Thermowell protection

Thermowells, while protecting temperature sensors from a process fluid, can undergo tremendous stresses. A new standard is designed to lower risk of failures.

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Thermowells protect temperature sensors from direct contact with a process fluid. But once inserted into the process, the thermowell can obstruct flow around it, leading to a drop in pressure. This phenomenon creates low-pressure vortices downstream of the thermowell (the same principle underlying vortex flowmeters). Vortices can occur at one side of the thermowell and then the other, which is known as alternating vortex shedding. This effect can be seen in the example of a flagpole rippling a flag in the wind.

The result is that thermowells experience a combination of stresses: the flow pushing on the thermowell (drag forces) and the vortex shedding (lift forces). Instrument engineers should evaluate the thermowell to see if it can withstand these stresses as they can cause mechanical failure. The industry standard for this evaluation is ASME PTC 19.3 TW-2010, which, in 2010, superseded ASME PTC 19.3 1974.

Motivation for the new standard followed some catastrophic failures of thermowells in nonsteam service. These thermowells had passed the criteria laid out in 1974. The 2010 standard includes significant advances in the knowledge of thermowell behavior, increasing from four pages in 1974 to over 40 pages in 2010. The recent standard evaluates thermowell suitability with new and improved calculations including:

- Various thermowell designs including stepped thermowells
- Thermowell material properties
- Detailed process information
- Review of the acceptable limit for frequency ratio
- More accurate evaluation of stresses that affect thermowells.

Flow passing the thermowell creates alternating vortices downstream known as shedding vortices. These shedding vortices cause the thermowell to vibrate. If this vortex shedding rate (fs) matches the natural frequency (fnc) of the thermowell, resonance occurs, and dynamic bending stress on the thermowell greatly increases.

Forces created by the fluid in the Y plane (in-line with flow) are called drag, and forces created in the X plane (transverse to flow) are called lift, as shown in Figure 2 (online). The vortex shedding rate for the drag and lift must be calculated. The in-line forces (parallel to flow) are approximately 2x the transverse forces.

If the fluid is flowing at a very low velocity, the forces exerted on the thermowell are small, which greatly reduces the risk of thermowell failure. The new standard states that the natural frequency, frequency limit, steady-state stress, and dynamic stress do not need to be calculated if all the following conditions are met: The process velocity, V, is less than 0.64 m/s [2.1 ft/s]; Root diameter minus bore diameter $(A - d) \geq 9.5$ mm [0.376 in.]; Unsupported length, $L \leq 0.61$ m [24 in.]; Root diameter, $A \geq 12.7$ mm [0.5 in.]; Tip diameter, $B \geq 12.7$ mm [0.5 in.]; Maximum allowable working stress, $S \geq 69$ MPa [10 ksi]; Fatigue endurance limit, $Sf \geq 21$ MPa [3 ksi]; The thermowell material is not subject to corrosion or embrittlement.

Although the risk of thermowell failure is small if these conditions are met, in-line resonance can still be excited at low velocities, which may lead to sensor failure. **ce**

- Jennifer Wilson has worked for ABB for more than 5 years.

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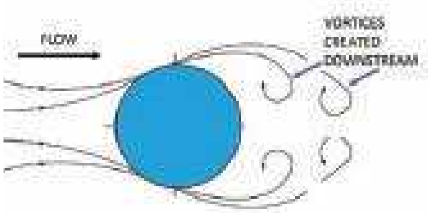

Figure 1: Flow around a thermowell Courtesy: ABB

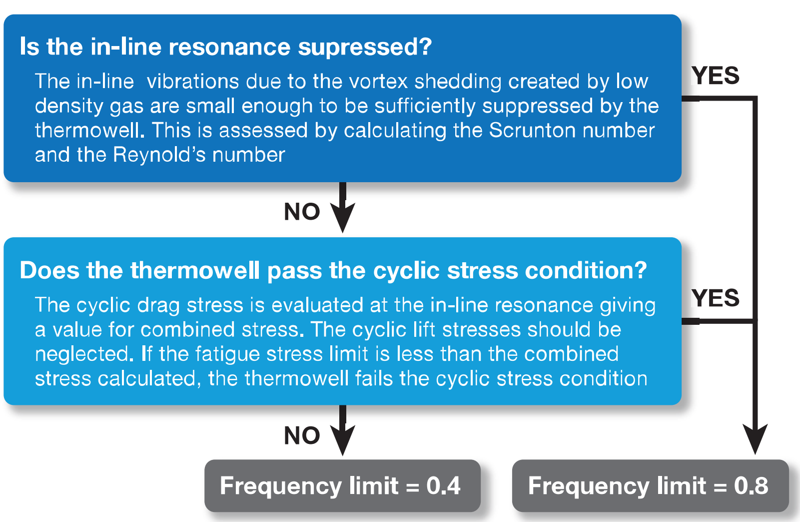

Figure 4: Frequency limit decision chart (simplified) Courtesy: ABB