A Guide to the Selection and Application of Thermowells

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Chris Chant, of Okazaki Manufacturing Company (OMC), discusses the basic principles of a thermowell and provides a guide to their selection for use in oil, gas & petrochemicals applications.

Thermowells enable a temperature sensor to be located within a process flow, whilst providing a process seal and protecting the sensor from the process fluid. The primary function of a thermowell is to protect the temperature sensor from excessive pressures, fluid velocities and viscosities, corrosion and damage, ensuring a longer operating life and accurate temperature measurements. Maintenance is also simplified by allowing the sensor to be easily and quickly removed without having to drain the process pipe or tank.

Thermowell types are designated by the style of stem or wetted portion of the well. Protection tubes are typically used for thermocouples but are not suitable for use with RTDs (Resistance Temperature Detectors), as they do not provide sufficient support for the sensor. Most thermowells are machined from bar stock to guarantee their integrity for high pressure applications. Flanges are normally welded to the thermowell stem. Smaller wells for low pressure applications can be designed from tubing and have the end welded closed and a process connection welded on.

Stepped, tapered and straight thermowells

Tapered wells represent a balance between strength and response time. They provide greater strength without sacrificing sensitivity. Because of its higher strength-to-weight ratio, a tapered thermowell provides greater resistance to high frequency vibrations than straight thermowells. This allows reliable operation at high fluid velocities.

Straight type wells are normally specified for lower fluid velocities or where increased protection is required. Stepped or reduced tip thermowells are normally ¾" diameter and step down to ½" diameter in order to improve response times.

Process connections include tapered pipe threads or adapted pipe or sanitary tubing flange connections. A blank or blind flange can be modified to accept the thermowell stem, easily attaching to standard flanges.

Material selection

When selecting a material for a thermowell, there are several factors to be considered. These include corrosion, temperature, pressure and fluid properties.

Material selection can be as simple as choosing the same material as the tank or pipe where it is to be installed. This works some of the time but in the case of high pressure, corrosion or erosion applications, an object placed into a flow is more susceptible to those effects and so a different material will be required to provide a longer life. Corrosion charts are normally available from thermowell manufacturers such as Okazaki, which list the preferred material for fluids and chemicals at different operating conditions. Concentration and temperature, in particular, heavily influence the recommended material. The higher the temperature and/or concentration, the more corrosive the fluid can be.

Choosing the wrong material can result in failure of the well – tips can corrode away and allow the process fluid to leak inside the well. Special corrosion resistant surface coatings can also be applied to the thermowell, particularly if media pressures or flow rates are high. These coatings can be applied in the form of sleeves or can be bonded directly to the surface of the thermowell. Fewer ridges and crevices will mean a smaller surface area for the corrosive media to exploit. Electropolishing or passivating the surface of the thermowell further increases corrosion resistance.

Performance and measurement accuracy

Wake frequency and strength calculations are critical factors that can adversely affect a thermowell's performance. These calculations reveal how long the thermowell can be immersed into the process based on the fluid flow conditions. This has to be balanced with the accuracy needs of the sensor to be immersed sufficiently preventing stem conduction or immersion error. Time response is slower with the addition of a thermowell and for processes in which there are frequent temperature fluctuations, this can be a significant source of measurement error.

ASME PTC 19.3 TW-2010

Companies that source thermowells for oil, gas and petrochemicals applications should now be consulting the latest, revised ASME PTC 19.3 (2010) standard, which recently underwent its first major revision in more than 35 years.

As a process fluid flows around the thermowell, low pressure vortices are created on the downstream side in both laminar and turbulent flow. The combination of stresses generated by the static, inline drag forces from fluid flow and the dynamic transverse lift forces caused by the alternating vortex shedding, create the potential for fatigue-induced mechanical failures of the thermowell. Until recently, ASME PTC 19.3 (1974) has been the standard by which most thermowells are designed.

The original standard worked on a frequency ratio of $f_s < 0.8 f_{c/n}$ but now this has changed to a more complex process whereby the cyclic stress condition of the thermowell needs to be taken into account. If the thermowell passes the cyclic stress then the ratio of $f_s < 0.8 f_{c/n}$ is still applicable. However, if it fails, then the ratio of $f_s < 0.4 f_{c/n}$ is applicable. Also of concern to manufacturers and end users is that the standard only applies to thermowells with a surface finish of 0.81µm (32µin.) Ra or better.

The 2010 standard addresses a number of new design factors that were not included in the original, more simplified standard. These include in-line resonance, fatigue factors for oscillatory stress, effects of foundation compliance, sensor mass, stress intensification factors at the root of the thermowell, and fluid mass/density. This means the new standard should lead to a greater variety of thermowell geometries and discourages the use of velocity support collars, allowing designers to achieve faster response times than ever before in applications that call for a wake frequency calculation.

