A flexible solution to a maintenance dilemma

Despite being used inside thermowells for a number of years, rigid temperature sensors are a nightmare for maintenance departments, says **Robert Pool**, sales engineer at Process Measurements & Monitors, a systems integrator based in Baton Rouge, LA. A solution, however, can be found through the use of flexible sensors from Moore Industries which can go where rigid sensors cannot

As a systems integrator that services refineries and chemical plants in Louisiana, we find that the biggest maintenance headache our customers have is temperature sensor replacement. Rigid temperature sensors, used inside thermowells for 20-50 years, are the nightmare of every maintenance department. There are a number of problems when using rigid sensors, including stocking difficulties; finding suitable replacements; ordering the correct length and size; and being unable to install a replacement sensor in an existing thermowell.

Flexible temperature sensors, on the other hand, offer a universal solution for all maintenance dilemmas. A flexible sensor fits nearly everywhere, can be cut to the correct length, and reduces the number of spare parts a plant has to keep on hand. When asked to recommend solutions, we therefore often recommend using flexible sensors to solve all the tough problems.

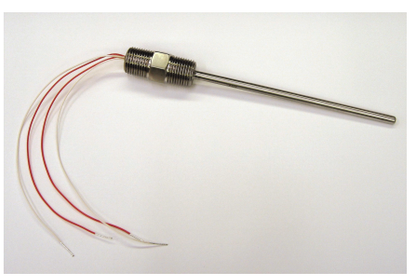
A flexible sensor, such as the WORM from Moore Industries, slides into thermowells without requiring disassembly of the conduit, unions and fittings

Rigid sensor challenges

A standard rigid temperature sensor, made by virtually every sensor manufacturer in the world, consists of a sensor element – thermocouple (T/C) or Resistance Temperature Device (RTD) – protected inside a rigid stainless steel shaft in a two-inch sensitive area. This forms what most users know as a 'fixed length sensor', and these are either spring loaded (for use with thermowells), welded to a hex nipple for a fixed immersion length into a process, or sealed with epoxy, exposing the sensor leads for external measurement connections.

Typically, the T/C or RTD element is embedded inside the bottom two inches of a stainless steel tube, which is then filled with mineral insulated powder (MGO) and sealed with epoxy to prevent moisture penetration. The rigid sensor assembly fits into the thermowell beneath the connection head. The wires from the sensor are then terminated in the enclosed head and connected to extension wires using a terminal block, or attached directly to a transmitter. Wiring is then run back to the control room, usually encased inside conduit for long wire runs.

The first problem posed by rigid sensors is the difficulty involved in replacing a faulty sensor. Typically, a maintenance technician has to remove the enclosure cap, disconnect the wires from the transmitter or terminal block, disassemble the union, conduit and fittings attached to the transmitter and thermowell, and then move them out of the way before he or she can pull the rigid sensor out of the thermowell. Depending on the age of the installation, the corroded conditions of the conduit or junction, and the amount of room available, this can be an arduous task – particularly when on the top of towers or columns, or in close confinement areas.



A rigid temperature sensor incorporates a T/C or RTD sensor and a stainless steel shaft

The next problem involves determining the correct length of the replacement sensor. In many cases, a maintenance technician may know that the sensor needs to be replaced, but doesn't know the exact length of the rigid sensor. In addition, if the loop is critical, the plant may make all the necessary measurements first, order a new sensor, and wait for it to arrive, before pulling out the old sensor.

In that case, the technician will have to make multiple visits to the sensor: first to determine as much information about the installation as possible, including sensor type, connection style (nipple union nipple, direct thread, lagging length, approximate insertion length, etc.); and then go back to stores to try to find a best fit (which may then mean returning with a number of different sizes to avoid a third trip, then returning the unused sensors).

In some cases, the technician leaves the old system intact, gets on the phone to a sensor representative, and the two of them make an educated guess based on a thermowell's length, size of the union, length of nipples, etc. At least one sensor manufacturer we deal with, however, admits that they only get it right about 85% of the time when they have to guess. Another solution is for a maintenance technician to carry eight to ten spare sensors out into the plant, in the hope that one of them will be the right size.

All this could be avoided, of course, with proper documentation – recording the size and type of each temperature sensor for when replacements are needed. This, however, can be a daunting task, as some plants have hundreds if not thousands of temperature sensors. Plus, engineering drawings do not always represent the 'as built' installation.

Once a replacement sensor is found, ideally it will simply slide back into the thermowell, unfortunately some thermowells will 'sag' (bend) when

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exposed to high temperatures over prolonged periods, such as in flare stacks. While it may be possible to extract the existing sensor from a sagging thermowell, it is usually impossible to install a new rigid sensor into one. Instead, the thermowell itself must be replaced.

Thermowells can also accumulate debris, which makes it difficult to install a new replacement sensor. In areas with high humidity, thermowells can fill up with assorted contaminants that condense out of the air and, when the rigid sensor is removed, this debris can then prevent a new sensor from being fully inserted back into the well.

Finally, the length of a rigid sensor can affect accuracy of the measurement: A rigid sensor inside a short, 2-3in thermowell may not be measuring the correct process temperature. This is because a sensor with a rigid metal sheath is not measuring just the process inside a short thermowell; some of the sensor's sheath protrudes up into the nipple, union or enclosure, which is outside the process. Such a sensor actually measures part of the process temperature and part of the ambient temperature.

