TG Scope and Exemptions
Update to
The National Board

REVISIONS TO THE SCOPE REGARDING
RULES FOR CONSTRUCTION OF PRESSURE
VESSELS

Section VIII-1, 2 & 3
October 9, 2019
Mark Lower
Chair - Task Group Scope
& Exemptions
Quick Update

• Task Group meets on Monday evenings @6:00pm during Code Week
  – Teleconference available
  – Participation from regulators is highly desired

• Reaffirm proposals for Divisions 2 and 3
  – Custom engineered vessels, must identify jurisdictions
  – No public comments directed towards Division 2 or 3
  – BPV VIII Letter Ballot 19-2099

• Jurisdictional rules vary and are not always consistent with ASME VIII-1 exemptions
  – VIII-1, VIII-2, & VIII-3 Scope are not identical
Focus of Public Comments

• Exemptions removed from the scope
  – U-1(c)(2)(f) – vessels containing water under pressure \( P \leq 300 \text{ psi}, \ T \leq 210^\circ\text{F} \)
    • Exemption commonly used for water side of shell and tube H/X
  – U-1(c)(2)(g) – hot water supply storage tank [heat input \( \leq 200,000 \text{ BTU/hr}, \ T \leq 210^\circ\text{F}, \text{volume} \leq 120 \text{ gallons} \]
  – U-1(c)(2)(i) – vessels having and inside diameter, with, height, or cross-section diagonal not exceeding 6 inches, with no limitation on length of vessel or pressure
    • Several codes and standards available to cover small diameter equipment (i.e. UL, ASHRAE)

• Public comments primarily from:
  – Heating, Ventilation, Air Conditioning, Refrigeration industry
  – Small, high pressure vessel industry (super high pressure but use Div. 1)
# Scope Revisions

<table>
<thead>
<tr>
<th>Division 1</th>
<th>Division 2</th>
<th>Division 3</th>
</tr>
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<tbody>
<tr>
<td>• Modified <em>Introduction</em> to clarify scope&lt;br&gt;  • Definition of pressure vessel&lt;br&gt;  • 15 psi threshold&lt;br&gt;  • Modified/removed exemptions to the scope&lt;br&gt;  • Included Nonmandatory Appendix “Guidance for Mandatory Application of Code Rules for Pressure Vessels”&lt;br&gt;  • Harmonize language between Division 1 and Division 2</td>
<td>• Modified <em>Overview</em> to clarify scope&lt;br&gt;  • Definition of pressure vessel&lt;br&gt;  • 15 psi threshold&lt;br&gt;  • Modified/removed exemptions to the scope&lt;br&gt;  • Included Nonmandatory Annex “Guidance for Mandatory Application of Code Rules for Pressure Vessels”</td>
<td>• Added “U-1(c)(1)” to state jurisdiction has authority&lt;br&gt;  • Modify language to state vessels exclusively in the scope of other Sections may not be built to Division 3</td>
</tr>
</tbody>
</table>

**Focus of public comments**
Summary and Conclusions

- AHRI members are unanimously opposed to these scope changes that apply to HVAC&R type equipment and components.
- Existing standards have a convincing track record of providing safe products
- No information is available to indicate there are safety-related issues, no extension of BPVC is needed
- Risk of misinterpretation with other well-established governing standards adopted by the building codes
- Creates unnecessary uncertainty at the jurisdictional level
Recent Task Group Discussions

• How are requirements for HVAC industry flowed down?
• Vessel requirements in IBC (I-Codes) vary and different than many state requirements
• How do manufacturer’s comply with varied jurisdictional requirements?
• Is there any impact to removing scope exemptions from VIII-2 & VIII-3?

Why should ASME provide exemptions??
ASME Section VIII, Divisions 1, 2 & 3
Comparison of Construction Standards

Mark Lower

National Board
October 9, 2019
A brief introduction…..

• SEC student background

• ASME Section VIII for almost 20 years
  - Subgroup General Requirements - past Chair
  - Task Group Scope and Exemptions - Chair
  - BPV VIII - Vice Chair

• “Day job” activities
  - Pressure systems SME
  - Established 1st FIA
  - DOT pipelines and facilities
  - Additive Manufacturing Demonstration Facility
    • “printable” nuclear reactors
    • Printed vehicles

Newest NB Advisory Committee member to the BoT
Today’s Discussion

- Scope
- Failure Modes
- Materials
- Design
- Joining
- Nondestructive Examination
- Pressure Testing
- Overpressure Protection
- Final Thoughts
BPV VIII Scope

**Division 1**
- (not so) Simple pressure vessel code
- Several exclusions of vessel classes from Scope
- Many jurisdictional requirements built around Division 1 scope (although not the same as)
- Typically thought to be <3000psi (additional design principles and construction practices apply)
- Mass production

**Division 2**
- Custom Engineered pressure vessels
- Similar (but not the same as) exemptions to Division 1
- 2 vessel classes

ASME accepts responsibility for the technical excellence of any code it sponsors and for its suitability as a basis for regulation. But ASME cannot itself regulate or enforce – a fact that needs constantly to be remembered.