Today, petrochemical plants tend to use smaller diameter pipelines but with higher fluid velocities. This means that the design of the thermowell is critical. For example, the original ASME standard did not provide guidance on liquid mass, as the standard was originally developed for steam applications. However, for oil and petrochemical pipeline applications, liquid density or mass must always be taken into account when sizing thermowells.

Velocity collars

Many thermowell suppliers incorporate a velocity collar on a thermowell in order to move the point of vibration or resonance. But adding a velocity collar means the thermowell needs to be manufactured to a very high tolerance (on the collar OD) and that the corresponding nozzle is similarly machined to suit. This tolerance must be an interference fit so that no resonance can occur.

If supplied and fitted correctly, the collar only moves the point of resonance and does not solve the root problem. While this seems to work in practice, the extra costs incurred by the thermowell manufacturer and installation contractor are passed on to the buyer, which increases the overall cost. The addition of the collar also increases the need for stocking specific spares for

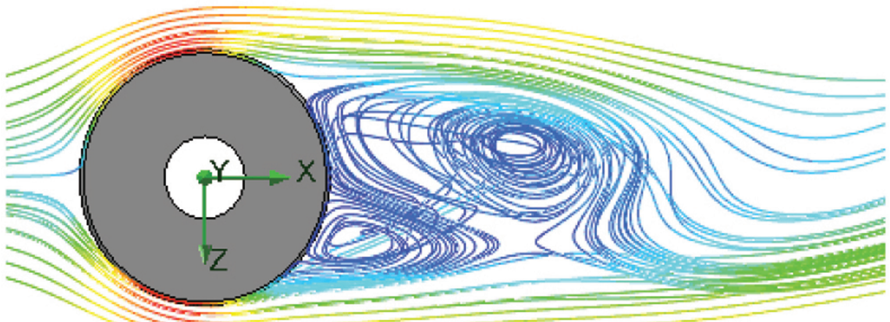

Fig 1 - Standard Tapered Thermowell

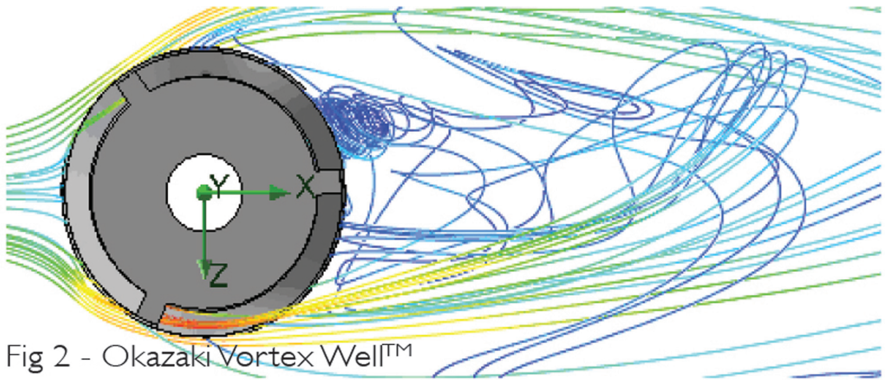

Fig 2 - Okazaki Vortex Well™

a single measuring point.

So fitting a velocity collar is not always the most appropriate solution. In effect, by adding a collar, the manufacturer is simply moving the problem somewhere else.

Genuine alternatives

One such solution is the VortexWell®, a unique design of thermowell manufactured by OMC. This groundbreaking design of thermowell incorporates a 'helical strake' design, rather like the helical strakes found on a car aerial or cooling tower fins. After extensive R&D using the latest Computational Fluid Dynamics (CFD) software, as well as third party, independent evaluation, OMC was able to visualise and accurately compare the flow behaviour of its helical strake thermowell design with a standard tapered thermowell.

In these analyses, the standard tapered thermowell showed classic shedding behaviour as expected, whereas the new helical strake design demonstrated no signs of regular flow behaviour. The helical strake design disturbed the flow sufficiently to interrupt the regular formation of vortices. Whilst a small vortex was observed in the wake of the helical strake design, this was a localised stagnation point and didn't shed.

However, the most significant comparison made was with regard to the pressure fields. For the standard tapered well design, an oscillating pressure field was observed around the structure. The helical strake design displayed a constant and stable pressure field, presenting no dynamic variations. As this pressure is the source of vortex-induced vibrations, it can be assumed that the helical strake design would experience a significant improvement in practice compared to a standard thermowell design.

