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PV Newsletter

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Introduction to ASME Boiler & Pressure Vessel Code, Section VIII, Div. 2

This is a summary of the General Requirements, and the Responsibilities and Duties of the User, the Manufacturer, and the Inspector, as laid out in ASME Section VIII, Div. 2 (hereafter referred to as ASME VIII-2, or the Code). Readers are advised that this is only a summary, and that they must refer to the Code to understand the full requirements for the design and construction of pressure vessels.

What is ASME Section VIII, Div. 2?

ASME VIII-2 contains mandatory requirements, specific prohibitions, and non-mandatory guidance for the design, materials, fabrication, examination, inspection, testing and certification of pressure vessels and their associated pressure relief devices. This Code is also applicable to those chambers of combination units that are in the scope of ASME VIII-2.

How is the Code organized?

The requirements of the Code are contained in nine parts as listed below:

Part 1 - General Requirements, provides the scope of ASME VIII-2 and establishes the extent of coverage.

Part 2 - Responsibilities and Duties, sets forth the responsibilities of the User and Manufacturer, and the duties of the Inspector.

Part 3 - Materials Requirements, provides the permissible materials of construction, applicable material specification and special requirements, physical properties, allowable stresses, and design fatigue curves.

Part 4 - Design by Rule Requirements, provides requirements for design of vessels and components using rules.

Part 5 - Design by Analysis Requirements, provides requirements for design of vessels and components using analytical methods.

Part 6 - Fabrication Requirements, provides requirements governing the fabrication of vessels and parts.

Part 7 - Examination and Inspection Requirements, provides requirements governing the examination and inspection of vessels and parts.

Part 8 - Pressure Testing Requirements, provides pressure testing requirements.

Part 9 - Pressure Vessel Overpressure Protection, provides rules for pressure relief devices.

Each part also contains mandatory and non-mandatory requirements provided as normative and informative annexes. This is different from ASME VIII-1 where the Appendices are provided at the end of the Code.

What type of pressure vessels may be constructed to the rules of ASME VIII-2?

The rules of ASME VIII-2 may be applicable to the following types of pressure vessels:

a) Pressure vessels to be installed at a fixed location for a specific service. The operation and maintenance of the pressure vessel during its useful life is under the User's control.

b) Pressure vessels installed in ocean-going ships, barges and other floating craft, or used for motor vehicle or rail freight. The operation and maintenance of the pressure vessel during its useful life is under the User's control.

c) Pressure vessels or parts subject to direct firing from the combustion of fuel that are not within the scope of Sections I, III or IV may be constructed in accordance with the rules of ASME VIII-2.

d) The following pressure vessels in which steam is generated shall be constructed in accordance with the rules of ASME VIII-1 or ASME VIII-2:

   1) Vessels known as evaporators or heat exchangers

   2) Vessels in which steam is generated by the use of heat resulting from operation of a processing system containing a number of pressure vessels such as those used in the manufacture of chemical and petroleum products

   3) Vessels in which steam is generated but not withdrawn for external use

Does the Code contain any additional requirements for very high pressure vessels?

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

What is the geometric scope of ASME VIII-2?

The scope of ASME VIII-2 includes only the vessel and the integral communicating chambers.

a) Where external piping, other pressure vessels including heat exchangers or mechanical devices are to be connected to the vessel:

   1) The welding end connection for the first circumferential joint for welded connections.

   2) The first threaded joint for screwed connections.

   3) The face of the first flange for bolted and flanged connections. If the first flange is welded to the nozzle neck, the weld connecting the flange to the nozzle neck may be considered as the first circumferential joint.

   4) The first sealing surface for proprietary connection or fittings.

b) Where non-pressure parts are welded directly to the pressure retaining surface of a pressure vessel, the scope of ASME VIII-2 shall include the design, fabrication, testing, and material requirements established for non-pressure parts attachment

c) Pressure retaining covers and their fasteners for vessel openings, such as manhole and handhole covers.

d) The first sealing surface for proprietary connections, fittings or components that are designed to rules not provide by ASME VIII-2, such as gages, instruments and non-metallic components.