ASME President L.N. Rowley
Mechanical Engineering Magazine, 1968
Division 3 - Scope

**High Pressure Vessels**

- Uses thick shell theory
- Can’t assume plane strain
- Thin shell theory (Barlow’s formula) can give non-conservative results
- Division 1 & 2 applications for D/t ratios do not apply

**Scope:**

- INTENT - Generally above 10,000psi (no hard limits)
- Some exemptions, no exclusions
- Small lab-type vessels have relaxed requirements
U-Stamps

- Total number of U-Stamps – 5,665
  - U-1 Only 84%
  - U-1 & U-2 15%
  - U-2 Only 0.12%
  - U-1 & U-3 0.51%
  - U-3 Only 0.14%
Failure Modes

- Failure modes are organized into 4 categories
  1. Materials
  2. Design
  3. Fabrication
  4. Service

- ASME does not provide rules specifically for the prevention of service-related failures
Material specifications provided in Section II & Code Cases. Only Code Cases specifically identified as being applicable to the Section/Division may be used.

**Division 1:** Few restrictions, impact testing required unless exempted (extensive exemptions!)

**Division 2:** More restrictive on materials, similar exemptions on impact testing as VIII-1

**Division 3:** Most restrictive on materials
- Fracture toughness testing for fracture mechanics evaluations
- CTOD for establishment of $K_{IC}$ and/or $J_{IC}$

*Only latest edition of Code Cases may be used, not allowed by all jurisdictions*
### Design Factors

<table>
<thead>
<tr>
<th>Plastic Collapse</th>
<th>Plastic Collapse</th>
<th>Fatigue</th>
<th>Brittle Fracture</th>
<th>Creep</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5/$S_y$</td>
<td>D1 – 3.5</td>
<td>Division 1 – N/A</td>
<td>$K_{IC} \propto \sigma^2 \pi a_c$</td>
<td>Allowable stress limits based on:</td>
</tr>
<tr>
<td></td>
<td>D2 CL 1 – 3.0</td>
<td>Division 2 &amp; 3</td>
<td>LEFM criteria with a fracture margin ($K_{IC}/K_{IA} \geq 1.8$)</td>
<td>• 100,000h stress rupture limits</td>
</tr>
<tr>
<td></td>
<td>D2 CL 2 – 2.4</td>
<td>• 2 on stress</td>
<td>Minimum Toughness</td>
<td>• $10^{-7}$/h creep strain rate</td>
</tr>
<tr>
<td></td>
<td>D3 – 1.73</td>
<td>• 20 on cycles</td>
<td>D1 - 15 ft-lbs</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>D2 - 20 ft-lbs</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>D3 - 20 ft-lbs</td>
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</table>

**Plastic Collapse Stress Limit**

- $P_u/S_y = 1.5 (1 - (P_u/S_y)^3)$

**Fatigue**

Division 1 – N/A

- LEFM criteria with a fracture margin ($K_{IC}/K_{IA} \geq 1.8$)

**Brittle Fracture**

- Minimum Toughness
- D1 - 15 ft-lbs
- D2 - 20 ft-lbs
- D3 - 20 ft-lbs

**Creep**

- Allowable stress limits based on:
  - 100,000h stress rupture limits
  - $10^{-7}$/h creep strain rate
### Design

<table>
<thead>
<tr>
<th>Division</th>
<th>DBR</th>
<th>DBA</th>
<th>Experimental</th>
<th>Fatigue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Division 1</td>
<td>X</td>
<td>U-2(g)</td>
<td>UG-101</td>
<td>UG-22 [U-2(g)]</td>
</tr>
<tr>
<td>Division 2</td>
<td>X</td>
<td>Part 5</td>
<td>Annex 5-F</td>
<td>Required (unless exempted through screening)</td>
</tr>
<tr>
<td>Division 3</td>
<td>X</td>
<td>X</td>
<td>Limited</td>
<td>Required</td>
</tr>
</tbody>
</table>

**DBR:** Prescriptive rules and closed-form solutions based on known allowable stress, loading conditions and combinations, geometry, joint efficiencies

**DBA:** Numerical stress analysis for protection against plastic collapse, local failure, buckling, & cyclic loading. Can only be used if the allowable stress is governed by time independent properties

**EXPERIMENTAL:** Division 1 allows proof testing. Division 2 and Division 3 are similar, but Division 3 has tighter requirements for strain limits.

