ASME PTB-1-2014

ASME Section VIII – Division 2 Criteria and Commentary

ASME
SETTING THE STANDARD

PTB-1-2014

ASME Section VIII – Division 2 Criteria and Commentary

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Date of Issuance: May 27, 2014

The American Society of Mechanical Engineers

Two Park Avenue, New York, NY 10016-5990

ISBN No. 978-0-7918-6927-7

Printed in the U.S.A.

TABLE OF CONTENTS

LIST OF FIGURES

FOREWORD

In 1998 the ASME Boiler and Pressure Vessel Standards Committee authorized a project to rewrite the ASME B&PV Code, Section VIII, Division 2. This decision was made shortly after the design margin on specified minimum tensile strength was lowered from 4.0 to 3.5 in Section I and Section VIII, Division 1. ASME saw the need to update Section VIII, Division 2 to incorporate the latest technologies and to be more competitive. In lieu of revising the existing standard, the decision was made to perform a clean sheet rewrite. By doing so it was felt that, not only could the standard be modernized with regard to the latest technical advances in pressure vessel construction, but it could be structured in a way to make it more user-friendly for both users and the committees that maintain it.

Much new ground was broken in the development of the new Section VIII, Division 2, including the process taken to write the new standard. Traditionally, development of new standards by ASME is carried out by volunteers who serve on the different committees responsible for any given standard. Depending upon the complexity of the standard, the development of the first drafts may take up to 15 years to complete based on past history. The prospect of taking 15 or more years to develop VIII-2 was unacceptable to ASME and the volunteer leadership. The decision was made to subcontract the development of the draft to the Pressure Vessel Research Council (PVRC) who in turn formed the Task Group on Continued Modernization of Codes to oversee the development of the new Section VIII, Division 2 Code. PVRC utilized professionals with both engineering and technical writing expertise to develop new technology and the initial drafts of the new Section VIII, Division 2.

A Steering Committee made up of ASME Subcommittee VIII members was formed to provide technical oversight and direction to the development team with the goal of facilitating the eventual balloting and approval process. ASME also retained a Project Manager to manage all the activities required to bring this new standard to publication.

The project began with the development of a detailed table of contents containing every paragraph heading that would appear in the new standard and identifying the source for the content that would be placed in this paragraph. In preparing such a detailed table of contents, the lead authors were able to quickly identify areas where major development effort was required to produce updated rules. A list of some of the new technology produced for VIII-2 rewrite includes:

- Adoption of a design margin on specified minimum tensile strength of 2.4,
- Toughness requirements,
- Design-by-rule for the creep range,
- Conical transition reinforcement requirements,
- Opening reinforcement rules,
- Local strain criteria for design-by-analysis using elastic-plastic analysis,
- Limit load and plastic collapse analysis for multiple loading conditions,
- Fatigue design for welded joints based on structural stress method, and
- Ultrasonic examination in lieu of radiographic examination.

Users of the Section VIII, Division 2 Code (manufacturers and owner/operators) were surveyed at the beginning of the project to identify enhancements that they felt the industry wanted and would lead to increased use of the standard. Since the initial focus of the Code was for the construction of pressure equipment for the chemical and petrochemical industry, the people responsible for specifying equipment for this sector were very much interested in seeing that common requirements that are routinely found in vessel specifications would become a requirement within this standard. This was accomplished by close participation of the petrochemical industry during the development of this standard. Some of the enhancements included:

- Alternatives provided for U.S. and Canadian Registered Professional Engineer certification of the User Design Specification and Manufacturers Design Report,
- Consolidation of weld joint details and design requirements,
- Introduction of a weld joint efficiency and the use of partial radiographic and ultrasonic examination,
- Introduction of the concept of a Maximum Allowable Working Pressure (MAWP) identical to VIII-1,
- Significant upgrade to the design-by-rule and design-by-analysis procedures,
- Extension of the time-independent range for low chrome alloys used in heavy wall vessels,
- Extension of fatigue rules to 900°F (400°C) for low-chrome alloys used in heavy wall vessels,
- Adoption of new examination requirements and simplification of presentation of the rules,
- User-friendly extensive use of equations, tables, and figures to define rules and procedures, and
- ISO format; logical paragraph numbering system and single column format,

Many of these enhancements identified by users were included in the first release of Section VIII, Division 2 in 2007.

After publication of Section VIII, Division 2, ASME contracted with the Equity Engineering Group, Inc. to develop the ASME Section VIII, Division 2 Criteria and Commentary. Valuable background information is provided in this document to assist users in using the Code. In addition, the Criteria and Commentary also ensures that the technology introduced into the Code is properly documented.

