Thermowells – a Lesson in Performance Under Pressure

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Thermowells must be properly designed and specified to withstand the pressure and stresses of their environment. Andrew Dunbabin, Product Manager, High Temperature Products for ABB Limited's instrumentation business, argues that users should be aware of all the relevant standards, in order to guard against potentially disastrous failures.

A thermowell is the pressure-tight receptacle designed to protect sensitive temperature measurement instrumentation from harsh process conditions. The danger is that a hollow tube sticking into a process pipe or vessel could present a point of weakness if not properly specified. Any failure could result in damaged plant, or even injury and prosecution. So it's vital that thermowells are manufactured and specified correctly to withstand the pressure and mechanical stresses that they may be exposed to, as well as any corrosive or erosive media they are likely to meet in a given process environment.

The first concern is obviously pressure. There is currently no thermowell equivalent to the legally binding pressure vessel regulations, but international pressure vessel and piping standards, such as ASME VIII and its European counterpart, PD 5500, set out clear standards for pressure-retaining parts. Although these standards are not enshrined in law, it would be hard to justify any deviation from them, especially following an incident.

End users specifying thermowells from reputable manufacturers can generally be confident that the correct standards have been met. But if in any doubt, it can be useful for them to know their own way around the relevant standards so that they can ask suppliers the right questions.

Pressure Fittings

Thermowells are generally fixed to vessels and pipes using a flange. ASME VIII refers to ANSI B16.5 when it comes to defining the standard for flanged fittings. It is ANSI B16.5 that gives us the familiar flange rating system.

ANSI B16.5 in turn relies on other standards to specify the types of material that may be used, such as ASTM A182 for austenitic steels and ASTM A105 for carbon steels.

These materials standards are complex, but one of the main points to note is that, unlike thermowell stems, flanges must not be machined from bar stock. Instead, the parts must be manufactured from plate or from forged material that is hot worked into shape before being machined. This ensures that the flow lines of the metal follow the shape of the flange closely and so make it as strong as possible.

Material traceability starts with the mill that made the steel. A materials certificate describes the chemical and mechanical properties of any material supplied by a mill, and any manufacturer with good engineering practices and a third-party verified quality system in place should be able to trace any material back to the mill certificate.

Any flange manufactured and supplied under the ASME codes must have the flange size and rating stamped on it. Some manufacturers may also add marks indicating the cast number and the order against which it was supplied.

PD 5500 is the equivalent European standard. Although it is not legally binding as yet, it will become law when it completes its journey through the lengthy European ratification process and is adopted as a European Directive. It follows the ASME codes closely in its underlying principles, although the requirements for dimensions and markings differ.

Welding Standards

Of course, materials standards are only part of the story. Thermowells manufactured from more than one part will be welded, in which case ASME VIII calls on the welding standard, ASME IX.

The situation is slightly more complicated in the European system, where there are a number of different standards that apply to welding. Once again they make largely the same demands as the American equivalent, ASME IX, but it's a good idea to seek advice from a reputable supplier as to which particular European standard applies in a specific case.

Whether the user is working within the US or European system, there are two distinct aspects to the welding standards.

First there is the qualification of the person carrying out the work. The standards require that the quality of the individual's workmanship will have been regularly verified by a Welding Specialist appointed by the trade's governing body, which is The Welding Institute in the UK.

Next there is the welding procedure. Choosing the right procedure for a particular service is a highly skilled job and a competent manufacturer should be able to indicate which welding procedure they used.

Mechanical Stress

Pressure is not the only physical challenge for thermowells. In pipelines, they will also experience mechanical stresses on their stem as fluid flows past them. It's easy enough to calculate the static forces that are exerted by the mass of fluid impacting on the stem, but at higher flow rates the stem will also shed vortices, known as Von Karmen vortices. These can present a real danger if the frequency of the shedding approaches the resonant frequency of the stem.

ASME PTC 19.3 is the accepted standard for analysing the harmonic frequency of thermowells. Given the calculated harmonic frequency of the stem, the standard also provides a method for calculating the induced frequency of the vortices.

The standard recommends designing in a safety margin so that the induced frequency is no more than 80% of the harmonic frequency of the thermowell. However, many plant engineers prefer to take a more cautious approach and work to a margin of 25 or 30%, especially if the consequences of any failure are likely to be disastrous.

Some applications are more at risk of vortex-induced failure than others. Where the fluid flow rate is high and the damping effect of the fluid is low (mainly gases), it's a good idea to check by running the calculation based on ASME PTC 19.3. If the calculation shows that a particular thermowell could be at risk, there are several possible solutions.

Geometry plays a key role, so a shorter or thicker thermowell may be more suitable. Some operators may suppose that the required length is fixed by the diameter of the pipe, but the thermowell does not have to reach the very centre. Temperature measurements should still be representative as long as the measuring element reaches the middle third of the pipe, so there is some flexibility.

Velocity collars can also change the resonant frequency of the thermowell. These devices form a tight fit where the stem meets the pipe wall, effectively shortening the unsupported length of the stem. The downside of this approach is that velocity collars can be expensive. Again, a reputable supplier should be able to carry out the necessary calculations to ensure that a thermowell is safe to use. All they'll need from the user is information on the fluid, including the operating temperature and pressure, the specific volume and the velocity.

Failure is not an option

They may seem like standard pieces of kit, but thermowells routinely face some of the toughest conditions encountered in industry. In many applications, particularly in the oil and gas industries, the consequences of failure would be disastrous, so it's worth checking with your supplier that all the relevant standards have been met.

New Viscosity Sensor Offers Capabilities for Oil Condition Monitoring Applications

SenGenuity, the Sensors and Advanced Packaging division of **Vectron International** (USA) announced that its ViSmart™ Viscosity Sensors are now able to correlate to data acquired from lab instrumentation for challenging, real-time, in-line oil condition monitoring applications. In today's market, significant legacy data and industry standards require that sensor readings be equivalent to those obtained by lab methods. This latest capability ensures that customers can obtain lab-compatible results from the ViSmart sensor in-line and real-time for in-situ viscosity measurements, complimenting lab measurements and analysis methods.

"Measuring the viscosity of oil is a rapid method of determining oil condition, and is universally considered to be one of the key parameters in assessing asset readiness," said Kerem Durdag, director of business development, SenGenuity. "By successfully creating correlation functions that relate our ViSmart sensor data to ASTM lab viscometer data, SenGenuity has clearly demonstrated that its solidstate, real-time, in-line viscosity sensor can trend and track viscosity data in a similar fashion to a lab tool—with accuracy levels ranging from 91% to 99%, as compared to an industry-standard lab viscometer."

Helping Customers Innovate, Improve & Grow: SenGenuity obtained the constants in the interpolation function between kinematic viscosity and ViSmart's native unit of measurement, acoustic viscosity. SenGenuity used the sensor to obtain a functional dependence of the constants on shear rate for each oil tested, which included mineral and synthetic oils for engine, turbine, hydraulic and gear applications. The results were a look-up function that allowed an oil viscosity (kinematic, dynamic, or acoustic) to be interpolated at temperature and shear rate. For each oil, a pair of correlation functions converting between the measured acoustic viscosity and interpolated kinematic viscosity were evaluated. The R2 of the correlation for individual oils and groups of oils were determined.

