



## Pressure Vessel Codes and Thermowells

When specifying and buying thermowells for the process industries there are some points that you must be aware of. International pressure vessel codes are explicit about the types of materials and the methods of construction allowed.

Although there is no equivalent to the pressure vessel codes for thermowells, care must be exercised when specifying these as integral parts of the plant. Errors in the specification of pressure retaining parts could have disastrous results leading to loss of life, loss of the plant and prosecution.

Pressure vessel and piping codes such as ASME VIII and the European code P.D. 5500 (2006) describe the standards required for pressure retaining parts. These codes are the ultimate reference for the process plant designer. Although none of these codes are statute law, deviation from them would be difficult to explain in a court of law after an incident.

### **So what do the Codes say and, more importantly, how should the Instrumentation Engineer interpret them in the specification of Thermowells?**

ASME VIII refers to yet another American standard, ANSI B16.5, for pipe flanges and flanged fittings (a flanged Thermowell is a flanged fitting); it is this standard that gives us the familiar ANSI flange rating standard. If a flange is specified as an ANSI X" 150 or greater, ANSI B16.5 is the standard to which it must comply. ANSI B16.5 states that flanges must comply with yet more standards; this time they are material standards, such as ASTM A182 for austenitic steels and ASTM A105 for carbon steels. Taking ASTM A182 as an example, it states in clause 5.4 that:

"The material shall be forged as close as practicable to the specified shape and size. Except for flanges of any type, forged or rolled bar may be used without additional hot working for small cylindrically shaped parts within the limits defined by specification A234/A234M for low alloy steels and martensitic stainless steels, and specification A403/A403M for austenitic and ferritic-austenitic stainless steels. Elbows, return bends, tees, and header tees shall not be machined directly from bar stock."

So forged or rolled bar may be used for cylindrically shaped parts (within limits) but not for flanges. The standard is quite explicit that this applies to flanges of any type. Thermowells of the highest standards are made from solid bar and this is acceptable to the standards so long as the flange is made either from a hot-worked forging or a plate. Where a forging is used to make the Thermowell the first sentence of the clause applies; these thermowells must be made from hot-worked shaped forgings. Even without this sentence the next sentence of the clause would prohibit the use of rolled bar to machine the flange.

In case this argument is not convincing enough, all of these materials standards reference ASTM A 961 – "Standard Specification for Common Requirements for Steel Flanges, Forged Fittings, Valves, and Parts for Piping Applications". ASTM A 961 states in clause 6:

#### **6 Manufacture**

**6.1** The finished part shall be manufactured from a forging that is as close as practicable to the finished size or shape. Alternative starting materials may be used, but with the following exceptions and requirements.

**6.1.1 Bar** Flanges, elbows, return bends, tees and header tees shall not be machined directly from bar. Other hollow cylindrical shaped parts up to, and including, NPS 4 can be machined from bar provided that the axial length of the part is approximately parallel to the metal flow lines of the starting stock.

The conclusion is clear, flanges must not be made from bar. The last clause gives us an indication of why; it also allows us to machine the stem of a Thermowell from bar. Forged-flanged Thermowells must be machined from a shaped forging to ensure that the metal flow lines of the starting stock are in the correct orientation.

**How do I know that the Thermowell I am being offered complies?**

Any flanged device provided under the ASME codes must have the flange size and rating and the material specification stamped on it. So, in practice, the flange will be marked something like 'ANSI 1" 150lb ASTM A 182', clearly indicating that it complies to ANSI B 16.5 and is made from a forging in accordance with ASTM A 182. For a stainless steel flange, ASTM A 240 may be used instead. This indicates that the flange is manufactured from plate and is equally acceptable. Additional markings from reputable manufacturers may also state the cast number of the material and the order against which it is supplied.

