PRESSURE POINTS

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ASME CODE NEWS

Developments in Boiler Materials for High Temperatures and Pressures

By John P. Swezy, Jr., Senior Code Consultant

In October 2004, the Electric Power Research Institute (EPRI) hosted a conference for engineers from around the world to present papers detailing progress in the development of materials and fabrication techniques for Ultra Supercritical (USC) boilers.

"What is a USC boiler?" you might ask. A USC boiler is designed to operate at steam temperatures in excess of 600 C (1112 F), and steam pressures approaching ~30 MPa (4200 psi). These extremes of temperature and pressure have thermal efficiencies approaching 48%, compared to today's supercritical plant efficiencies of 41%. There are unique problems associated with operating at these high temperatures and pressures. The key goal is to identify materials capable of achieving a creep rupture strength goal of 100 MPa (14.5 ksi) after 100,000 hours of service in this temperature range. At the same time, these materials must be amenable to forming and welding using traditional fabrication methods. And as always, the ever-present issue of corrosion and erosion resistance remains.

Increased efficiency is very desirable for a public utility, as it drives down generating costs. USC boilers reduce the total fuel consumption requirements, and make it easier to meet emissions requirements for coal-fired plants. Coals with a higher sulfur and ash content are somewhat cheaper than the currently preferred low sulfur strains. Emerging emissions technologies are making the economic viability of coals with higher sulfur content more attractive. Superior corrosion and ash erosion resistance of the new super-alloys is making higher sulfur and ash content coals more appealing.

Fossil fuels such as oil and natural gas have recently shown increasing price volatility and unstable market availability, while coal prices and supplies have remained quite stable. Coal is abundant in the continental United States; known coal reserves imply continued stability in the foreseeable future. The nuclear plant construction moratorium may end soon, but lead times are still long enough to prevent their immediate construction. EPRI reports that more than 1,000 coal fired power generation plant projects have been proposed in the continental United States for the next few years. Some of these projects may not actually be built, but these announcements indicate that the immediate future of cheap energy is coal.

Austenitic materials have been successful at achieving supercritical operational parameters of 540-565 C (1000–1050 F) at pressures up to ~22 MPa (3208 psi). However, austenitic materials undergo a significant reduction in strength and resistance to ash erosion at USC operating parameters. Some significant gains have been made using materials with higher nickel and lower chromium contents. Additional elements such as titanium and tungsten have been added in trace quantities to some alloys for strength improvements.

The emerging leader in this parade of new materials appears to be a Ni-Cr-Co superalloy. Initial creep rupture strength test data have been extrapolated to indicate values greater than 100 MPa after 100,000 hrs in sustained operations at 750 C (1380 F). Longer term testing is still proceeding to obtain 10,000 hours test data. This alloy has a nominal Co content of 20%. It exhibits excellent resistance to general corrosion, stress corrosion cracking, and high temperature ash erosion. It has proven relatively simple to form and weld. Other materials were capable of producing satisfactory creep strength and resistance to corrosion and erosion, but only two Ni-Cr-Co alloys were able to maintain superior performance at high temperature extremes approaching 750 C.

The early reports indicate that weldability of the high nickel alloys being considered for high temperature service is very good, and less demanding than the 9-12% Cr steels in current use. Though costly, the projected availability of these materials appears to be quite good.

So, just who is building USC boilers, and where are they building them? Most are being built outside the United States, primarily in Europe and Asia. Europe and Asia are each spear-

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ANNOUNCEMENT

The "Synopsis" of changes to the ASME Code published in the 2005 Addenda is completed and available for review and in printable format on www.hsbglobalstandards.com.

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heading regional research and development programs to establish this technology.

The U.S. DOE has enjoined several manufacturers in a joint development effort as well. They are still in the materials and fabrication methodology development phase, and not actually constructing a project yet. Until the consortium has settled upon the materials and fabrication techniques to apply, a final design is in a state of flux. On the surface it may appear that the U.S. based group is moving more slowly. This is partially due to the U.S. program having a more lofty design goal of 750 C (1380 F) and 35 MPa (5000 psi).

Industry demand for USC units has not been high thus far. No power generating plant proposals using USC technology have been announced for the U.S. market. The initial costs of such a plant are significantly higher than for a typical coal fired supercritical plant. However, this may change, since the cost differential could be more than recovered over the projected life of the plant from the increased thermal efficiency of USC technology offering reduced fuel consumption and overall fuel costs.

QUESTIONS & ANSWERS

Some Interpretations of significant interest to a broad cross-section of Code users are shown below, along with a short commentary on their application and use.

Interpretation I-04-20

Subject: PWT-11, Fig. PWT-11, Illustrations (c) and (d)
Date Issued: September 14, 2004
File: BC03-1842

Question (1): On a watertube boiler, is it a mandatory requirement to re-expand the tube after seal welding as shown in Fig. PWT-11, illustration (c)?

Reply (1): Yes.

Question (2): On a watertube boiler, is it a mandatory requirement to re-expand the tube after seal welding as shown in Fig. PWT-11, illustration (d)?

Reply (2): Yes.

The heat of welding relaxes strains induced by cold forming when expanding tubes into tube holes. Seal welds do not provide significant additional strength to offset the associated reduction in mechanical joint strength. Unless the expansion is repeated, the strength of the expanded attachment may be compromised, leading to potential tube-to-tubesheet joint failure in service. The text of PWT-11.1(c) and (d) clearly mandate re-expansion to be performed after welding.

Interpretation IV-04-05

Subject: Burst Test Procedures, HC-402
Date Issued: October 8, 2004
File: BC04-715

Question: Is it the intent of HC-402 that a burst test may be stopped prior to rupture when the test pressure reaches a value that will, by the formula, justify the design pressure?