Typically, this will result in erroneous temperature readings with possibly adverse effects on process control. In one tyre plant, for example, the lower inaccurate reading resulted in higher process temperatures that, in turn, caused the thermowells to overheat and sag. This was because the actual temperature was much higher than the sensor could record.

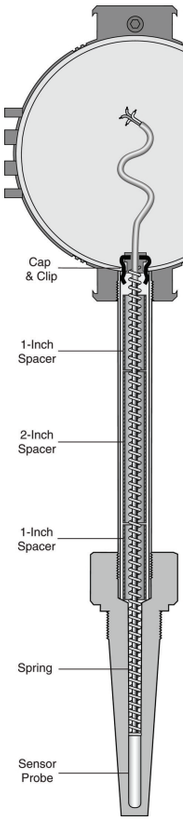
Flexible solutions

Even if an application spec calls for a rigid sensor, a flexible sensor can fill the requirement. These typically consist of a one inch, stainless steel sensor element and lead wires that are protected either with Teflon or with fibreglass insulation. These flexible wires can be trimmed to the correct length depending on assembly.

The sensor element is held in place with a spring at the top of the thermowell which keeps the sensor in constant contact with the bottom of the thermowell, allowing the best heat transfer to the sensor. If there are large open areas within the union/nipple junction, spacers can be used to facilitate insertion through these areas.

Replacing a flexible sensor in the field is also much simpler: a technician only has to remove the cap, disconnect the sensor wires, remove the transmitter or terminal block, and pull out the old sensor. It is not necessary to disassemble the union, conduit or any other fittings.

Furthermore, as a flexible sensor can be trimmed to the correct length, a technician only has to carry a single sensor to the field. Flexible sensors typically are available in various lengths to accommodate nearly every size of thermowell or application a plant may have.



A flexible sensor includes a 1in T/C or RDT probe, flexible Teflon or fibreglass insulation, and a spring to hold the sensor in place

In the case of a sagging thermowell, if the rigid sensor can be removed, a flexible sensor can be installed without replacing the old thermowell. We usually purchase flexible sensors that are slightly smaller in diameter than rigid sensors, making it easier to slide into a sagging well, or into dirty thermowells that have built-up or caked-on debris inside them.

In addition, as the spring and lead wires cannot conduct ambient temperatures to the sensor, outside measurement errors cannot exist. Like at the tyre plant, we have had several applications on other flare stacks where we have installed flexible sensors, and the process engineers were surprised to see that their stacks were operating at much higher temperatures than the previous rigid sensors had indicated. The resulting energy savings and fuel costs obtained from operating these stacks at the proper temperatures paid for the replacement sensors many times over.

Intriguing applications

Flexible sensors offer several interesting ways to approach temperature measurement applications and their problems. For example, the intense humidity in Louisiana causes 'Green Rot' at the wire termination points with thermocouples, so engineers and technicians try to avoid as many termination points as possible. Because a flexible sensor can be made with any length of wire, we now have several plants that run the wires directly to temperature transmitters located in a separate cabinet, instead of using terminal blocks. This eliminates one major source of failure.

Another plant noted that since the sensor wire did not carry any dangerous voltage or current, it was not necessary to encase it inside conduit. Therefore, all their sensor cables run directly from the thermowell to a remote transmitter without conduit. The flexible insulation covering the sensor wires is sufficient to protect it from most environments, but stainless steel braid or flex armour can be added at very little cost.

In another application, a plant had a burner with dozens of temperature sensors, but none of them could be replaced without shutting down the entire burner – it was too hot for someone to walk into the burner while it was operating. By using flexible sensors inside long protection tubes attached to the points of measurement, it was possible to slide a flexible sensor in and out of the tube from a safe location without shutting down the burner.

In a similar situation, a refinery had a problem with calibrating and replacing sensors with transmitters on top of columns or towers. It was physically dangerous for someone to climb to such heights while the hot process was running, and try to work with rigid conduit, fittings, and transmitters safely.

As a result, they replaced all their rigid sensors with flexible sensors, and installed the transmitters at the bottom of the towers for easy access. Again, because a flexible sensor can be made to any wire length, the transmitter could be calibrated or replaced from the bottom of the tower, and the flexible sensors were easier to change if they failed.

Over the last year, several refineries in Louisiana have begun systematically replacing all their rigid temperature sensors with flexible sensors because of the cost savings they expect to gain. Maintenance will be easier, take less time, and cause fewer shut downs or process interruptions. Fewer thermowells will have to be replaced because of sagging or foreign debris clogging the wells, and only two or three standard sensor lengths will be needed for an entire plant, reducing the spare parts inventory. They will get better measurements in shorter thermowell applications, leading to increased accuracy and energy savings.

Although conventional rigid temperature sensors have proven to be a workhorse for the past 50 years, modern flexible sensors are now starting to replace.

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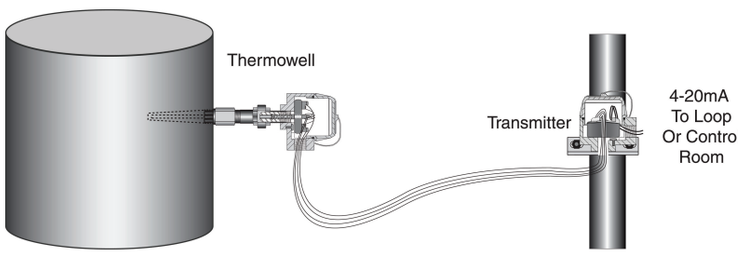

Some refineries are using flexible sensors without conduit, allowing them to install transmitters at the bottom of columns, tanks or towers