

**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 [$P \leq 300$ 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 $\leq 200,000$ BTU/hr, $T \leq 210^\circ\text{F}$, volume ≤ 120 gallons]
 - U-1(c)(2)(i) – vessels having an 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

Division 1

- Modified *Introduction* to clarify scope
 - Definition of pressure vessel
 - 15 psi threshold
- Modified/removed exemptions to the scope
- Included Nonmandatory Appendix “Guidance for Mandatory Application of Code Rules for Pressure Vessels”
- Harmonize language between Division 1 and Division 2

Division 2

- Modified *Overview* to clarify scope
 - Definition of pressure vessel
 - 15 psi threshold
- Modified/removed exemptions to the scope
- Included Nonmandatory Annex “Guidance for Mandatory Application of Code Rules for Pressure Vessels”

Division 3

- Added “U-1(c)(1)” to state jurisdiction has authority
- Modify language to state vessels exclusively in the scope of other Sections may not be built to Division 3

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??



SETTING THE STANDARD

ASME Section VIII, Divisions 1, 2 & 3 Comparison of Construction Standards

Mark Lower

National Board
October 9, 2019

ORNL is managed by UT-Battelle LLC for the US Department of Energy

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

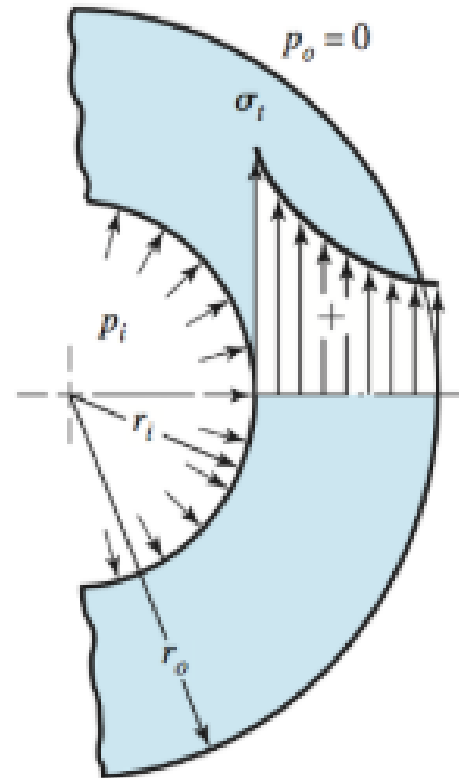
ASME accepts responsibility for the technical excellence of any code it sponsors and for its suitability as a basis for regulation. But ASME cannot itself regulate or enforce – a fact that needs constantly to be remembered.

