STP-PT-029-1

EXTERNAL PRESSURE DESIGN IN CREEP RANGE

ASME STANDARDS TECHNOLOGY, LLC

STP-PT-029-1

External Pressure Design in Creep Range

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Summary of Changes
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The following changes have been made to the first revision of STP-PT-029.

Rev. 1 Page	*Location*	*Change*
vi-vii	Table of Contents	Updated to reflect changes
3	table 2, row 8	Corrected from "9Cr-1M0-V" to "9Cr-1Mo-V"
5	last paragraph, line 3	Replaced "*k'*" with "*k'T*"
5	equation (10)	Removed "*T*"
6	paragraph 1	Inserted "*K' = k'T*"
6	equation (11)	Replaced "1464" with "39,300"
6	equation (10)	Removed "*T*"
6	equation (11)	Replaced "1464" with "39,300"
7	bullet 2	Replaced "48" with "120"
7	bullet	Replaced "10,000" with "100,000"
7	section 3.3.1.1, line 3	Replaced "10,000" with "100,000"
7	section 3.3.1.1, line 3	Replaced "860" with "8,600"
7	equation	Removed "100"
7	equation	Replaced "48" with "120"
7	equation	Replaced "5,880" with "94,100"
7	equation	Replaced "<" with ">"
7	paragraph 8	Replaced "5,880" with "14,200"
7	paragraph 8	Replaced "860" with "8,600"

Rev. 1 Page	*Location*	*Change*
7	section 3.3.1.2, line 3	Replaced “10,000” with “100,000”
7	section 3.3.1.2, line 3	Replaced “380” with “3,800”
8	first equation	Removed “10,000”
8	first equation	Replaced “48” with “120”
8	first equation	Replaced “515” with “5,570”
8	paragraph 3	Replaced “515” with “5,570”
8	paragraph 3	Replaced “380” with “3,800”
8	section 3.3.1.3, line 1	Replaced “40” with “20”
8	section 3.3.1.3, line 2	Replaced “300” with “3,800”
8	second equation	Removed “100,000”
8	second equation	Replaced “48” with “120”
8	second equation	Replaced “2.94” with “2.96”
8	second equation	Replaced “300” with “4,740”
8	paragraph 9	Replaced “300” with “4,740”
8	paragraph 9	Replaced “equal to” with “greater than”
8	paragraph 9	Replaced “300” with “3,800”
8	paragraph 9	Replaced “40” with “20”
11	equation (19)	Replaced “*K’* ” with “*k’* ”
11	paragraph 5	Replaced “*K’* ” with “*k’* ”
11	paragraph 5	Replaced “(2) ” with “(1)”
12	equation (20)	Removed “*T”*
12	paragraph 1	Inserted “*K’* = *k’T*”
13	bullet 4	Replaced “24.7” with “24,700”
13	paragraph 5	Removed “8”
14	paragraph 4	Removed “8”
15	bullet 3	Inserted “S = 20,700 psi at 1000°F for short time”
15	bullet 4	Inserted “S = 6,300 psi at 1000°F for 100,000 hours”
15	bullet 6	Replaced “1.0” with “1.5”
15	paragraph 4	Inserted “This stress is < 20,700 psi and”
15	last equation	Removed “100,000”
15	paragraph 7	Replaced “395 <” with “12,300 psi > 6,300 psi. Use B = 6,300 psi >”
15	paragraph 8	Removed “not”
16	paragraph 3	Replaced “low” with “high”

Rev. 1 Page	*Location*	*Change*
16	bullet 1	Inserted “The ratio e/t of the cylinder is highly arbitrary and does not have an influence on the results.”
16	bullet 1	Removed “assumed to have a very large R_o/t ratio. However, the ratio in this case is only 45.”
16	bullet 2	Replaced “get to be too conservative” with “become approximate”
16	paragraph 4	Removed “the conservative”
18	equation (29)	Replaced “*K’* ” with “*k’* ”
18	paragraph 5	Replaced “*K’* ” with “*k’* ”
18	paragraph 5	Replaced “(2) ” with “(1)”
19	equation (30)	Removed “*T”*
19	paragraph 1	Inserted “$K' = k'T$”
20	paragraph 4	Replaced “1.0” with “1.5”
21	first equation	Replaced “1.0” with “1.5”
21	first equation	Removed “100,000”
21	first equation	Replaced “0.55” with “16.9”
21	paragraph 2	Replaced “0.55 psi <” with “16.9 psi >”
21	paragraph 3	Replaced “inadequate” with “adequate”
21	bullet 1	Inserted “The ratio e/t of the cylinder is highly arbitrary and does not have an influence on the results.”
21	bullet 1	Removed “assumed to have a very large D_o/t ratio. However, the ratio in this case is only 144.”
21	bullet 2	Replaced “get to be too conservative” with “become approximate”
23	equation (40)	Replaced “P_a” with “σ_c”
23	equation (40)	Removed “*T”*
23	equation (40)	Replaced “0.588” with “0.353”

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FOREWORD

This document was developed under a research and development project that 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 2009 sponsorship which are intended to establish and maintain the technical relevance of ASME codes & standards products. The specific project related to this document is project 09-03 (BPVC #2) titled "External Pressure Design in Creep Range".

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ABSTRACT

At the present time the ASME Boiler and Pressure vessel code does not include rules for the design of components under external pressure and axial compressive loads in the time-dependent creep regime. A method is suggested in this report for designing components in the time-dependent creep regime. The design methodology is developed for columns and cylindrical shells under axial compression as well as cylindrical, spherical and conical shells under external pressure. An external pressure chart for 2.25Cr-1Mo steel was developed at 1000°F to demonstrate the applicability of the methods developed in this report. In addition, variable factors of safety are imbedded in the design equations in order to transition from the design factors used in the time-independent External Pressure Charts of Section II to the lower design factors specified in Section III for time-dependent, creep buckling.

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1 INTRODUCTION

The 2007 edition of the ASME Boiler and Pressure Vessel Code, Sections I and VIII, includes rules for the design of cylindrical, conical, spherical, ellipsoidal and torispherical shells subjected to external pressure. Rules are also given for the design of cylindrical and conical shells under axial compressive loads. In addition, Section VIII gives rules for the design of structural members subjected to axial compressive loads such as heat exchanger tubes. All of these rules are applicable at temperatures below the creep range of the material. The ASME code gives approximate temperatures above which creep becomes prominent as shown in Table 1. These temperature limits are approximate and serve as guidelines for design purposes and should not be thought of as absolute values for a given specified material.

Table 1 - Approximate Temperatures at Which Creep Becomes a Design Consideration for Various Materials (these temperatures may vary significantly for specific product chemistry and failure mode under consideration).

Material	Temperature (°F)	Temperature (°C)
Carbon and Low Alloy Steel	700-900	370-480
Stainless Steels	800-1000	425-535
Aluminum Alloys	300	150
Copper Alloys	300	150
Nickel Alloys	900-1100	480-595
Titanium and Zirconium Alloys	600-650	315-345

There are situations where it is beneficial for newly constructed boiler and pressure vessel components to operate at temperatures beyond the creep cut-off limits of the material. Thus, new design criteria are needed for establishing allowable compressive stress for various components. In this report, suggested procedures are presented to address the design of ASME components under compressive and external pressure loads operating at elevated temperatures in the creep range.