SenGenuity's breakthrough ViSmart viscosity sensor compliments IR spectroscopy and other bulk property sensors and provides instantaneous on-line viscosity and temperature data, has no moving parts with an extremely wide operating range and offers universal plug-n-play connectivity for integration with and into other handheld products. The sensor has been tested in actual commercial and military specified oils in order for a correlation function to be established between the ASTM methods acquired dataset and the sensor generated viscosity values. These correlation functions can be stored on any handheld for automatic conversion. The ViSmart viscosity sensor is currently installed in commercial markets such as machine tool oil monitoring and coating applications in rigorous environments where ROI benefits have been realized. The ViSmart model series can be connected to any computer or control platform via the standard protocols, the VisConnect™ transmitter and the forthcoming CANBUS option to provide a continuous audit trail for process monitoring markets to control operating costs and maintain quality standards. Additionally, customers can leverage SenGenuity's starter kit bench-top viscometer data station to acquire multiple channels of continuous viscosity and temperature data.

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Infrared Flammable & CO_2 Gas Sensor Detects Hazards Where Conventional Sensors Fail

Xgard IR from **Crowcon** (UK) is a low cost infrared (IR) flammable gas and carbon dioxide (CO_2) sensor designed for use in fixed point detection systems where conventional detectors can prove unreliable or suffer from interference and damage.

Conventional flammable gas detectors based on catalytic pellistors are susceptible to poisoning or temporary inhibition when exposed to gases such as hydrogen sulphide. This can make their readings unreliable and even destroy the sensor altogether. The new Xgard IR is totally immune to poisoning and will reliably warn of gas hazards in environments that are unsuitable for other types of sensor. Infrared sensing has other benefits too. Unlike catalytic pellistors, IR sensors will fail to safety, detect flammable gas in inert backgrounds and are not damaged by high gas concentrations.

Typical environments requiring flammable gas monitoring include water and sewage treatment facilities. Continuous CO_2 monitoring is common in laboratories.

This new IR sensor can be specified with two types of enclosure: polyester-coated aluminium or 316 stainless steel for maximum corrosion resistance in extreme environments. The sensor, which has a life expectancy of over 5 years, is a simple plug-in module that makes replacement quick and easy. ATEX* approved for use in hazardous areas, the Xgard IR is Exd flameproof rated.

The standard junction box is designed for both wall and ceiling mounting, and four cable gland options ensure compatibility on any site. The detector takes a range of accessories for harsh or wet conditions and for remote sampling.

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Industry's First High-Performance, Long-life pH/ORP Sensor Available for a Broad Range of Processing Applications

Emerson Process Management has introduced the Rosemount® Analytical PERpH-X 3500 high-performance pH and ORP sensor, the industry's first general-purpose pH sensor that includes advanced technologies for longer life in difficult processing applications, providing a lower total cost of ownership.

The Model 3500 is the newest member of the PERpH-X family and is designed from the ground up to provide superior performance in the most aggressive fouling applications. It combines the high performance of the complete PERpH-X pH sensor family with the convenience of a wide range of mounting options making it ideal for use in numerous industries and processing applications.

The PERpH-X 3500 brings advanced, long-life technologies previously only available in sensors designed for specialised, demanding process applications. These include improved pH glass electrode durability, increased reference electrode stability and overall mechanical design reliability. This results in longer sensor life in challenging processes, faster response, less drift, higher accuracy, and minimised maintenance requirements.

Most pH measurements fail due to fouled or poisoned electrolytes and clogged reference junctions, which are the most common reference electrode problems. The PERpH-X sensor family features an enhanced double junction electrode that excels in harsh applications, and the specially designed porous Teflon liquid junction has a large surface area to maintain a steady reference signal in dirty and fouling applications. The large surface area and high porosity also minimise junction potentials leading to accurate measurements without standardisation. The porous Teflon reference junction is easily replaced if it becomes fouled or plugged.

The reference electrolyte is a chemically inert viscous gel that is unaffected by thermal or pressure cycling. With the junction removed, the outer reference electrolyte can be recharged using a gel-filled syringe supplied in the various solution kits available as an accessory. Replacing a clogged junction or recharging the electrolyte will rejuvenate most failed sensors. Proper preventative maintenance can dramatically extend the life of the sensor by minimising the depletion or poisoning of the primary reference.

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