Application Description AD/TEMP/003–EN

Temperature measurement
Thermowells

Giving customers what they want – a simple guide to thermowells

Introduction

A thermowell is an integral part of a process plant that serves two important functions:

- it protects an industrial thermometer from the process fluid
- it enables the thermometer to be replaced without breaking the containment of the process plant

Selection of the right thermowell for any application is therefore primarily a question of plant integrity and safety and secondly a question of measurement accuracy and speed.

Why use a thermowell?

Where a temperature measurement is to be made in an industrial plant the first question should be 'do I need a thermowell?'; the most common answer to this question is 'yes'. However, if the measurement is not critical either to the safety of the plant or to the efficiency of the production, and if the process fluid is not particularly aggressive or dangerous, it may be possible to insert a stainless steel, sheathed, industrial thermometer into the plant pipeline through a suitable compression fitting. Obviously, the thermometer could not be removed while the plant is running and should a problem occur with the measurement, maintenance will be delayed until the process can be stopped and the line drained and made safe.

What kinds of thermowells exist?

The simplest thermowell is made from tube material that is sealed at one end and has some form of fitting to enable it to be attached to the plant. These pipe-type thermowells are often made from high-integrity, seamless, stainless steel tubing. Fig. 1 shows two pipe-type thermowells – note that the flanged thermowell has a reduced tip for greater speed of response.

Fig. 1 Two pipe-type thermowells

Thermowells for more demanding applications can be manufactured from solid material. A solid bar of material is drilled to within a defined distance from the end of the bar and a suitable plant fitting is either machined into the bar material or attached to it by means of welding in the case of metal thermowells.

Fig. 2 Two solid drilled thermowells both with forged flanges

What kinds of materials can be used to make thermowells?

Almost any kind of material can be used to make a thermowell but the following questions must be considered carefully:

- Will the thermowell be strong enough to resist the forces from the process?
- Will the thermowell corrode or erode in the process?
- Will the thermowell withstand the process temperature?
- Are there any regulatory reasons for selecting or rejecting certain materials?
- Will the thermowell provide an adequate speed of response to changes in the process temperature?

For most process plant applications, metal thermowells are chosen but thermowells can be made from plastics and other polymers or even from ceramic material. There is often a good reason for choosing such materials; for example, ceramic thermowells perform better at the very high temperatures that are found typically in glass or cement making processes. You will notice in the list above that questions relating to the plant's safe operation come first – speed of response may also be a plant safety question but the speed of response of an industrial thermometer in a metal thermowell is insignificant when compared to the speed of change possible in the entire system. Be aware that there are some exceptions.

Metals used in the manufacture of thermowells are as diverse as the metals used to build the process plant pipework and this is often a good starting point in the selection of the correct material. An all stainless steel process plant (for example, those found in the pharmaceutical and food & beverage industries) uses this material for regulatory reasons and as a result, all plant fittings must be made from the same materials with detailed specifications for such things as surface finishes and suitable fittings. In other applications (for example, the oil & gas industry), plant integrity overrides all other considerations. Factors such as corrosion (chemical attack of the thermowell material) and erosion (mechanical attack of the thermowell material) lead to stringent material specifications and all associated welding (for example, flange to thermowell welds) are also tightly controlled. In summary, process pipework gives a good indication of the type of material to be used when selecting a thermowell but plant design engineers with a detailed knowledge of suitable materials must be consulted if additional factors are likely to influence the choice.

What factors influence the choice of thermowell type?

For most process plant applications the primary consideration must be the safety of the plant, its operators and the surrounding environment. For this reason, careful consideration is made regarding the suitability of the various types of thermowell available. Where process pressure is low and the process fluid relatively harmless, the choice of 'pipe-type' thermowells makes economic sense. Where the process temperature is very high (above the safe operating limit of stainless or other steels), a ceramic thermowell and high temperature measuring thermocouple is the only sensible option. Where process pressures are high and / or the process fluid is potentially harmful (either a poison or an explosion hazard), the robust 'solid drilled' type of thermowell must be considered.

Where a rapid response to temperature changes is required, the thermowell may be supplied in 'reduced tip' or 'stepped' form where the profile of the thermowell is such that the portion containing the sensing element is reduced in diameter (removing metal while retaining the strength required is the only way to improve the system's speed of response). The actual speed of response is influenced by numerous factors so the best way to determine this is to conduct tests with the thermowell and process fluid. As stated before, most thermowell installations respond to changes in temperature faster than the process can possibly change; it is the exceptions that make this a challenge.

Process connections

Connecting a thermowell to the process plant is another area where considerable variation exists. The simplest connection method is via a screw thread; this is either machined into the bar material in the case of the 'solid drilled type' or welded to the pipe in the 'pipe-type' thermowell. A huge number of different screw threads exist in both tapered and parallel form. The choice of thread is frequently based on 'best practice' within the country or industry. Flanged thermowells are very common with the flange being welded onto the thermowell or machined from a solid forging. As with threaded connections, a wide variety of flange standards exist and the choice again tends to be based on 'best practice'. Specialist flanges are required in some industries (for example, pharmaceutical and food & beverage) where considerations such as ease of cleaning and easy dismantling for contamination checks are regulatory requirements. Some thermowells are designed to be welded into the process pipework. Weld-in thermowells are typically used in very high pressure applications where little or no corrosion or erosion is likely.