Reply: Yes.

The provisions of HC-402 have been revised in the 2005 Addenda to clarify this intent.

Interpretation V-04-07

Subject: Section V (2001 Edition, 2003 Addenda) Article 6, T-660, Light Meters
Date Issued: April 1, 2004
File: BC04-306

Question: Except when the visible lighting technique has been previously demonstrated as acceptable, must an examiner performing visible or fluorescent liquid penetrant examinations in compliance with Article 6 have a calibrated light meter available to determine the acceptability of available lighting per the requirements of T-676.3 and T-676.4?

Reply: Yes.

Calibrated light meters are required only when demonstrating a lighting technique for documentation, or when using lighting techniques which have not been documented as being compliant with Article 6, T-660. Once a lighting technique demonstration has been fully documented as meeting T-676.3 as measured by a calibrated light meter, the technique may be used without any light meter required, whether calibrated or not.

Interpretation VIII-1-04-30

Subject: Section VIII, Division 1 (2001 Edition, 2003 Addenda); UG-34(c)(1) and UG-44, Pressure Temperature Ratings of Standard Blind Flanges
Date Issued: April 7, 2004
File: BC03-623

Question (1): May a raised-face blind flange, conforming to a flange standard referenced in UG-34(c)(1), be used at the pressure-temperature ratings in the respective standards, without additional design calculations, if they are altered in such a manner that their final dimensions fall outside the tolerances of the respective standard?

Reply (1): No.

Question (2): May a raised-face blind flange, conforming to a flange standard referenced in UG-34(c)(1) and having a corrosion resistant overlay welded to its interior face in such a manner that the final dimensions of the base material comply with the respective standard, be used at the pressure-temperature ratings in the respective standards, without additional design calculations?

Reply (2): Yes.

Careful consideration should be given for any modifications to standard pressure parts, to evaluate their impact upon the final pressure-temperature rating. Modifying standard pressure parts in such a manner that they no longer comply with fundamental requirements of the product standard makes the modified parts unacceptable for use at the assigned pressure-temperature rating of the standard. The suitability of the part must be determined by applying Code formulas for pressure ratings. Modifications which do not violate fundamental requirements of the standard, such as overlaying with corrosion resistant weld metal, do not invalidate the pressure-temperature rating assigned by the standard.

Interpretation VIII-1-04-33 (also VIII-2-04-04)

Subject:	Section VIII, Divisions 1 & 2; U-1(c)(2)(c) and AG-121(c), Pulp Refiners
Date Issued:	April 7, 2004
File:	BC03-1277

Question: Is a pressurized pulp refiner exempt from the scope of Section VIII, Division 1 by U-1(c)(2)(c) and Section VIII, Division 2 by AG-121(c), provided the primary design considerations and/or stresses are derived from the functional requirements of the device?

Reply: Yes. See U-1(c)(1) and Footnote 1 to AG-100.

The designs of some products require greater thicknesses for structural loads and other stresses, which are more controlling than incidental pressure induced stresses. While these thicknesses may control the ultimate design, they do not necessarily exempt the manufacturer from applying the Code requirements to the pressure retaining areas. The regulatory authorities at the point of installation may impose Code requirements in a more restrictive manner, per U-1(c)(1) (Div. 1) and Footnote 1 to AG-100 (Div. 2).

THE 2004 "METRICATED" CODE

Don't get metrocuted!

By Jay Cameron, P.E., Senior Consulting Engineer

History

The last metric Code was discontinued in 1986. Previous to the 2004 Edition, the parenthetical metric values were for reference only. Until the 2004 Edition was available, construction, including marking and stamping, had to be in U.S. customary units. The 2004 Edition to the ASME Boiler and Pressure Vessel Code is now metricated - now, it is truly possible to produce a vessel or boiler with metric ratings. ASME's motivation for doing this is to be more responsive to their customers on an international basis, and to achieve broader ISO recognition as an international standard.

General Code Implementation

The Forewords in each Code book included the following statement, "one system [of units] shall be used consistently throughout for all phases of construction". Also, a new Mandatory Appendix with appropriate units for each system of units and a new Nonmandatory Appendix with guidelines for the use of each system of units were added.

Code Cases and Revisions

It became apparent that there were unintended consequences with the new words added to the Forewords. An ASME Task Group was formed to develop rules and guidelines for practical implementation of the metric Code. This resulted in two Code Cases and Code revisions that were proposed by the Metric Task Group.

Code Cases 2523 (non-nuclear) and N-744 (nuclear) were developed (and are currently in their final stage of ASME Committee Balloting) to provide clarifications to metric implementation. According to the draft Code Cases, in general, it is preferred that a single system of units be used, but local units may be used for a component. Each equation must be in a single system of units and, when two equations are presented, the appropriate equation is used. Other company documentation and equipment may be in any units in accordance with the fabricator's practice. Units must be converted for verification using dimensional consistency and accuracy. Metric materials are also officially acceptable.

Data report forms and marking/nameplates must both be in the same units - any units are acceptable but must be consistent with drawings.

The following revisions for the 2006 Addenda are being proposed: revised Forewords and construction Code paragraphs consistent with Foreword philosophy, cleaned up data report forms to permit proper documentation in the permitted units, clarification in Section II, Part D and Section VIII, Divisions 1, 2 &3 regarding the use of metric materials, and consistency within and between books, such as PWHT time at temperature.

There are innumerable "what-if" issues that will have to be worked through, and it is anticipated that there will be further adjustments in this transitional period. HSB is here to help with that transition.

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