So the geometric scope for ASME VIII-2 is identical to that for ASME VIII-1.

What vessels are not included in the scope of ASME VIII-2?

Although the vessels listed below are not considered in the scope of this Code, any pressure vessel, with the exception of a) below, that is not excluded from the scope of this Code (for e.g., unfired steam boilers are included only in scope of ASME I or ASME VIII-1), and that meets all applicable requirements of this Code may be stamped with the Code symbol.

a) Vessels within scope of other Sections.

b) Fired process tubular heaters as defined in API RP560.

c) Pressure containers that are integral parts or components of rotating or reciprocating mechanical devices, such as pumps, compressors, turbines, generators, engines, and hydraulic or pneumatic cylinders where the primary design considerations are derived from the functional requirements of the device.

d) Structures consisting of piping components such as pipe, flanges, bolting, gaskets, valves, expansion joints and fittings whose primary function is the transport of fluids from one location to another within piping systems.

e) Pressure containing parts of components such as strainers and devices that serve such purposes as mixing, separating, snubbing, distributing, and metering or controlling flow, provided that pressure containing parts of such components are generally recognized as piping components or accessories.

f) A vessel for containing water under pressure when none of the following limitations are exceeded:

   1) A design pressure of 2.07 MPa (300 psi)

   2) A design temperature of 99°C (210°F)

g) A hot water supply storage tank when none of the following limitations is exceeded:

   1) A heat input of 58.6 kW (200,000 Btu/hr)

   2) A water temperature of 99°C (210°F)

   3) A nominal water containing capacity of 454 liters (120 gal)

h) Vessels with an internal or external design pressure not exceeding 103 kPa (15 psi) with no limitation on size; for multi-chambered vessels, the design pressure on common elements shall not exceed 103 kPa (15 psi)

i) Vessels with an inside diameter, width, height or cross section diagonal not exceeding 150 mm (6 inch), with no limitation on length of pressure vessel or the pressure.

j) Pressure vessels for human occupancy

Disregarding errors in unit conversion, the vessels excluded from the scope of ASME VIII-2 (with the exception of a) above) are almost identical to the vessels excluded from the scope of ASME VIII-1.

What are the rules of ASME VIII-2 for field assembly of vessels?

Field assembly of vessels may be performed as follows:

a) The manufacturer completes the vessel in the field, completes the Form A-1 Manufacturer's Data Report, and stamps the vessel.

b) The manufacturer of parts of a vessel to be completed in the field stamps these parts and supplies the Form A-2 Manufacturer's Partial Data Report to the party that will complete the vessel in the field. This

party (that must hold a valid U2 Certificate of Authorization) makes the final assembly, performs the required NDE, performs the final pressure test, completes the Form A-1, and stamps the vessel.

c) The field portion of the work is completed by a holder of a valid U2 Certificate of Authorization other than the vessel manufacturer. The stamp holder performing the field work supplies the Form A-2 to the manufacturer responsible for the Code vessel. The vessel manufacturer applies his U2 stamp in the presence of a representative from his inspection agency and completes the Form A-1 with his Inspector.

In all three cases, the party completing and signing the Form A-1 assumes full Code responsibility for the vessel.

What are the User's responsibilities?

It is the responsibility of the user or his agent to provide a certified User's Design Specification (UDS) for each pressure vessel to be constructed in accordance with the rules of ASME VIII-2. Usually, the UDS can be certified by a Professional Engineer registered in any one state of US. The UDS shall specify the effective Code Edition and Addenda to be used, and shall provide a complete basis for design and construction of the pressure vessel.

What does User's Design Specification include?

