Piping Stress?

Bentley's Mark Upston looks at the latest European Pressure Equipment Directive for Plant Applications, and outlines how Bentley's AutoPIPE, Pipe Stress Analysis software, has been developed to meet its requirements

It is well known that local standards are developed to maintain quality of products supplied by manufacturers to local & national markets (BS, DIN, AFNOR etc.), meet local safety rules but restrict free trade by protecting local manufacturers against foreign competitors. The European Union, as a multinational organisation, needed to find the right solution to enable free trade inside the EU, so in May, 1985 European Community Ministers agreed on a "New Approach to Technical Harmonisation and Standards", to start building a real 'common market'.

To put the directives into effect, CEN (European Committee for Standardisation) and CENELEC (Electrotechnical Equivalent to CEN) were mandated to elaborate and publish harmonised Standards that were to replace all previously published national standards in the EU. Harmonised Standards are voluntary, but following their recommendation, each country member ensures the advantage of getting the "presumption of conformity" related to the 'New Approach Directive'.

One such directive is the Pressure Equipment Directive (PED - http://ped.eurodyn.com/) which defines the scope & requirements of the new European Harmonised Piping Standard.

EN 13480 "METALLIC INDUSTRIAL PIPING"

In November 2002, the European Standard EN 13480 was given the status of a national standard, and conflicting national standards were to be withdrawn at that time. As of today only Finland and Norway have complied with this. Industrial piping systems including above ground, ducted or buried piping and supports, must be constructed of materials and designed in accordance with EN 13480 and harmonised standards referenced therein. There is one very important legal advantage of complying with the European Standards. Member countries may not, on grounds of hazard due to pressure, prohibit, restrict or impede placing on the market and putting into service, pressure equipment and assemblies which comply with provisions of PED i.e. bears the CE marking.

SCOPE AND REQUIREMENTS OF PED

The main scope of PED covers pressure equipment and assemblies with maximum allowable pressure greater than 0.5 bar. One important requirement is full responsibility for equipment and assemblies (including piping) compliant to PED directives rests firmly on the manufacturer or its authorised representative. This differs from ASME codes where full responsibility lies with the owner user.

PED enforces certain requirements on pressure equipment and assemblies. Piping systems above 0.5 bar must:

- Be safe in service
- Meet essential safety requirements covering design, manufacture and testing as defined in standard EN 13480.
- Satisfy appropriate assessment procedures;
- Bear the CE markings and carry other required information.

EN13480 DESIGN RULES

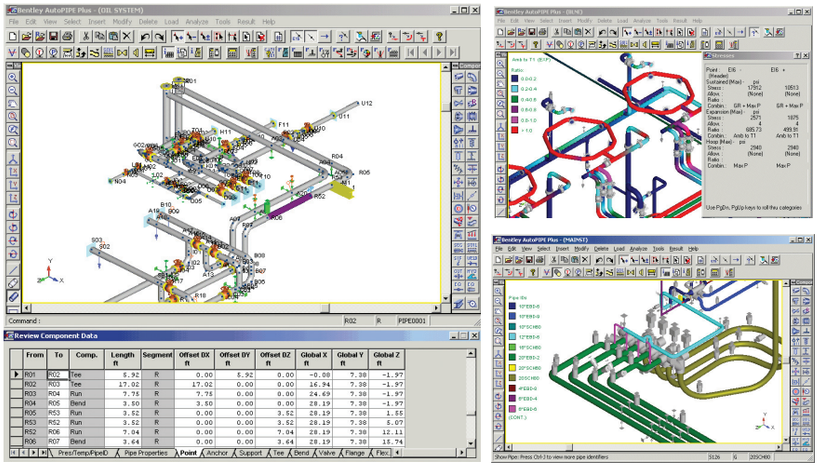
The design rules and basic flexibility analysis methodology are defined in Part 3 of the EN 13480 standard and clause 12 outlines the flexibility calculations and acceptance criteria. In addition, the design pressure requirements for piping components are given in clause 6. The published EN 13480 design rules are noticeably more comprehensive than the ASME piping codes.

LOADS

The piping system shall be designed to withstand the effects of pressure, weight and other loads including the effects of thermal expansion or contraction or to similar movements imposed by other sources. Clause 12.3 of EN 13480-3 shows how to consider these different loadings on the piping system.

