

Agenda Item: 620-2082

Title: API 620 Low Temperature Low Stress – Update to ASME 2025

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Purpose: To provide updated rules to using ASME VIII-Div2-2025 Ed for low temperature/low stress provisions.

Source: Follow up after 620-2069 agenda item to review ASME VIII Div 2 2025

Revision: A

Impact: Appropriate use of ASME VIII-Div2 2025 Ed

Rationale: The purpose of this agenda item is to review the changes in ASME/BPVC VIII Div 2 2025 version to determine the necessary updates to API 620 Section 4.2.2 regarding the provisions for low temperature low stress rules.

API 620 Section 4.2.2 uses ASME Div-2 approach to establish a stress ratio R_{ts} which is used to determine the temperature reduction (T_R) that can be added to the MDMT established for the material grade and thickness.

The emphasis of this agenda item focuses on the choice of allowable stresses to apply as a stress ratio (R_{ts}), which will lead to a permitted temperature reduction of the allowable minimum design metal temperature (MDMT) without impact testing.

R_{ts} is based the ratio of the actual stress of the component to the allowable ASME VII-Div 2 Class 1 stress to establish the ratio. ASME VIII-2 2023 had Class 1 and Class 2 for stress, but now only has Class 2. Hence, a new basis must be established for the stress ratio R_{ts} in Section 4.2.2.

Items covered as part of the rationale are:

1. Basis for ASME VIII-2 2023 had Class 1 and Class 2, but now only Class 2.

Class 1 was dropped due to the following:

- 1) Redundant safety philosophy: Class 1 vs Class 2 was trying to mimic:
Higher reliability → lower allowable stress.
Lower reliability → higher allowable stress.
That sounds logical but in practice explicit stress limits (Part 5), Strain limits, Fatigue evaluation and Fracture mechanics, made this obsolete.
- 2) Design-by-Analysis with Primary stress limits, Local stress limits and Elastic-plastic checks ensured that the analyst is no longer relying on a single allowable stress number. This made class-based reduction factors irrelevant.
- 3) Inconsistency and confusion in practice regarding when to select Class 1 vs Class 2. This led to inconsistent designs for similar risks. ASME eliminated that ambiguity.
- 4) This allowed a move to a single, reliability-based framework with a single allowable stress combined with Material toughness requirements, NDE requirements, Fatigue, and fracture checks.
- 5) Alignment with modern codes and international practice. The class system does not align well with international codes such as EN and modern reliability-based design methods. Removing Simplified global use and Reduced interpretation issues

2. Safety factors used for allowable stress in API 620 and ASME VIII-Div 2

- a. API 620 – min of $((0.3 \cdot F_u) \text{ or } (0.6 \cdot F_y))$
- b. ASME VIII Div 2 Class 1 – min of $(F_u/3 \text{ or } F_y/1.5)$
- c. ASME VIII Div 2 Class 2 – min of $(F_u/2.4 \text{ or } F_y/1.5)$

Background about the allowable stresses from API 620, ASME VIII Div 2 Class 1 (2023), and ASME VIII Div 2 Class 2 (2023) may be helpful to review. Below is the summary of the allowable primary stress rules for these codes. F_u means ultimate tensile strength and F_y means yield strength (ASME refers to ST and SY for ultimate tensile strengths and yield strengths, respectively).

- 1) API 620 – min of $(0.3 \cdot F_u \text{ or } 0.6 \cdot F_y)$ (and quality factor, if required)
- 2) ASME VIII Div 2 Class 1 – min of $(F_u/3 \text{ or } F_y/1.5)$
- 3) ASME VIII Div 2 Class 2 – min of $(F_u/2.4 \text{ or } F_y/1.5)$

Another way to state this is that the factor of safety against ultimate strength is as follows:

- 1) API 620 = 3.33
 - 2) ASME VIII Div 2 Class 1 = 3
 - 3) ASME VIII Div 2 Class 2 = 2.4
- (note, the factor of safety on yield strength is 1.5 in both cases)

However, it is recognized that API 620 does apply a quality factor of 0.92 on certain grades of steel that further reduces the allowable stress.

3. Reason for using Class 1 previously.

- a. See initial agenda item on the low temp/low stress.
- b. Class 1 close to API 620

In the development of the original agenda item to address low temperature low stress provisions per Agenda item 620-2007, the allowable stress ratio was to permit the use of Class 1 allowable stresses.

Therefore, the stress ratio was actual stress divided by the Class 1 allowable stress when determining the permissible temperature reduction of the MDMT per ASME VIII Div 2 rules. It was reasoned in that agenda item that the safety factor of API 620 is within 10% of Class 1, so it was recognized that it was suitable to use the allowable stresses per Class 1.

The proposal proposes using API 620 allowable stresses in lieu of ASME Class 1 allowable stresses. This approach is conservative. To support this, examples of stress ratios and corresponding temperature reductions are shown in the following tables.