The UDS includes the following information necessary for design and construction of the pressure vessel:

- Location
- Jurisdictional authority, if applicable
- Environmental conditions
- Vessel identification
- Vessel configuration and controlling dimensions
- Design conditions
- Operating conditions
- Design fatigue life
- Materials of construction
- Loads and load cases
- Overpressure protection

UDS shall also state any additional requirements for the intended vessels service:

- NDE, restricted chemistry, heat treatments
- Type of weld joints and the extent of the required NDE
- Non-mandatory provisions of the Code that may be considered mandatory for the subject vessel
- Special marking and their location(s)
- Seals and/ or bolting for closures and covers
- Special erection loadings
- Any operation & maintenance control agreements unique to the subject pressure vessel

What is included in the documentation of Design by Rule calculations?

Documentation of Design by Rule calculations shall include the following:

- The name and version of computer software, if applicable

- Loading conditions and boundary conditions used to address the load cases in the UDS
- Material models utilized for all required physical properties, strength parameters, and allowable stresses
- Detailed calculations, including results from all the applicable steps in the calculations, showing the acceptance criteria utilized to meet the requirements of this Code
- A summary of calculation results

What is included in the documentation of Design by Analyses calculations?

Documentation of Design by Analyses calculations shall include the following:

- A detailed description of the numerical method used, including the name and version of computer software, if applicable
- Description of model geometry
- Loading conditions and boundary conditions used to address the load cases in UDS
- Material models utilized for al physical properties, strength parameters, strain limits, if applicable, and the design membrane stress intensity per Part 3
- Description of whether material non-linearity is utilized in the analyses including a description of the material model
- Description of the numerical analyses procedure and whether a geometrically linear or nonlinear option is invoked
- Graphical display of various results
- Methods used to validate the numerical model
- Description of results processing performed to established numerical analyses results
- A summary of numerical analysis results showing the acceptance criteria utilized to meet the requirements of this Code
- Electronic storage of analysis results including input files and output files that contain numerical analysis results utilized to demonstrate compliance with the requirements of this Code

What are the Manufacturer's responsibilities?

The manufacturer is responsible for code compliance, materials selection, manufacturer's design report, manufacturer's data report, manufacturer's construction records, the quality control system, certification of subcontracted services, inspection and examination, and application of code stamp. Each of the responsibilities is briefly described below:

Code Compliance: The manufacturer is responsible for the structural and pressure retaining integrity of a vessel or part thereof by conforming to the rules of ASME VIII-2 and the requirements of UDS. The manufacturer completing any vessel or part marked with U2 symbol in accordance with ASME VIII-2 has the responsibility to comply with the applicable requirements of this Code, and must ensure that any work completed by others also complies with the requirements of the Code.

Material Selection: When the material is not completely specified by the User, the manufacturer shall select the appropriate material from Part 3, considering the information provide in the UDS. Any material substitutions must be approved by the User.

Manufacturer's Design Report: The design report must include the following.

- Final as-built drawings

- The actual material specifications used for each component
- Design calculations and analysis that establish the design in conformance with the requirements of this Code for the design conditions specified in the UDS
- The results of any fatigue analysis according to paragraph 5.5 as applicable.
- Any assumptions used by the manufacturer to perform the vessel design.

Manufacturer's Data Report: The manufacturer shall certify the compliance to the requirements of this Code by the completion of the appropriate Manufacturer's Data Report.

Manufacturer's Construction Records: The manufacturer shall prepare, collect and maintain construction records and documentation as fabrication progresses, to show compliance with the manufacturer's design report. An index of the construction records files shall be maintained in accordance with the manufacturer's Quality Control System.

Quality Control System: The manufacturer shall maintain a Quality Control System.

Certification of Subcontracted Services: The Quality Control System shall describe the control and execution of subcontracting of activities. The manufacturer shall ensure that all the subcontracted activities meet the requirements of ASME VIII-2. Subcontracts that involve welding on pressure boundary components shall be awarded only to subcontractors holding a valid U2 Certificate of Authorization. All such subcontracted welding shall be documented on Form A-2. After ensuring compliance and obtaining concurrence of the inspector, the vessel may be stamped with the ASME symbol.