Times have changed since only basic pressure requirements for piping and equipment were established. So now, before the pipeline is constructed, important design loadings must be considered:

- Internal/external pressure;
- Temperature - ambient and operational, including temperature range;
- Weight of piping and contents in operating, as well as in test conditions;
- Climatic loads, traffic, wind, earthquakes, movement of the ground and buildings;
- Reaction forces and moments which results from anchors, supports, attachments i.e. vibrating equipment nozzle connections, structural changes in overall system geometry etc.
- Corrosion, erosion, fatigue and other



material related factors;
•Interaction fluid/piping system, that includes various dynamic effects (see Annex A) like water hammer, relief valve opening, reciprocating equipment influence, decomposition of unstable fluids etc.
Various combinations of loads may often occur at the same time, so all these interactions should be taken into account. To properly define these loadings can be quite a complex task, requiring experience and a good knowledge of various engineering disciplines but the EN 13480 standard does a good job of guiding the Engineer /Designer through this process as in clauses 4.0 and 12.3.

LOAD CATEGORIES

The load categories defined in clause 12.3 include:
•Stress due to sustained loads - e.g. pressure and weight.
Stress due to sustained and occasional or exceptional loads - e.g. wind, seismic, snow etc.
•Stress range due to thermal expansion and alternating loads - e.g. thermal expansion or contraction and any dynamic reversing seismic loads.
•Additional conditions for the creep range - high temperature piping operating in the creep range i.e. sustained + creep stress.
•Stress due to a single, non-repeated support movement - e.g. ground settlement.
•Circumferential stress due to internal pressure - although not defined explicitly, in clause 6.1 the minimum required wall thickness formula for a straight pipe is defined, which can be calculated as a hoop stress for any given pipe wall thickness.

NOMINAL DESIGN STRESS

Nominal Design Stress, is a value calculated from the material physical data then used to determine the allowable stress. Nominal Design Stress is defined separately as a time-independent design stress for non-creep range of operating conditions, but a time dependent design stress for creep range operating conditions. The engineer should carefully determine not only operating conditions, but also take into account material reduction factors which apply to those steels that have no specific control certificates, and test reports in accordance with European Standard EN 10204. Details are described in clause 5 of EN 13480-3.

ALLOWABLE STRESSES

EN 13480 defines in clause 12.1.3, three basic allowable stress values; hot allowable (fh), stress range allowable (fa), and creep allowable (fcr) which are used as the acceptance criteria, Hot allowable and stress range allowables are derived from the nominal design stress.

AUTOPIPE - A DESIGN TOOL

Bentley has been working with this PED initiative since 2000 and AutoPIPE was one of the first pipe stress programs released in April 2003 with the new EN13480 piping standard. Commercially available since 1986, AutoPIPE is used in the plant industry for the calculation of piping stresses, flange analysis, pipe support design, and equipment nozzle loading analysis under static and dynamic loading conditions. AutoPIPE meets stringent QA standards, making it one of the few PC-based pipe stress programs approved for use in nuclear safety applications. AutoPIPE is also used extensively in the design of land based process & power plants, and has a large user base in offshore subsea pipeline and riser analysis.
AutoPIPE provides strict code compliance and verified material properties in accordance with the European Standard EN 13480. For example, designing high temperature pipework, AutoPIPE considers the time-dependent creep effect of the material, which can lead to a lower design stress limits. The AutoPIPE material library conveniently provides the mechanical properties such as minimum yield, tensile, 0.2% proof, 1% proof, and average creep rupture strength values but also elongation values. A comprehensive list of Carbon, Alloy-Steel and Stainless Steel European materials (EN), Swedish, German, DIN, British and American piping materials are provided. These properties are automatically used in the calculation of EN 13480 design nominal and allowable stresses, which saves time and eliminates costly input mistakes. Today AutoPIPE is used worldwide in more than 55 countries.

SUMMARY

The intention of this paper is to further discussion about the new European EN 13480 piping standard, and summarise its design rules and application. For some member states changes are not significant - for others, they require more time to be accepted by the engineering community. However at least the Pressure Equipment Directive and resulting standard EN 13480 precisely unify and standardise the design and construction requirements that must be met by flexible structures like piping systems. CU
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