STP-PT-053

CRITERIA DOCUMENT FOR SHELL-AND-TUBE HEAT EXCHANGERS ACCORDING TO PART UHX OF ASME SECTION VIII DIVISION 1

ASME STANDARDS TECHNOLOGY, LLC

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Date of Issuance: March 22, 2013

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ISBN No. 978-0-7918-6876-8

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FOREWORD

The purpose of this document is to justify and provide technical criteria for the rules of Part UHX of ASME Section VIII Division 1, 2010 Edition, devoted to the design of U-tube, Fixed and Floating head Tubesheet Heat Exchangers. Confirmation and documentation of the basis for UHX-rules is important for the SG-HTE members for future reference and developments or if additional confirmation or comparisons are required. It will be a valuable reference for early career engineers that are using the UHX rules or becoming involved in Code developments of such rules in the future.

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ABSTRACT

The purpose of this document is to justify and provide technical criteria for the rules of Part UHX of ASME Section VIII Division 1, 2010 Edition, devoted to the design of U-tube, Fixed and Floating head Tubesheet Heat Exchangers. The criteria document applies also to paragraph 4.18 of Section VIII, Division 2 which is entirely based on Part UHX.

The analytical treatment of the fixed tubesheet heat excangers is based on classical discontinuity analysis methods to determine the moments and forces that the tubesheet, tubes, shell and channel must resist.

- The heat exchanger is assumed to be a symmetrical unit with identical tubesheets on both ends.
- The Tubes are replaced by an equivalent elastic foundation.
- The Perforated tubesheet is replaced by an equivalent solid circular plate with effective elastic constants depending on the ligament efficiency of the tubesheet. This equivalent solid circular plate is treated by the theory of thin circular plates subjected to pressure and and other applied loads to determine the stresses in the tubesheet
- The unperforated tubesheet rim is treated as a rigid ring.
- Its Connection to the shell and channel accounts for the edge displacements and rotations of these 3 components. Shell and channel are treated by the elastic theory of thin shells of revolution subjected to edge loads to determine the maximum stresses.

The treatment provides, at any radius of the perforated tubesheet, the deflection, the rotation, the bending and shear stresses and the axial stress in the tubes.

- A parametric study permits to determine the maximum stresses in the tubesheet and in the tubes which are given in UHX-13.
- The treatment also determines the loads and displacements acting on the shell and channel at their connection to the tubesheets and then the shell and channel stresses.
- The maximum stresses in tubesheets, tubes, shell and channel so determined are limited to the appropriate allowable stress-based classifications of Section VIII Division 2 Appendix 4, 2004 edition.

The Floating Tubesheet and U-tube Tubesheet heat exchangers are treated as simplified cases of fixed tubesheets heat exchangers.

A checking of the results obtained is provided by comparison with FEA, TEMA, French pressure vessel code CODAP. Applying the appropriate simplifications, the classical formulas for circular plates subjected to pressure have been obtained.

PART 1
Introduction

1 SCOPE

Develop a criteria document covering the development of the TS design rules for the U-tube, Fixed, and Floating Head TS HEs configurations contained in Part UHX of Section VIII Division 1, 2010 Edition. The criteria document will apply also to paragraph 4.18 of Section VIII, Division 2 which is entirely based on Part UHX.

The free body diagram of the HE, the equilibrium and compatibility equations, the solution of resulting differential equations and all intermediate steps are provided to show the derivation of:

- the deflection and the rotation at any radius of the TS,
- the bending and shear stress at any radius of the TS,
- the axial stresses in the tubes at any radius of the TS,
- the axial stretch force acting in the shell,
- the axial displacement of the shell.

The document provides the technical basis of the following items:

- the required loading case combinations,
- the acceptance criteria for each TS configuration, as applicable,
- the TS characteristics including the Effective Elastic Constants,
- the TSs extended as a flange.

The following effects are in addition to the above basic items:

- the effect of different shell material or thickness adjacent to the TS,
- the effect of plasticity at TS-shell-channel joint,
- the effect of radial differential thermal expansion between the TS and integral shell and channel,
- the tubesheet calculated as simply supported TS.