ACKNOWLEDGEMENTS

The original manuscript for this document started as an update to Chapter 22 in the Third Edition of K.R. Rao's publication entitled Companion Guide to the ASME Boiler & Pressure Vessel Code: Criteria and Commentary on Select Aspects of the Boiler & Pressure Vessel Code and Code for Pressure Piping. The authors of Chapter 22 were: Thomas Pastor who developed Parts 1, 2, and 8; David Osage who developed Part 4; Robert Brown who developed Part 5; Clay Rodery who developed Parts 6 and 7; and Philip Henry who developed Part 9. Guido Karcher provided valuable comments and corrections as the final editor for Chapter 22. The ASME Section VIII, Division 2 Criteria and Commentary, represents a significant update to the background material originally provided in Chapter 22. Additional details, insights into Committee decisions, and analytical derivations of much of the key technology features are provided.

The Equity Engineering Group, Inc. contributed significant resources to the development of the Criteria and Commentary. In particular: Jeffery Brubaker provided assistance in the documentation of the toughness rules of Part 3; Jeremy Staats reviewed the work of Pellini and developed the documentation for operation on the lower-shelf; James Sowinski developed the background material for conical transition without knuckles or flares in Part 4; Dr. Warren Brown provided background information on both current and future directions for the flange design rules; Dr. Zhenning Cao developed the theory and documentation for the stress analysis of conical transitions with knuckles and flares in Part 4 as well as the overview of the Structural Stress and Master Curve approach for the fatigue evaluation of welds in Part 5; Joel Andreani provided background material covering the development of the load factors in Part 5; and Robert Brown assisted in the development of Part 5.

A special commendation for technology development for the new Section VIII, Division 2 is extended to Dr. Martin Prager of MPC and WRC. Dr. Prager developed many key technology features of the Code including a new universal stress-strain curve that is used for Design-By-Analysis in Part 5 and also for design for external pressure. This stress-strain curve model replaces the A-B Charts in Section II Part D. Dr. Prager developed the material models used in conjunction with the API 579-1/ASME FFS-1 FAD assessment technology for the evaluation of crack-like flaws to develop the new toughness rules of Part 3 that is based on a 20 ft-lb criteria similar to European practice. He also developed the technology for the new strain-based Protection Against Local Failure in Part 5. Together with Dr. Pingsha Dong, Dr. Prager was instrumental in introducing and incorporating the new Structural Stress and Master Fatigue Curve approach for the evaluation of welded joints. This new method is considered state-of-the-art for fatigue assessment of welded joints; it first appears in a code and standards environment in Section VIII, Division 2 and API 579-1/ASME FFS-1. Dr. Prager is currently working to develop new creep-fatigue interaction rules that may be published in future editions of VIII-2.

The authors acknowledge the following individuals for their technical and editorial peer review of this document: Gabriel Aurioles, Ramsey Mahadeen, and Jay Vattappilly.

Finally, the authors would also like to commend the efforts of Tiffany Shaughnessy for her editing and document preparation skills in the publication of this document and Debbie Samodell for her work in producing the graphic images used in most of the figures.

ORGANIZATION AND USE

The 2009 Edition of the ASME B&PV Code, Section VIII, Division 2 Criteria and Commentary, covers the 2007 Edition of Section VIII, Division 2 including the 2008 and 2009 Addenda. In addition, some of the changes planned for the 2010 Edition of the Code are also included. This document will be updated as required to keep pace with future developments in Section VIII, Division 2.

In the ASME B&PV Code, Section VIII, Division 2 Criteria and Commentary, a complete description of the Code is provided including technical background, an overview of many new features, and where significant differences now exist between the new and old Section VIII, Division 2. In this document, the editions of the ASME B&PV Section VIII Codes are identified as follows:

- VIII-1 – Section VIII, Division 1, 2007 Edition
- VIII-2 – Section VIII, Division 2, 2007 Edition
- Old VIII-2 – Section VIII, Division 2, 2004 Edition, 2006 Addenda
- VIII-3 – Section VIII, Division 3, 2007 Edition

The paragraph numbering in the Criteria and Commentary matches that of VIII-2. Figure and tables are numbered consecutively within each part of this document. If the figure or table is from VIII-2, then the VIII-2 figure or table number is provided in parenthesis. Rules for referencing paragraphs, tables and figures are described below.

- References to paragraphs, tables and figures within the Criteria and Commentary are made directly. For example, a reference to paragraph 4.2 in this document would be designated as paragraph 4.2, a reference to Figure 5-20 in this document would be designated as Figure 5-20.
- References to paragraphs, tables and figures in VIII-2 are preceded by the applicable section number. For example, a reference to paragraph 4.2 in Part 4 of VIII-2 would be designated in this document as Section 4, paragraph 4.2, a reference to Table 3.4 in Part 3 of VIII-2 would be designated as Section 3, Figure 3.4, and a reference to Figure **5-20**5.20 of Part 5 of VIII-2 would be designated Section 5, Figure 5-20.
- References to paragraphs, tables and figures in VIII-1, Old VIII-2, or VIII-2 are preceded by this code designation. For example, a reference to paragraph UW-26(d) in VIII-1 would be designated in this document as VIII-1, UW-26(d), a reference to Table UW-12 or VIII-1 would be designated as VIII-1, Table UW-12, and a reference to Figure UW-13.1 of VIII-1 would be designated VIII-1, Figure UW-13.1.
- References to other sections of the ASME B&PV Code are made directly. For example a reference to the ASME B&PC Code, Section II, Part D would be designated as Section II, Part D, and a reference to Article 23 of Section V would be designated as Section V, Article 23.