Inspection and Examination: The responsibilities and duties for inspection and examination during construction of pressure vessels lie both with the manufacturer and the inspector. Specifically, the manufacturer has the responsibility of assuring that the quality control, the detailed examinations and the tests required by ASME VIII-2 are performed at various stages of construction.

Application of Code Stamp: The vessels or parts shall be stamped in accordance with the requirements given in Annex 2.F.

What are the Inspectors's responsibilities?

It is the duty of the inspector to make all the inspections specified by ASME VIII-2, as well as such inspections as considered necessary in order to ensure that all requirements have been met. Some of the responsibilities are as follows:

- Verification that the manufacturer has a valid Certificate of Authorization and is working according to an approved Quality Control System.
- The inspector does not have the duty of establishing the accuracy of the design analysis but has the duty of establishing that the required analyses have been performed.
- Verifying that the manufacturer of the completed vessel has the UDS on file, and that the requirements specified therein have been addressed in the Manufacturer's Design Report.

Sources:

1. ASME Boiler and Pressure Vessel Code, Section VIII, Division 2 - Alternate Rules, Edition 2010

*****END OF THE ARTICLE*****

About CoDesign Engineering

CoDesign Engineering is involved in providing training and consultancy services as described below:

Training

- Pressure vessel & heat exchanger design (ASME Section VIII, Div. 1 and Div. 2, TEMA)
- Power and process piping and piping system design (ASME B31.1, B31.3 and Valves)
- Solar PV power plant design

Consultancy

- Engineering solutions related to pressure vessels and heat exchangers
- PMC as well as EPC services for solar PV power plants

We have designed a 3-day training courses for ASME BPVC Section VIII, Div. 1 and for Shell and Tube Heat Exchangers, and a 2-day training course for ASME Section VIII, Div. 2 that can be offered at most cities in India. In-house training can also be provided at any location in India or in US upon request. The training is designed as a workshop where the delegates are encouraged to do all calculations using only pencil, paper and calculators. Please contact rtiwari123@gmail.com or training@codesignengg.com for the training calendar and rates.

Contents of 3-Day Training Course for Pressure Vessels (Div.1):

- Organization of ASME Pressure Vessel Code
- Design Loads and Stresses in Pressure Vessels
- Materials of Construction
- Low Temperature Operation
- Joint Efficiencies
- Design of Shell Sections
- Design of Conical Sections
- Design of Formed Heads and Flat Heads
- Openings and Reinforcements
- Nozzle Loads
- Design of Flanges
- Design of Tall Towers
- Design of Column Supports
- Fabrication and Inspection

Contents of 3-Day Training Course for Heat Exchangers:

- What are Heat Exchangers used for?
- Basic Heat Transfer Principles
- Major Types of Heat Exchangers
- General Description of Shell-and-Tube Heat Exchanger
- Thermal Design of Shell-and-Tube Heat Exchangers
- Major Components of Shell-and-Tube Heat Exchangers
- Mechanical Design of Heat Exchanger Components
- Heat Exchanger Fabrication
- TEMA Standards
- Thermal/ Mechanical Design Interaction
- Tube Vibration
- Heat Exchanger Fouling
- Specifying Shell-and-Tube Heat Exchangers
- Maintenance & Inspection
- Heat Exchanger Cleaning and Repair

Visit our website www.codesignengg.com for contents for the Division 2 course.

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Ramesh Tiwari holds a Master's degree in Mechanical Engineering from Clemson University in South Carolina, and is a registered Professional Engineer from the state of Maryland in the United States. He has over 22 years of experience designing pressure vessels, heat exchangers and tanks. Ramesh is a contributing member of ASME Section VIII Subgroup on Heat Transfer Equipment. He is also an approved pressure vessel instructor at National Thermal Power Corporation (NTPC), a premier thermal power generating company in India.