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Criteria for Shell-and-Tube Heat Exchangers According to Part UHX of ASME Section VIII-Division 1

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

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FOREWORD

The purpose of this document is to justify and provide technical criteria for the rules of Part Unfired Heat Exchanger (UHX) of ASME Section VIII Division 1, 2013 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, 2013 Edition, which is entirely based on Part UHX.

Confirmation and documentation of the basis for UHX-rules is important for the members of the ASME Subgroup on Heat Transfer Equipment to use as a future reference, for confirmation or comparisons of code requirements, and for code development. It will be a valuable reference for both early career and experienced engineers who are using the UHX rules and may become involved in code development of such rules in the future.

The analytical treatment of the fixed tubesheet heat exchangers is based on classical discontinuity analysis methods to determine the moments and forces that the tubesheet, tubes, shell and channel must resist. 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 one to determine the maximum stresses in the tubesheet and in the tubes which are given in UHX-13. The Floating Tubesheet and U-tube Tubesheet heat exchangers are treated as simplified cases of fixed tubesheet heat exchangers. A check of the results obtained is provided by comparing Finite Element Analysis (FEA) results, Tubular Exchanger Manufacturers Association (TEMA) results, and the French pressure vessel code Code Français de Construction des Appareils à Pression (CODAP). Applying the appropriate simplifications, the classical formulas for circular plates subjected to pressure, have been obtained.

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ABBREVIATIONS AND ACRONYMS

ASME	American Society of Mechanical Engineers
CL	Clamped
EEC	Effective Elastic Constants
FEA	Finite Element Analysis
FL	Floating
HEs	Heat Exchanger(s)
LE	Ligament Efficiency
SG-HTE	Subgroup on Heat Transfer Equipment
SS	Simply Supported
ST	Stationary
TEMA	Tubular Exchanger Manufacturers Association
TSs	Tubesheet(s)
UHX	Unfired Heat Exchanger

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PART 1
INTRODUCTION

1 SCOPE

This criteria document covers the development of the tubesheet (TS) design rules for the U-tube, Fixed, and Floating Head TS Heat Exchangers (HE) configurations contained in Part UHX of Section VIII Division 1, 2013 Edition. It applies 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 TS 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 a simply supported TS.