The term Section VIII Committee used in this document refers to the Section VIII Standards Committee of the ASME B&PV Code.

Annex A of this document includes the original criteria document for Section VIII, Division 2 entitled *Criteria of the ASME Boiler and Pressure Vessel Code for Design by Analysis in Sections III and VIII, Division 2* originally published in: *Pressure Vessels and Piping: Design and Analysis, A Decade of Progress, Volume One, Analysis, ASME, New York, N.Y., 1972, pages 61-83*. This reference is provided because some of the original criteria in Old VIII-2 have been kept in the development of VIII-2.

1 GENERAL REQUIREMENTS

1.1 General

1.1.1 Introduction

Section 1 contains general type requirements addressing the following subjects:

- Paragraph 1.1 – General; Introduction; Organization of the standard
- Paragraph 1.2 – Scope
- Paragraph 1.3 – Reference Standards
- Paragraph 1.4 – Units of Measurement
- Paragraph 1.5 – Tolerances
- Paragraph 1.6 – Technical Inquiries
- Paragraph 1.7 – Tables
- Annex 1-A – Deleted
- Annex 1-B – Definitions
- Annex 1-C – Guidance for the Use of US Customary and SI Units in the ASME Boiler and Pressure Vessel Codes

1.1.2 Organization

The requirements of VIII-2, are contained in the nine Sections listed below. Each of these Sections and related Annexes is composed of paragraphs that are identified by an alphanumeric numbering system in accordance with the ISO Standard Template for the Preparation of Normative-Type Documents. References to paragraphs are made directly by reference to the paragraph number. For example, the Scope is referenced as paragraph 1.2.

a) Section 1 – General Requirements: provides the scope of VIII-2 and establishes the extent of coverage.

b) Section 2 – Responsibilities and Duties: sets forth the responsibilities of the user and Manufacturer, and the duties of the Inspector.

c) Section 3 – Material Requirements: provides the permissible materials of construction, applicable material specifications, and special requirements, physical properties, allowable stresses, and design fatigue curves.

d) Section 4 – Design By Rule Requirements: provides requirements for design of vessels and components using rules.

e) Section 5 – Design By Analysis Requirements: provides requirements for design of vessels and components using analytical methods.

f) Section 6 – Fabrication Requirements: provides requirements governing the fabrication of vessels and parts of vessels.

g) Section 7 – Examination and Inspection Requirements: provides requirements governing the examination and inspection of vessels and parts of vessels.

h) Section 8 – Pressure Testing Requirements: provides pressure testing requirements for fabricated vessels.

i) Section 9 – Pressure Vessel Overpressure Protection: provides rules for pressure relief devices.

The organization within each section is as follows:

a) Rules and requirements organized in paragraphs using the ISO numbering system

b) Nomenclature

c) Tables

d) Figures

e) Normative Annexes (mandatory)

f) Informative Annexes (non-mandatory)

Mandatory and non-mandatory requirements are provided as normative and informative annexes, respectively, to the specific Part under consideration. The Normative Annexes address specific subjects not covered elsewhere in this Division and their requirements are mandatory when the subject covered is included in construction under this Division. The Informative Annexes provide information and suggested good practices.

Unlike all of the other ASME BPV Standards, VIII-2 has been published in single column format, which facilitates use of the standard in electronic form, since its initial release in 2007. A detailed Table of Contents precedes each Part, and each is numbered independently of each other.

1.1.3 Definitions

The definitions for the terminology are provided in Annex 1-B.

1.2 Scope

1.2.1 Overview

Part 1, paragraph 1.2 defines the scope of coverage for VIII-2. The term scope refers to both the type of pressure equipment being considered in the development of these rules, as well as the geometric scope of the vessel that is stamped with the Certification Mark and U2 Designator as meeting VIII-2.

In accordance with Part 1, paragraph 1.2.1.1, pressure vessels are defined as containers for the containment of pressure, internal or external. This pressure may be obtained from any external source, or by the application of heat from a direct or indirect source, as a result of a process, or any combination thereof.

The manner in which the scope of the standard is described follows very closely to the introduction section of VIII-1. In the following paragraphs, a discussion of requirements is provided only where a significant difference exists between VIII-2 and the scope definition from VIII-1, or where a major change was made from Old VIII-2.

