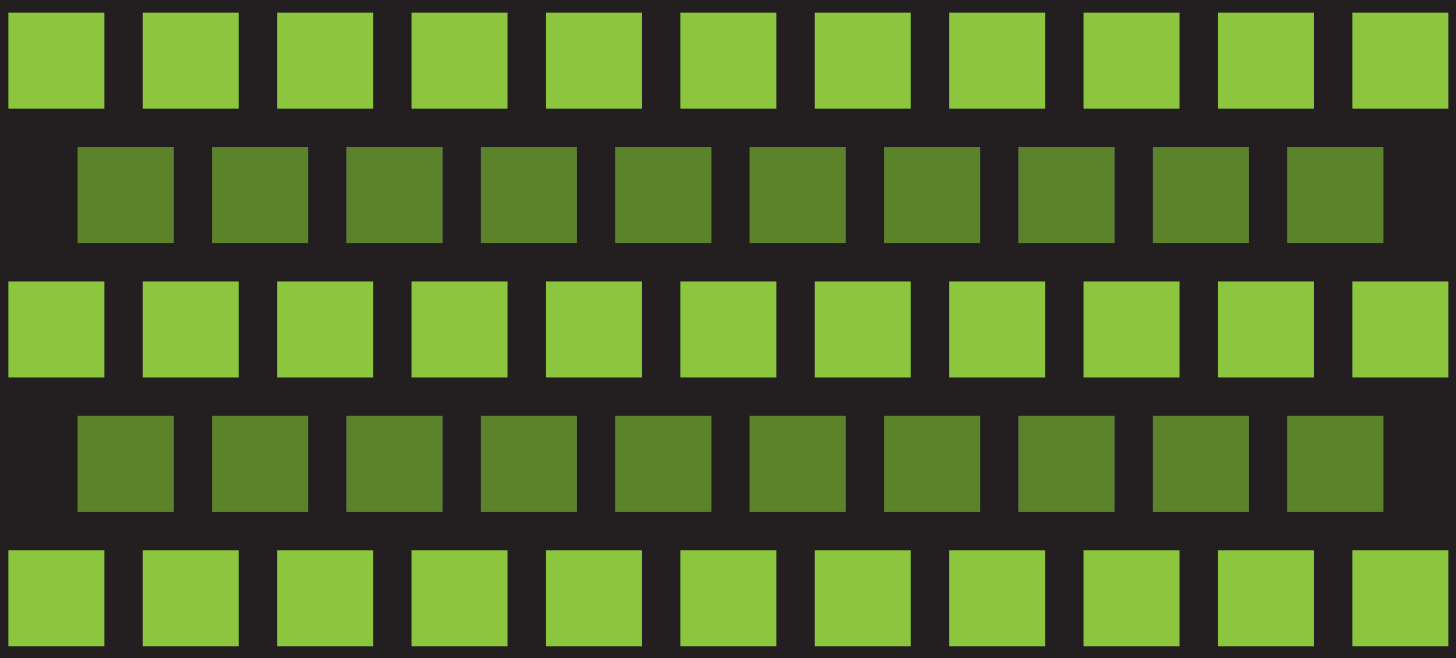
STP-PT-025

EXTENDED FATIGUE EXEMPTION RULES FOR LOW CR ALLOYS INTO THE TIME-DEPENDENT RANGE FOR SECTION VIII DIV 2



ASME STANDARDS TECHNOLOGY, LLC

STP-PT-025

EXTEND FATIGUE EXEMPTION RULES FOR LOW CR ALLOYS INTO THE TIME-DEPENDENT RANGE FOR SECTION VIII DIV 2 CONSTRUCTION

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

FOREWORD

This document was developed under a research and development project which resulted from ASME Pressure Technology Codes & Standards (PTCS) committee requests to identify, prioritize and address technology gaps in current or new PTCS Codes, Standards and Guidelines. This project is one of several included for ASME fiscal year 2008 sponsorship which are intended to establish and maintain the technical relevance of ASME codes and standards products. The specific project related to this document is project 07-03 (BPVC#1), entitled "Extend Fatigue Exemption Rules for Low Cr Alloys Slightly into the Time-Dependent Range for Section VIII Div 2 Construction."

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ABSTRACT

A number of alloys have applications slightly into the creep range that are in cyclic service, such as process reactors. The 2007 edition of Section VIII, Div 2 [1] provides allowable stresses for these materials, which may be controlled by creep properties. However, the fatigue design rules and fatigue exemption rules are not applicable, precluding construction of vessels using these materials at temperatures above 370°C (700°F). This report provides a simplified approach for exemption of low chrome alloys from fatigue analysis that are slightly into the creep range.

1 BACKGROUND

A number of alloys have applications slightly into the creep range that are in cyclic service, such as process reactors. The 2007 edition of Section VIII, Div 2 [1] provides allowable stresses for these materials, which may be controlled by creep properties. However, the fatigue design rules and fatigue exemption rules are not applicable. The fatigue exemption rule of Section VIII, Div 2, Part 5, paragraph 5.5.2.2, which permits exemption by prior experience, is not applicable since prior experience with vessels constructed to the new design margins provided in the 2007 edition of Div 2 are not applicable.

In the 2004 edition of Section VIII, Div 2 [2], the maximum temperature for which allowable stresses were provided was limited to temperatures where time independent properties governed the allowable stress, as discussed below. However, this does not mean that creep is not significant. For example, hold time fatigue data in Figure 1 from reference 3, clearly show a reduction in fatigue life from creep damage associated with hold times, for 2-1/4 Cr – 1 Mo at 482°C (900°F). Perhaps as a result of this, fatigue curves have not been provided for temperatures greater than 370°C (700°F). Fatigue curves based on continuous cycling tests without hold time would be non-conservative for general design. These higher temperature vessels can only be designed per the present rules if they satisfy an exemption from fatigue analysis.

Reducing the margin on tensile strength in the 2007 edition of Section VIII, Div 2, drops the temperature at which creep properties govern to a lower temperature. A change was made to specifically consider the effect of creep properties on allowable stress. However, the same issue remains, the Div 2 rules can only be used if the component satisfies an exemption from fatigue analysis as there are no fatigue curves in the Code for temperatures greater than 370°C (700°F).

For the materials in question, the basis for the allowable stresses in the 2004 edition of Section VIII, Div 2 construction was the least of the following (per ASME Section II, Part D, and Appendix 2 [4]).

$S_T/3$

$1.1\ S_T R_T/3$

$2/3\ S_y$

$2/3\ S_Y R_Y$

From ASME Section II, Part D, these values are defined as:

R_T ratio of the average temperature dependent trend curve value of tensile strength to the room temperature tensile strength.

R_Y ratio of the average temperature dependent trend curve value of yield strength to the room temperature yield strength.

S_T specified minimum tensile strength at room temperature.

S_Y specified minimum yield strength at room temperature.

In Section VIII, Division 1 [5], the following additional considerations in setting the allowable stress are required when the material is in the creep regime.

$F_{avg}\ S_{R\ avg}$

$0.8\ S_{R\ min}$

S_c

From ASME Section II, Part D, these values are defined as: