Overcome temperature measurement installation challenges with best practices

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Your design looks great on paper. Now it has to work just as well in the real world, so make sure you install it using the same care.

You have designed and purchased the optimal temperature measurement system to meet the performance requirements of your process. Your job is done, right? Wrong, because if it is not installed properly, the actual measurement results can fall far short of expectations. The field installation technician must understand the design decisions that were made to ensure that the "as installed" details agree with the "as designed" specification.

Best practices for proper installation

The level of effectiveness of a temperature system (a sensor with a connection head, a thermowell, and a transmitter) is dependent upon several factors including proper installation. If you were not the design engineer, you may not know what decisions were made about such things as mounting location, mounting style, what the immersion depth should be, or what the environmental conditions are at the intended mounting location. Therefore, several installation factors should be considered, including the installation, point-of-penetration, insertion length, mounting, and installation wiring.

Here are some considerations made in engineering a temperature system and the installation requirements that follow:

1. Locate the point of penetration—Start by locating a suitable measurement point that is representative of the desired measurement and is accessible. Determine the size of the pipe or vessel, the insulation thickness, and the presence of surrounding structures that may impede installation of the thermowell and access for future maintenance or replacement. Take into consideration the dimension of the entire assembly including an integrally mounted transmitter or connection head.

For installations downstream of static mixers, heat exchangers, or other turbulence producing elements, the insertion point must be far enough downstream where the streams have recombined into a homogeneous mixture that flows smoothly. Generally, a downstream distance equal to about 25 pipe diameters is sufficient.

There are special considerations for some other difficult applications like viscous fluids with laminar flow where the temperature at the pipe wall is different than that at the centerline. Insertion length is critical to get to a representative part of the flow at the centerline. Small pipe diameters present more of a challenge where tee fitting mounting or angled insertion may be considered.

After a suitable location is chosen, determine if it will be necessary to drain and clean the pipe or vessel before cutting into it to install the well. Ensure that the appropriate permits and approvals are secured.

2. Verify insertion length and other dimensions—Although the design engineer has made decisions about the thermowell mounting and insertion lengths based on the information at hand, it is incumbent upon the installation technician to verify pipe or tank diameter dimensions to determine that the thermowell provided has the correct insertion length. There is no standard formula to determine the insertion length of the thermowell. Rather, there are a few common practices that process industry plants follow along with good engineering judgment. Ideally, the tip of the thermowell should be located at an optimal process point, typically near the centerline, with flow conditions that represent the true process temperature. A general guideline for insertion length into pipe for optimal performance is 10 times the diameter of the thermowell for air or gas and 5 diameters for liquids.

The other dimensions of the thermowell may be verified by consideration of factors such as:

- Insulation thickness
- Connection type
- Lagging length, and
- Length of any required extensions to protrude through the insulation layer.

Be aware of connection head or integral transmitter housing dimensions added to the extension length relative to interference with nearby structures or equipment at the mounting site. (See Figure 1.)

3. Mounting the assembly—During the design phase, the engineer would have made mounting style decisions about using a threaded, welded, or flanged style of thermowell to meet the required process conditions of pressure rating, fluid velocity, type of fluid, conformance with codes and standards, and plant piping specifications and preferences. Consideration of speed of response, mechanical strength, and wake frequency concerns would have led to a decision of using a straight, tapered, or stepped thermowell profile.

4. Installation wiring—There are several options to consider in choosing how to get the signal reliably from the field sensor to the control system with performance levels required by the application. Figure 2 shows the most common choices.

The most common and preferred installation is a transmitter integrally mounted with the sensor and thermowell. In other cases, the transmitter is mounted separately but near the sensor-thermowell assembly.

Alternatively, sensors are connected to a marshaling cabinet using a twisted, shielded two-wire cable. From there a multi-pair bundle is typically run back to the control room. Ideally, the proper cable types have been specified during the design phase of the project. In all cases the conductors should be twisted and shielded with an outer insulated sheath selected in conformance with the environmental conditions where the wiring trays will be installed. For multi-conductor cables there are many designs. A common design has individually shielded pairs with an overall shield with drain wire for maximum noise protection and has an overall insulated sheath.

The sensor wires and output cables should be pulled through the conduits and fittings and into the transmitter housing and junction box through conduit seals.

Grounding and surge protection

Proper grounding and surge protection can pay huge dividends in enhanced performance. Here are some best practices to improve outcomes.