Additional considerations for thermowell design

A thermowell is an intrusion into a process and is supported at one end only. Fluid flowing across a thermowell produces a turbulent wake. Vortices are typically shed first from one side of a thermowell and then the other at a frequency that is a function of the fluid and the dimensions of the thermowell.

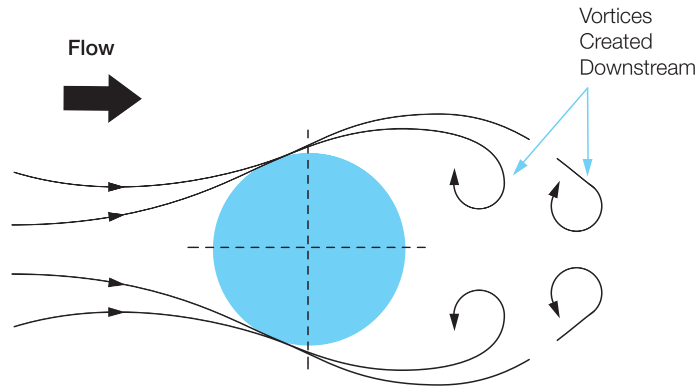

Fig. 3 Flow vortices from thermowell intrusion

These vortices create vibration that is an additional force to consider after the pressure forces exerted by the process fluid. Under some circumstances, the frequency of the wake vibration can approach the resonant frequency of the thermowell. This would be a disastrous situation with the potential for the thermowell to vibrate to destruction. More typically, poorly chosen thermowells crack at the point where they are attached to the process pipe work. All of this can be avoided by ensuring that the resonant frequency of the thermowell and the wake frequency induced by the process fluid are never too close. A reputable supplier of thermowells can advise when a wake frequency analysis is required and is also able to perform this calculation.

Summary

In summary, the selection of an appropriate thermowell comes down to a selection of an appropriately safe thermowell. There are often industry and / or national guidelines to assist in this selection. Designers of the process pipework also have a view on the suitability of materials. Finally, the producers of thermowells are able to advise on the various types of thermowell available and where to get further information to enable them to make a suitable offer. It is in everybody's interest to ensure that the solution chosen is safe and performs the function required.

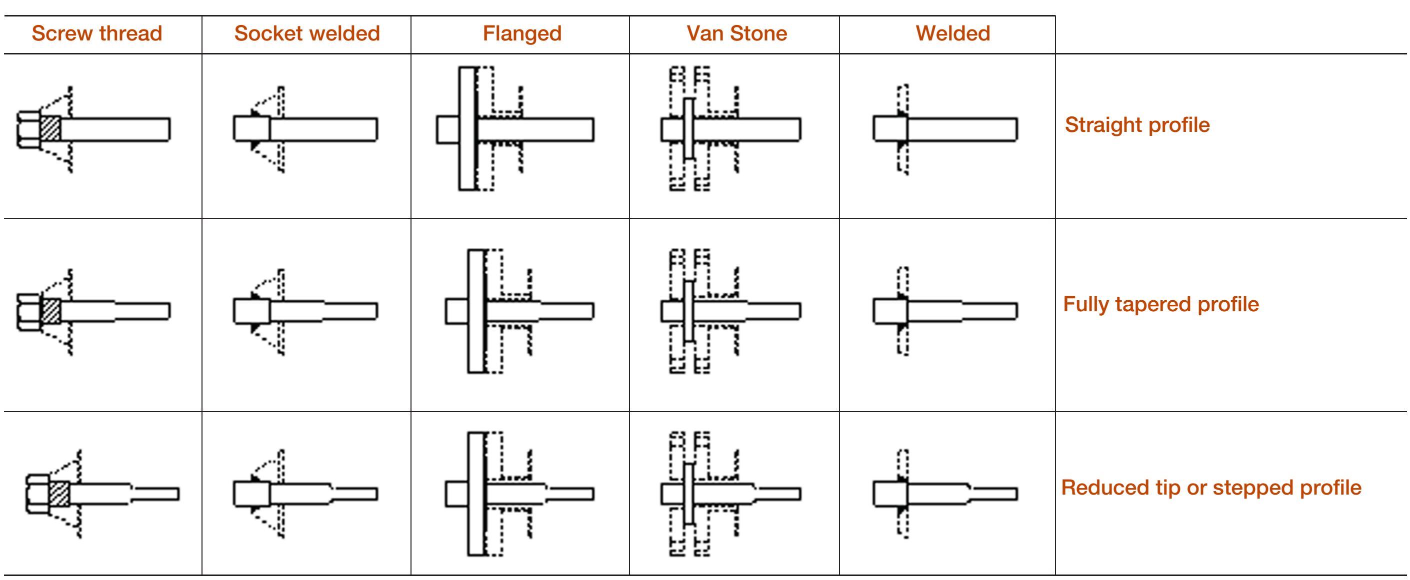

Fig. 4 Solid drilled thermowell types as described by ASME PTC19.3 2010 TW (the thermowell integrity standard)

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