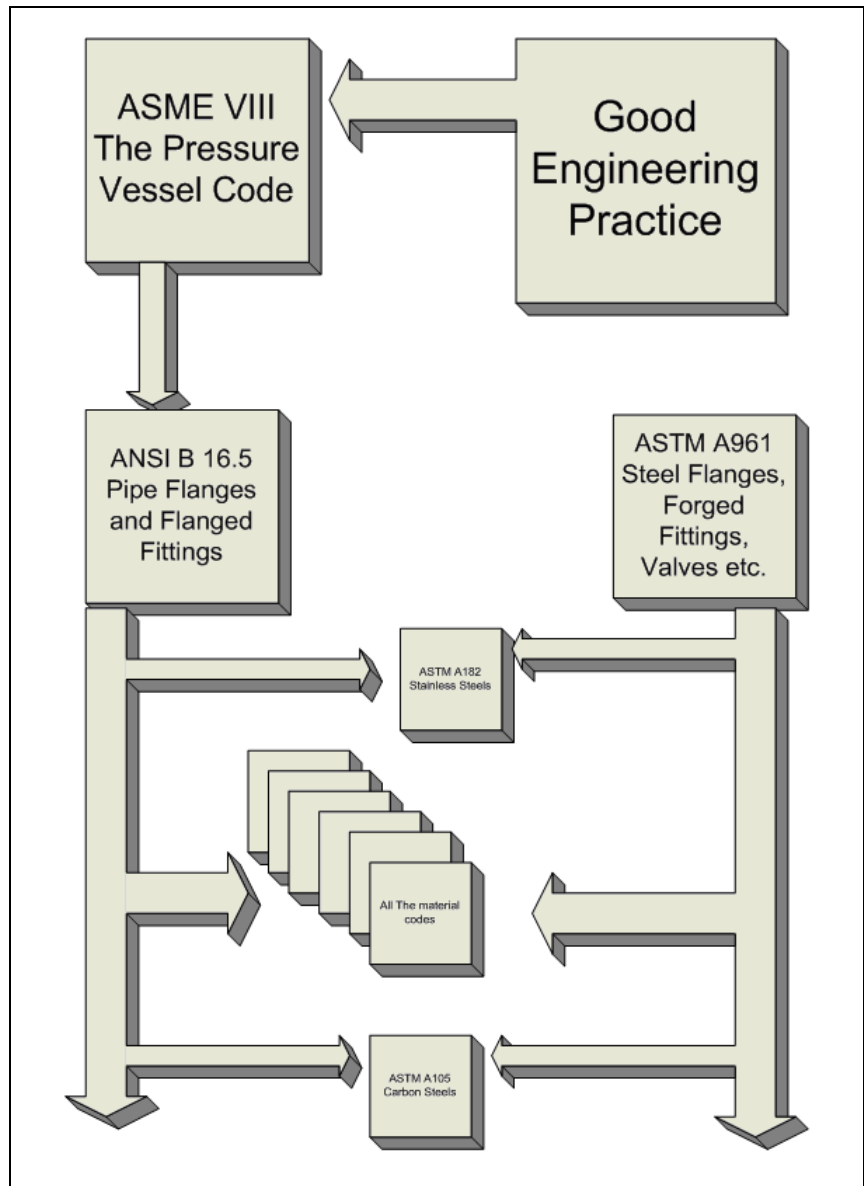
The supply of material certification and evidence of purchase of the forged or plate flanges should present a reputable supplier with no difficulties. It is unlikely that any supplier would place these markings on the flanges or produce supporting documentation, knowing that they do not comply to the standard as such a practice could be a criminal act.

**I'm buying thermowells to European standards. What applies to me?**

P.D. (proposed document) 5500 (2006) is a harmonizing document for the European Union. The word 'proposed' is misleading however; 'proposed documents' are published standards, but as they have not been through the full political ratification process they are not yet directives. Interestingly, once adopted into a European Directive, this code will effectively become statute law.

P.D. 5500 (2006) relies heavily on the ASME codes for its requirements. The standards and markings differ from the American standards but the principles remain the same. It is beyond the scope of this publication to discuss this in detail but ABB will be happy to discuss your requirements.

American Standards



*Interrelationship between the various American Standards*

**What about welding? What do I need to think about?**

For Thermowells manufactured from one or more parts, materials selection is only the beginning of the story. Thermowells of welded construction must be manufactured to an appropriate code. To continue with the theme above where ASME VIII has been used to provide the design specification, ASME VIII refers to ASME IX that covers the welding.

As with ASME VIII, European equivalents also exist for ASME IX but again, they rely heavily upon the established norms of the American standard. For ease of understanding we will continue with the American standard knowing again that any reputable supplier such as ABB can help with the European version.

ASME IX 'welding and brazing qualifications' describes two sets of criteria that must be met by the supplier:

- **The qualification of the personnel carrying out the work.**

Describes how they must be qualified to weld using the stated technique. This qualification can be achieved by verification of their work, either by a third party or by a Welding Specialist (Welding Specialists are qualified by their governing body, such as The Welding Institute in the UK). Qualification is usually carried out by a combination of methods, with regular verification test pieces being made by the welder under the supervision of a Welding Specialist; a sample is then verified by a third party.

- **The welding procedure or PQR (Procedure Qualification Record).**

This procedure is drawn-up by a Welding Specialist with reference to the guidance tables supplied by ASME IX. The procedure is then verified by a test piece welded by a qualified welder (see paragraph above). The code describes which test criteria must be met and how. Again, third party verification can be used here or the procedure can be signed-off by the Welding Specialist. Selection of the correct procedure for any particular service is a highly skilled job; a good indication of the competence of a manufacturer would be to ask for their relevant welding procedure. This should be signed either by a qualified Welding Specialist or a third party such as Lloyds.

**How do I know that I'm getting what I asked for?**

All of the above is relatively academic if there is no way of being certain that the material purchased is actually the material used to manufacture the item. Materials traceability starts with the Mill that made the steel. A materials (3.1) certificate describes the chemical and mechanical properties of the material supplied by the Mill. If good engineering practices and a third party verified quality system (ISO19001) are employed, a reputable manufacturer will have no difficulty in verifying that the material supplied was manufactured using a particular material referenced by a particular Mill certificate.

**Are there any other standards which I need to be aware of?**

Many end users have their own standards derived from, and in most cases more stringent than, ASME VIII. When working for large, end-user companies, it is worth checking whether they have additional requirements and whether the supplier of your choice can meet them.

