphical displays, versus character based displays, do not have this limitation.

Suppliers can also enhance measurement reliability by using two separate temperature sensors in a redundant mode or differential mode.

In a redundant mode, in the event of a primary sensor failure, the temperature sensor can transfer the loop control mode to the second sensor and ensure uninterrupted measurement.

There are situations where one sensor can degrade or drift faster than the other or one can show erroneous readings compared to the other. In these situations, it is possible to set up a drift alert limit detecting a variation between two sensors installed in the same location/application. If the reading exceeds the set limit, an alarm can be generated or the sensor can be switched to the second sensor.

Ambient temperature variation

Ambient temperature is one of the critical parameters impacting transmitter performance. Current transmitters employ an exclusive temperature sensor closer to the electronic module to monitor the ambient and Cold Junction temperature. This is used to adequately compensate for the variation in the process temperature measurement. In addition to this, the higher and lower limits are monitored to ensure the device is not subjected to abnormal limits. Alerts are set for the higher ambient or cold junction temperature so that a bad PV condition is eliminated. This alert helps the plant take timely action to avoid conditions that will degrade the life of the device.

Conclusion

Reliable temperature measurement requires temperature transmitters capable of delivering stable performance under noisy environments and addresses the challenges associated with sensor performance. To ensure reliable temperature measurement in harsh and noisy environment, users should evaluate the following transmitter features:

- ✓ Long-term stability performance
- ✓ Galvanic Isolation in thousands of volts to avoid ground loops and eliminate interference from electrical transients
- ✓ High common mode rejection capability to make measurements immune to common mode noise
- ✓ Sensor health diagnostics for thermocouples to avoid bad process temperature measurements
- ✓ Transmitter graphical display capable of showing a dynamic sensor health trend
- ✓ Hot back-up redundancy with dual sensors for improved availability
- ✓ Enhanced measurement reliability through sensor drift measurement and alert functionality with dual sensor inputs
- ✓ Built-in compensation for ambient temperature variation

For example, Honeywell's SmartLine Temperature Transmitter offers industry-leading performance with:

- ✓ Stability of 0.05% of span per year
- ✓ Built-in galvanic isolation level of 2000VAC
- ✓ High noise immunity for common as well as series mode noise
- ✓ Superior sensor health diagnostics capabilities on a graphical display
- ✓ Dual sensor input capability for redundancy as well as sensor drift alert
- ✓ Superior ambient temperature compensation

For More Information

To learn more about Honeywell's SmartLine Temperature Transmitters, visit our website <http://www.honeywellprocess.com/smartline> or contact your Honeywell distributor.

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