**ASME President L.N. Rowley
Mechanical Engineering Magazine, 1968**

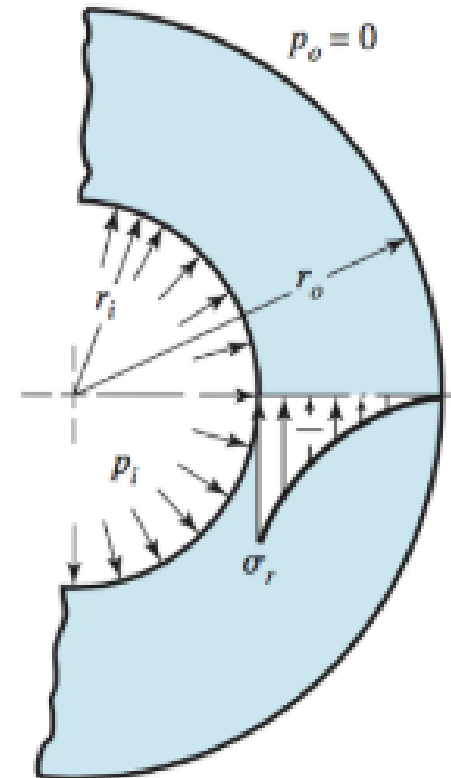
Division 3 - Scope

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



(a) Tangential stress distribution



(b) Radial stress distribution

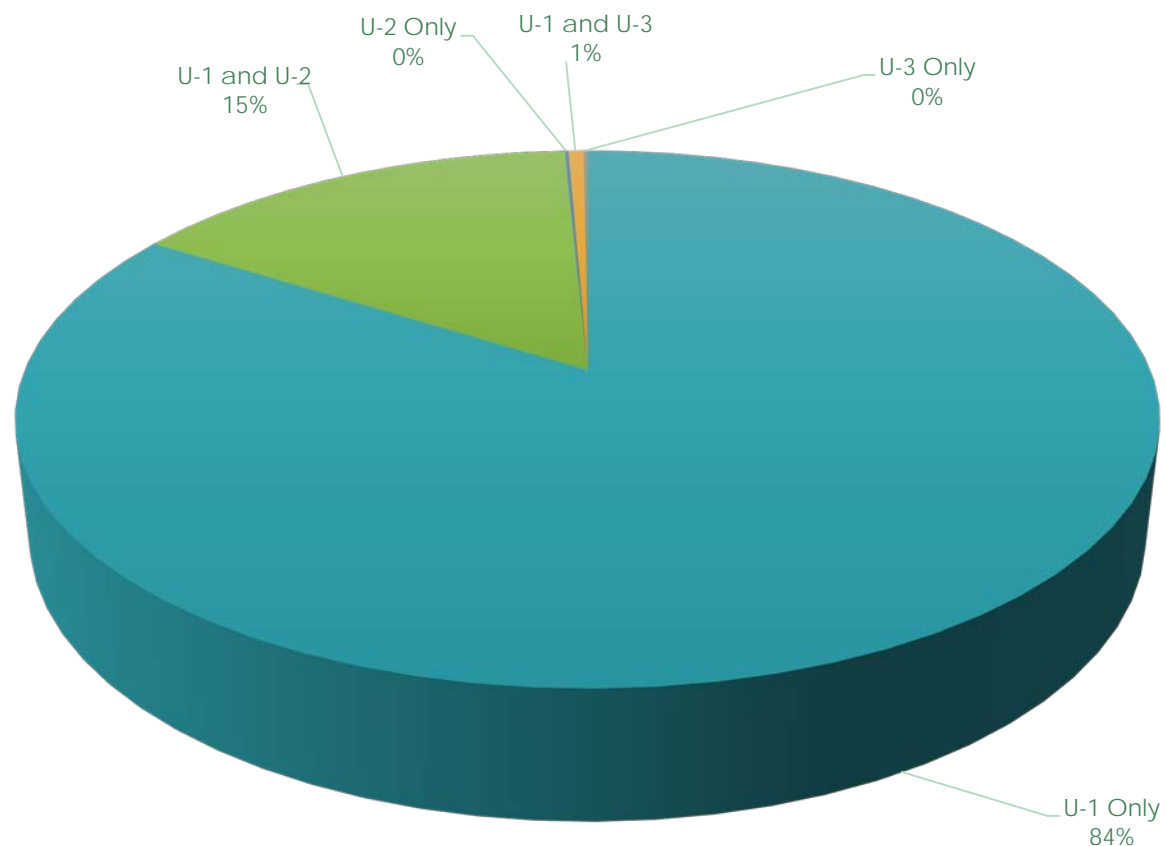
Scope:

- 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

Failure modes (Category)

- Buckling (2,3)
- Plastic Collapse (1,2)
- Brittle Fracture (1,2,3)
- Creep (1,2,4)
- Ratcheting (2,4)
- Fatigue (2,4)
- Corrosion (1,2,4)