Follow proper grounding and shielding practices-Each process facility has its own guidelines for proper installation of grounds and shields. These guidelines should be followed where practical and appropriate. However, it may be prudent to verify that these guidelines are appropriate for your installation and, if in doubt about how to proceed, consult with the on-site electrical team leader and/or refer to the guidelines below.

Option 1. Remote mount with two separate grounding points-Connect the sensor shield, if supplied, only at the remount mount head and ensure that it is not connected at any other point and is electrically isolated from any grounded equipment. Ground the signal wiring shield only at the power supply end to an instrument system grounding point and ensure that the transmitter end is carefully isolated. (See Figure 3.)

Option 2. Remote mount with a continuous shield-Connect the sensor shield only to the signal cable shield and ensure that it is electrically isolated from the transmitter and all other field equipment. Alternatively, connect the signal cable shield to instrument system ground only at the power supply end. (See Figure 4.)

Option 3. Integral mount-Ground the signal wiring shield at the power supply end only to the instrument system ground ensuring that it is electrically isolated from the transmitter housing and all other field equipment. This is used for integral mount installations. (See Figure 5.)

One additional tip: The instrument system ground should not be connected to a power wiring ground which can carry noise, surges, and spikes that could interfere with measurement signals and/or destroy transmitters. An instrument system ground must be a very low resistance path to an earth grounding rod or grid.

Transient and surge protection

In many plant environments surges from lightning and other induced transient overvoltage events can cause spikes and surges at high voltage levels. Adding protection from measurement errors or damage caused by these surges may be a prudent consideration. High-end transmitters offer transient suppression options that can be integrally mounted within the housing. (See Figure 6.)

Configuration and calibration

Depending on the ordering specification, the sensor and transmitter assembly may have been factory configured and calibrated to the specific process requirements, but if that isn't spelled out clearly, don't assume it's happened. It is always advisable to verify all settings to ensure that they conform to the latest revisions of the loop drawings. The vendor's user manual will provide guidance on such things as ranging, alerts, alarms, damping, and diagnostics.

Once the transmitter is configured, calibration may be required. This calibration may have been performed by the manufacturer, in which case it should not be changed. It may be good practice, however, to verify the sensor-transmitter integrity by using temperature baths or blocks to exercise the system over its range.

Commissioning

Commissioning has been referred to over the years as "ringing out the system," or "loop checking the system." Whatever the name in your facility, the task is the same. It includes verifying every connection of every loop is properly secured, tagged, and connected at both the field and control room ends. It further includes an operational check of each loop to verify that all settings are properly set and that the functionality of the design has been implemented. Extensive use of loop sheets and instrument specification sheets helps to guide this procedure. For a SIS (safety instrumented system) it is mandatory to document this procedure completely.

Ensuring optimal performance and accuracy

Before installing a system, it might be wise to review this guidance to verify that the design you are going to install is the best choice for the intended application. Should any changes be required, it is less expensive to change it while still in the shop instead of in the field.

Some of the more critical tips for ensuring the best accuracy and performance of your temperature measurement system include:

- For many applications a properly specified RTD sensor should be the first choice unless the temperature range exceeds 600 °C. Up to 850 °C, the choice is application driven; over 850 °C, a thermocouple is the only practical choice.
- Mount the sensor integrally with the transmitter whenever possible to minimize noise pickup on the sensor lead wires.
- Use a transmitter in a dual compartment housing to minimize environmental influence on the transmitter.
- Use a stepped thermowell for fastest response.

- Perform a wake frequency analysis to ensure selection of a proper thermowell configuration that will withstand the vibration caused by vortex shedding as the process fluid flows past the thermowell.
- Specify sensor-transmitter matching wherein the transmitter is configured to use the sensor-specific CVD constants which characterize the sensor, thus providing outstanding measurement accuracy.
- Consider use of dual element sensors or two separate sensors for redundancy and drift monitoring.
- For installations in electrically noisy environments, specify transient protection.
- Consider specifying and using transmitter intelligent filtering, diagnostics, and other options to enhance measurement integrity, reliability, and accuracy.

As-designed meets as-installed

It is often the case where design and instrumentation specifications are done before P&IDs and other drawings are finalized. Therefore, it is always important for the installation team to verify that the system specified by a design engineer meets the actual final design requirements of the application. The more critical the measurement, the more attention that should be given to every installation detail.

It is much easier and cost effective to do it right the first time instead of delaying a start-up or requiring an unscheduled shutdown to make system changes or to correct installation problems.