**FATIGUE:** Not usually performed for Division 1 vessels as no criteria for cyclic service is provided. Division 3 requires surface finish correction factor for fatigue analysis
Design Reports

1. **UDS**
   - Design basis document for vessel design
     - All loading conditions
     - May include operational and maintenance
     - Identifies jurisdictional authority

2. **MDR**
   - Contains the design calculations and analysis to support final (as-built) construction
     - Site specific environmental conditions
     - Jurisdictional requirements

### Division 1
- a. “Neither required nor prohibited”
- b. Nonmandatory Appendix KK

### Division 2
- • Mandatory
- • Certification required for Class 2

### Division 3
- • Mandatory
- • Certification required
Material Joining

*PRT certification to fabricate parts without design responsibility

**Welding**
- See Section IX
- Pressure and non-pressure parts requirements
- Division 2
  - More restrictive than VIII-1 in permitting processes, geometries, and PWHT
- Division 3
  - Most restrictive in processes, geometries, & PWHT
  - Requirements for considering residual stress

**Brazing**
- See Section IX
- “Welding” includes “brazing”
- VIII-1 Part UB
- Cannot be used for:
  - Lethal service
  - Unfired steam boilers
  - Direct firing

*PWHT IMPORTANT TO MATERIALS JOINING INTEGRITY*
Nondestructive Examination

Personnel Qualifications

Section V Article 1

Methods

Section V
- RT
- UT
- MT
- PT
- VT
- LT
- ET
- AE

Acceptance Criteria

“Essentially” identical
- Cracks, IF, IP
- Rounded
- Linear
- Surface Connected
NDE Requirements

Division 1:
- May be exempted using extensive knock-down factors
- Supplemental/Contractual/Non-mandatory

Division 2
- Increase NDE for reduced design factor per Part 7
- Both volumetric and surface examination required
- Harmonized with European practice

Division 3
- More stringent than Division 2
- UT on all butt welds
- RT on all other welds
- Extensive use of surface examination including post-hydro
Pressure Testing

Primary intent is to find gross design or fabrication issues and weld seam leaks

**Division 1**
- **Hydrostatic**
  - Min - 1.3*MAWP
  - Max - Permanent distortion
- **Pneumatic**
  - Min – 1.1*MAWP
  - Max – Permanent distortion
- **Vacuum Test**
  - MAEWP AND Leak test
- **Code Cases**
  - Ultrasound (2324)

**Division 2**
- **Hydrostatic**
  - Min - 1.25*MAWP
  - Max – 0.95Pm
- **Pneumatic**
  - Min – 1.15*MAWP
  - Max – 0.80Pm
- **Vacuum Test**
  - Min - 1.15*MAEWP

**Division 3**
- **Hydrostatic**
  - Min - 1.25*MAWP
  - Max – 0.95Pm
- **Autofrettage vessels exempt**
- **Surface exam after hydrotest**

In-service leak testing not allowed like B31 Codes
Overpressure Protection

**Divisions 1 & 2**

- Responsibility of the user
- Identical requirements (Division 2 references Division 1)

**Division 3**

- “pop action” relief devices for pressures above 10k psi not readily available
- Allows disk and holder to have different manufacturers
- Added requirements for springs (gas has density of liquid. Spring has different requirement to hold valve open)
- Different capacity certifications
## ASME Roles and Qualifications

<table>
<thead>
<tr>
<th>Certifying Engineer</th>
<th>Designers</th>
<th>Certified Individual</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Attest in writing that they meet the ASME Code of Ethics</td>
<td>• Manufacturer attests to competence</td>
<td>• Organization certifies the Individual</td>
</tr>
<tr>
<td>b. 4 yrs experience</td>
<td>• Qualified to perform design for:</td>
<td>• Division 1</td>
</tr>
<tr>
<td>c. Chartered, registered, or licensed within the jurisdiction where design takes place or location of installation</td>
<td>✓ General pressure vessels</td>
<td>✓ Miniature vessels (UM)</td>
</tr>
<tr>
<td></td>
<td>✓ Heat exchangers</td>
<td>✓ Pressure relief devices (UV, UD)</td>
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<td></td>
<td>✓ Numerical analysis</td>
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<td></td>
<td>✓ Quick-actuating closures</td>
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<tr>
<td></td>
<td></td>
<td>• See also:</td>
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<tr>
<td></td>
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<td>✓ ASME CA-1</td>
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<td>✓ NB-383</td>
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</tbody>
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- Division 2 & 3
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- Division 1
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<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Example problems for VIII-1 and VIII-2 (PTB-3, PTB-4)</td>
<td>2</td>
<td>“Common Rules” to allow VIII-1 vessels to incorporate VIII-2 DBR methods</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>VIII-1 can obtain authorization to fabricate VIII-2 Class 1 vessels (CC 2891 exp 2020)</td>
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<tr>
<td>5</td>
<td>VIII-1 considering adding certification requirements for U-2(g)</td>
<td>6</td>
<td>Division 2 provides latest complete update (VIII-2 Table E1.1)</td>
<td>7</td>
</tr>
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