With regard to pressure vessels installed in non-stationary applications, Part 1, paragraph 1.2.1.2.b now permits stamping with the Certification Mark and U2 Designator of VIII-2 vessels installed on motor vehicles and railway cars. This particular application was prohibited in the Old VIII-2. Construction and stamping with the Certification Mark and U2 Designator of VIII-2 vessels in non-stationary applications requires a prior written agreement with the local jurisdictional authority covering operation and maintenance control for a specific service. This operation and maintenance control must be retained during the useful life of the pressure vessel by the user in conformance with the Users Design Specification.

Part 1, paragraph 1.2.1.2.e defines pressure vessels in which steam is generated but which are not classified as Unfired Steam Boilers that require construction in accordance with the rules of Section I or VIII-1. A third category for a vessel that generates steam that may be constructed to VIII-2 was added, paragraph 1.2.1.2.e.3: vessels in which steam is generated but not withdrawn for external use.

One significant difference between VIII-2 and the Old VIII-2 is special service vessels such as those in lethal service. In Old VIII-2, paragraph AG-301.1(c), the user and/or his designated agent had to define in the UDS if a vessel was intended for lethal service. If lethal service was specified, then additional

technical requirements (e.g. enhanced NDE, restrictions on material, etc.) were imposed on this vessel. In VIII-2, additional requirements are not specified for lethal service or any other special service condition. The rationale behind this change is that the user and/or his designated agent are responsible to describe in the UDS (see Part 2, paragraph 2.2.2), the intended operation of the vessel, and if a vessel is intended for a service that is dangerous to life and property, then the user should specify any additional requirements to mitigate the risks. Just as it has been the rule in ASME that it's standards would not define when a vessel is in lethal service, what additional requirements would be appropriate for any given vessel are best defined by the user, and not by the Committee.

1.2.2 Additional Requirements for Very High Pressure Vessels

The rules of VIII-2 do not specify a limitation on pressure but are not all-inclusive for all types of construction. For very high pressures, additions to these rules may be required to meet the design principles and construction practices essential to vessels for such pressures. However, only in the event that, after application of additional design principles and construction practices, the vessel still complies with all of the requirements of the Code, may it be stamped with the Certification Mark. As an alternative to VIII-2, it is recommended that VIII-3 be considered for the construction of vessels intended for operating pressures exceeding 68.95 MPa (10,000 psi).

1.2.3 Geometric Scope of This Division

The geometric scope of VIII-2 is intended to include only the vessel and integral communicating chambers, and the boundaries set forth are the same as presented in the Introduction chapter of VIII-1. The vessel's scope is defined considering: the attachment of external piping, other vessels or mechanical device; nonpressure parts welded directly to the vessel's pressure retaining surface; pressure retaining covers and their fasteners; and the first sealing surface of connections, fittings or components that are designed to rules that are not provided in VIII-2.

1.2.4 Classifications Outside the Scope of this Division

Similar to the Introduction chapter of VIII-1, the description of pressure equipment covered by the scope of VIII-2 is handled by listing the type of equipment that is not covered under the scope of the standard. However, there is one significant difference between VIII-1 and VIII-2 in this regard. Both standards will allow a pressure vessel that is otherwise outside the scope of the standard to be stamped with the Certification Mark and appropriate U–Designator so long as all of the applicable requirements of the standard are satisfied. In VIII-1 this includes vessels that are otherwise covered under the scope of another standard. However, in Part 1, paragraph 1.2.4.2, if a pressure vessel is included in the scope of another ASME code section then it may not be constructed and stamped with the Certification Mark and U2 Designator. The rationale for this has to do with the fact that the rules in any ASME standard are developed by experts in a particular field or type of equipment. In the case of VIII-2, experts in the fields of design, fabrication, inspection and testing of pressure vessels developed the rules in this standard. For example, the developers of VIII-2 were not experts in the construction of power boilers, thus it was deemed inappropriate to allow a power boiler to be certified to VIII-2 even if it did comply with all of its rules.

Vessels that are not included in the scope of VIII-2 are shown below. Again with the exception of subparagraph a), below, all of the remainder of the use exempted vessels may be constructed and stamped with the Certification Mark and U2 Designator if all of the applicable requirements are met. But similar to VIII-1, the Local Jurisdictional Authority at the location of an installation of a vessel establishes the mandatory applicability of the Code rules.

a) Vessels within the scope of other ASME BPV Code Sections but not other design Codes (e.g., EN 13445, BSI PD-5500, etc.).

b) Fired process tubular heaters as defined in API RP 560.

c) Pressure containers that are integral parts or components of rotating or reciprocating mechanical devices.

d) Structures consisting of piping components whose primary function are the transport of fluids from