In further tests, this time using Finite Element Analysis (FEA) software, OMC discovered that the ASME calculations used by thermowell manufacturers could be placing significant limitations on the safety of petrochemical applications. Using the ASME calculations gave the lowest natural frequency of vibration for the standard tapered thermowell to be 68.5Hz. However, OMC's own FEA results showed a corresponding value of 90.3Hz, a difference of more than 30 per cent. This highlights that the ASME calculations design rules include assumptions that can, and do, lead to considerable inaccuracies when designing thermowells for petrochemical applications. The risk of a thermowell failing due to under-engineering, or the extra costs incurred by the end user because of an over-engineered thermowell, can both be avoided if the buyer works with a reputable, experienced thermowell supplier.

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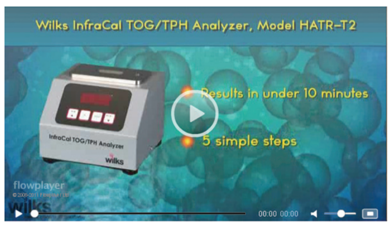
New Videos Demonstrate the Ease of Using Portable Infrared Analysers for On-Site Measurement of Oil in Water or TPH in Soil



Wilks Enterprise (USA) is pleased to announce several new videos that demonstrate the ease of using portable infrared analysers for measuring the level of total oil and grease in water and total petroleum hydrocarbons (TPH) in soil. These short videos demonstrate how on-site measurements with the InfraCal TOG/TPH Analysers take just a few simple steps to obtain accurate part per million (ppm) results in under 15 minutes. They are readily used by non-technical personnel and eliminate the need to wait for off-site lab results. Regular on-site measurements help ensure compliance with regulatory permits for the amount of oil in water being discharged from oil drilling platforms, industrial plants and refineries or for soil studies at remediation sites.

Based on field-proven infrared technology, the InfraCal TOG/TPH Analysers -- Model HATR-T2 or the Model CVH – depending on the solvent selected for the extraction process – provide accurate, on-site measurement of total oil in water concentration levels. Typical analysis time is 10-15 minutes, including the extraction procedure. Measurement data obtained with the Model HATR-T2 correlates to EPA Method 1664 and with the Model CVH to ASTM Methods D 7066-04 and D3921-11 and EPA Methods 413.2 and 418.1.

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A New Class of Multi-Ion Analysers

Aptisens (Ireland) is offering a new class of hand-held multi-ion analyser that can simultaneously measure multiple ions in liquids, including Ca2+, Cl-, K+, Na+, NO3-, NH4+, and Mg2+. All sensors can be calibrated simultaneously and up to 6 ions can be measured at once.

By leveraging the amazing properties of carbon nanotubes, our sensors have unique advantages over the standard ISEs on the market, such as being completely solid state, requiring very little maintenance and are very easy to use. It allows us to deliver products that open the field of multiple ion measurement to non-experts and drastically reduces the time it takes to measure multiple ions in a sample.

The robust portable multi-ion kit is perfect for a wide range of applications, for example, measuring nutrients in closed loop bioreactors or open pond systems, measuring formation water, seawater, or reverse osmosis.

Aptisens custom made multi-ion calibration solutions can be tailored made to suit your needs.

Aptisens multi-ion product was recently nominated for the G.I.T.

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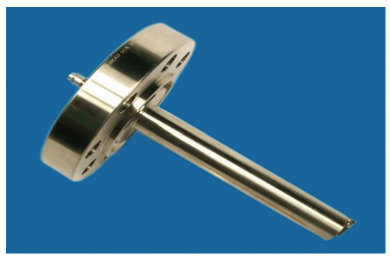
New Rugged Viscometer Withstands Harsh EOR Conditions



Cambridge Viscosity a PAC Company (USA) has developed a rugged, RTJ-flanged in-line process viscometer for a leading global oil company's Enhanced Oil Recovery (EOR) application in the North Sea. Cambridge designed the SPL-393 viscometer for use offshore, where safety and reliability are not just a priority but also a necessity. The new viscometer meets all electrical, plumbing material, pressure and temperature requirements for use on a platform where environmental conditions can reach extremes.

The sensor connects into a pipeline using a standard ANSI class 900/1500 2" RTJ round flange. The rugged 316SS construction can withstand up to 2200 PSI and 190 degrees C, and has long penetration for large diameter pipes. The SPL 393 satisfies ASME PTC 19.3 Thermowells requirements. The new sensor is designed for highly accurate, repeatable viscosity readings and clean-in-place simplicity. Coupled with Cambridge's standard VISCOPro 2000 or Digital Viscometer: VISCOPro 1600 electronics, the sensor has sophisticated multi-shear compatibilities.

Cambridge President Robert Kasameyer says, "We are very excited to introduce this product designed to meet the specific needs of the petroleum industry. The initial application of the SPL-393 sensor in EOR oil production improves production efficiency while withstanding harsh offshore drilling conditions. Our customer is achieving repeatable, reliable viscosity measurements that contribute to better control of EOR operations."

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