Materials

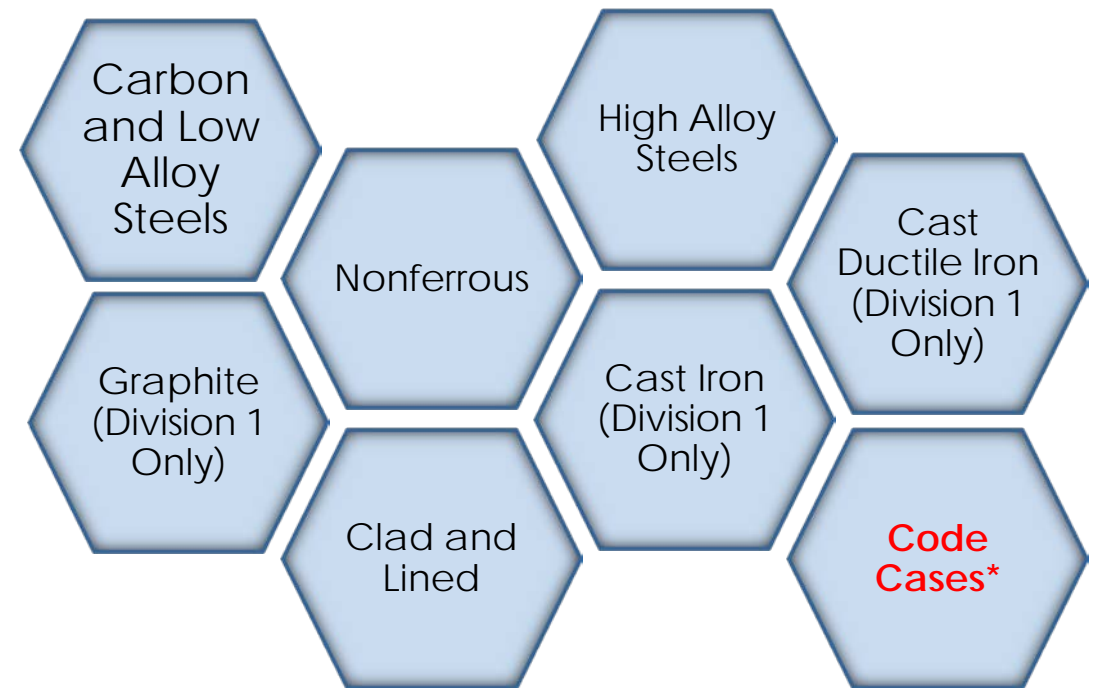
Material specifications provided in Section II & Code Cases. Only Code Cases specifically identified as being applicable to the Section/Division may be used.

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

Plastic Collapse

$$1.5/S_y$$

Plastic Collapse

D1 – 3.5
 D2 CL 1 - 3.0
 D2 CL 2 – 2.4
 D3 – 1.73

Fatigue

Division 1 – N/A

Division 2 & 3

- 2 on stress
- 20 on cycles

Brittle Fracture

$$K_{Ic} \propto \sigma^2 \pi a_c$$

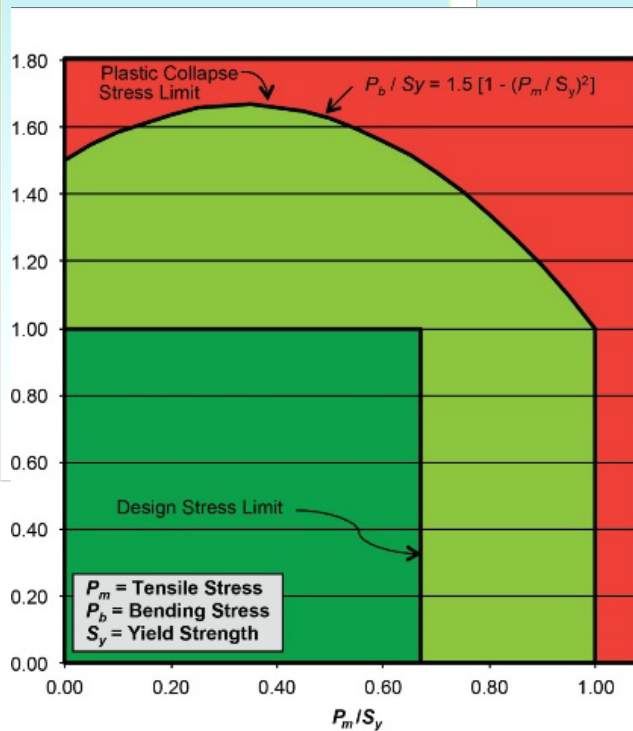
LEFM criteria with a fracture margin
 $(K_{Ic}/K_{IA}) \geq 1.8$