Some very demanding installations carry their own additional requirements. Typical amongst these is the NACE standard which works with ASME VIII but extends it. NACE is typically used for Sour Gas streams in the Oil and Gas industry. The concern here is with corrosion resistance. NACE is an extension to the materials verification that asks for certain mechanical tests to be performed. ABB will be happy to advise help you with your NACE requirements.

In the most demanding process industries such as Oil and Gas, compromising on the safe application of the ASME codes is at best risky and at worst could be deemed to be negligent.

# Finite Element Analysis of Thermowell Stress Patterns

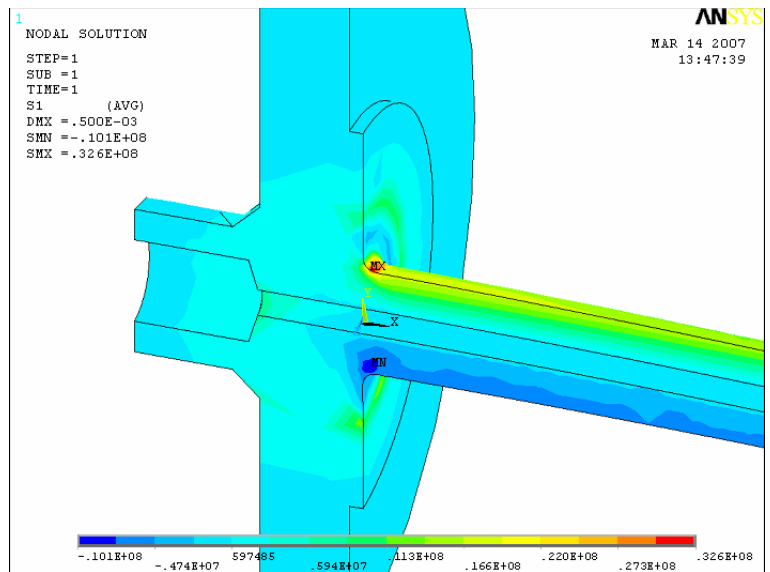
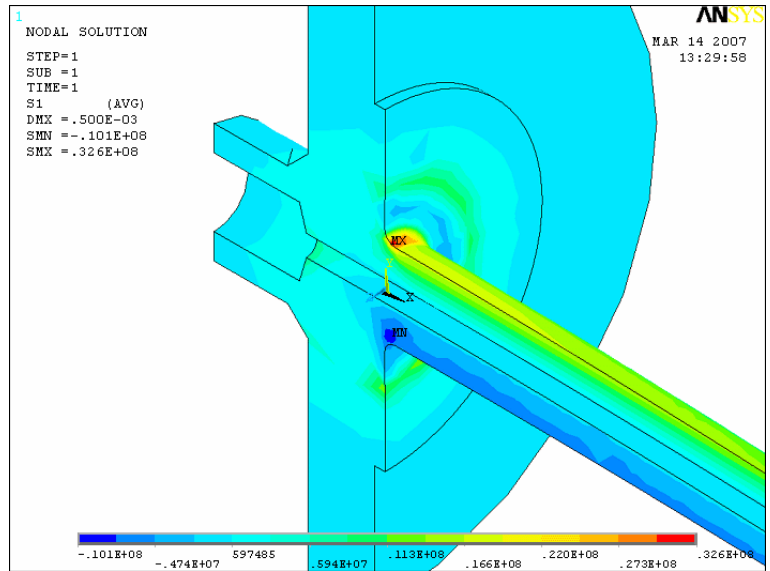
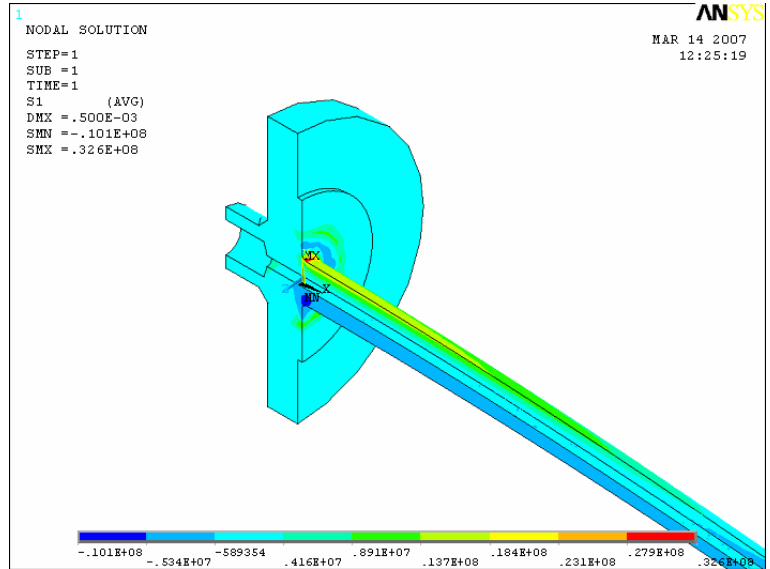


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Printed in UK (06.07)

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