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

	DBR	DBA	Experimental	Fatigue
Division 1	X	U-2(g)	UG-101	UG-22 [U-2(g)]
Division 2	X	Part 5	Annex 5-F	Required (unless exempted through screening)
Division 3	X	X	Limited	Required

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

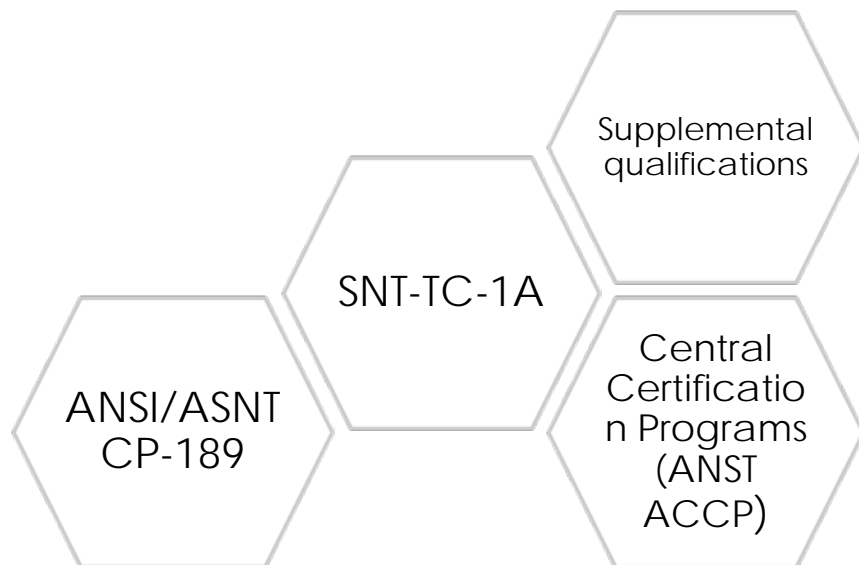
Section V

- ✓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 - $1.3 \cdot \text{MAWP}$
 - ✓ Max - Permanent distortion
- Pneumatic
 - ✓ Min - $1.1 \cdot \text{MAWP}$
 - ✓ Max - Permanent distortion
- Vacuum Test
 - ✓ MAEWP AND
 - ✓ Leak test
- Code Cases
 - ✓ Ultrasound (2324)

Division 2

- Hydrostatic
 - ✓ Min - $1.25 \cdot \text{MAWP}$
 - ✓ Max - $0.95P_m$
- Pneumatic
 - ✓ Min - $1.15 \cdot \text{MAWP}$
 - ✓ Max - $0.80P_m$
- Vacuum Test
 - ✓ Min - $1.15 \cdot \text{MAEWP}$

Division 3

- Hydrostatic
 - ✓ Min - $1.25 \cdot \text{MAWP}$
 - ✓ Max - $0.95P_m$
- 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

Certifying Engineer

- a. Attest in writing that they meet the ASME Code of Ethics
- b. 4 yrs experience
- c. Chartered, registered, or licensed within the jurisdiction where design takes place or location of installation

Division 2 & 3

Designers

- Manufacturer attests to competence
- Qualified to perform design for:
 - ✓ General pressure vessels
 - ✓ Heat exchangers
 - ✓ Numerical analysis
 - ✓ Quick-actuating closures

Division 2 & 3

Certified Individual

- Organization certifies the Individual
- Division 1
 - ✓ Miniature vessels (UM)
 - ✓ Pressure relief devices (UV, UD)
- See also:
 - ✓ ASME CA-1
 - ✓ NB-383

Division 1

Random Final Thoughts/Other Notables:

1

Example problems for VIII-1 and VIII-2 (PTB-3, PTB-4)

2

"Common Rules" to allow VIII-1 vessels to incorporate VIII-2 DBR methods

3

VIII-2 Class 1 eliminates certification of UDS and MDR

4

VIII-1 can obtain authorization to fabricate VIII-2 Class 1 vessels (CC 2891 exp 2020)

5

VIII-1 considering adding certification requirements for U-2(g)

6

Division 2 provides latest complete update (VIII-2 Table E1.1)

7

Division 2 requires "tuned" design to realize efficiencies ($Y/T < 0.7$)