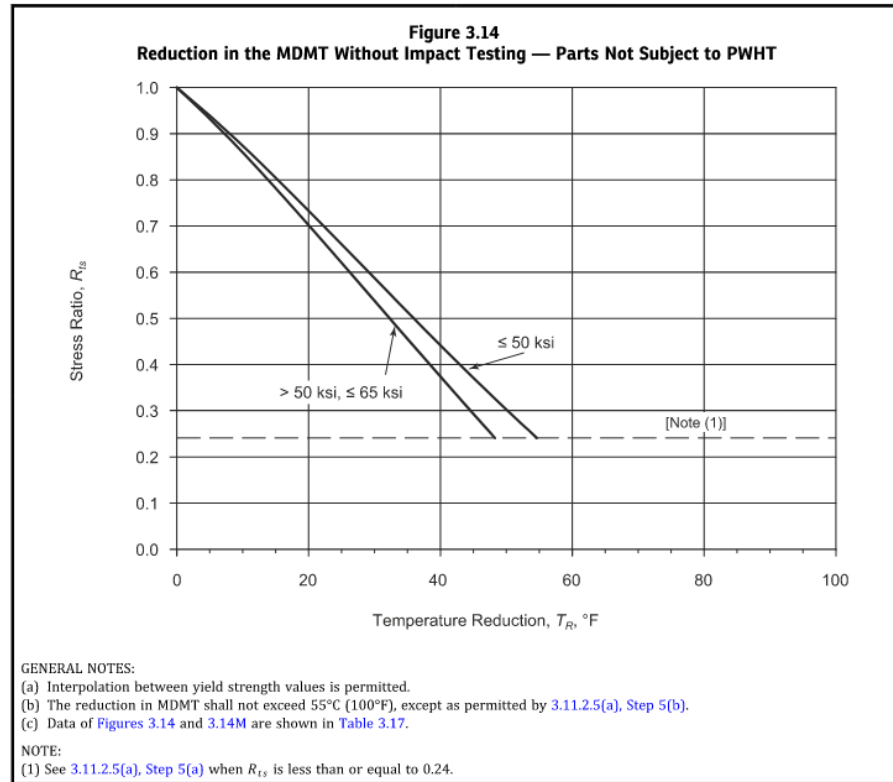
There were no other changes in ASME VIII-2 2025 in regards to list of materials or components, equations, figures, and tables when compared to ASME VIII-2 2017.

Calculation ASME Section VIII Division 2 uses a stress ratio (R_{ts}) approach to a permitted temperature reduction of the allowable minimum design metal temperature (MDMT) without impact testing.

R_{ts} is based the ratio of the actual stress to the allowable stress to establish the ratio. The rules in Section 3.11.2 Equation 3.4 in ASME/PBVC VIII Div 2 cover this approach and the steps to calculate a lower MDMT based on the stress ratio. As the actual tensile stress gets lower than the maximum allowable tensile stress, the greater the temperature reduction can be for the MDMT.

The figure below is the figure used to determine the permissible temperature reduction (T_R) per ASME VIII-2-2025 (figure is identical in ASME VIII-2-2023, but also has a Class 1 limit on the max reduction)

(25)



Below is a table of allowable stresses from API 620, ASME/BPVC VIII Div 2 Class 1-2023, and ASME/BPVC VIII Div 2 Class 2-2023.

Table of Materials and Allowable Stresses from API 620 and ASME

Material	Yield Strength (ksi)	Tensile Strength (ksi)	API 620 Allowable Stress (ksi) (250 °F)	ASME Class 1 2023 Primary Membrane Allowable Stress (ksi) (250 °F)	ASME Class 2 2023 Primary membrane Allowable Stress (ksi) (250 °F)
A36	36	58	16*	19.3 (17.7) *	21.6 (19.9) *
A516-60	32	60	18	19.2	19.2
A516-70	38	70	21	22.8	22.8
A662 C	43	70	21	23.3	25.8
A537 CL1	50	70	21	23.05	28.1
A537 CL2	60	80	24	26.7	33.3

(note * means quality factor per API 620 applied)

To demonstrate the MDMT reduction value (T_R), the following calculations were made. Tables were put together with the following assumed stress ratios.

(R_{ts}):

- 1) $R_{ts} = 0.95$ per API 620
- 2) $R_{ts} = 0.75$ per API 620
- 3) $R_{ts} = 0.50$ per API 620
- 4) $R_{ts} = 0.30$ per ASME VIII Div 2 Class 1

Below are a tables comparing the temperature reductions by using stress ratios with an assumed component stress and allowable stress from API 620, ASME/BPVC VIII Div 2 Class 1, and ASME/BPVC VIII Div 2 Class 2.

Table of Stress Ratios and Temperature Reductions at 250 °F
(stress ratio near max per API 620)

Material	Actual Tensile Stress (ksi)	620 Stress Ratio	ASME-23 CL 1 Stress Ratio	ASME-23 CL 2 Stress Ratio	620 Temp Red (°F)	ASME-23 CL 1 Temp Red (°F)	ASME-23 CL 2 Temp Red (°F)
A36	15.2	0.95	0.79 (0.86) *	0.70 (0.76) *	4.1	16.2 (11.4) *	22.1 (17.8) *
A516-60	17.1	0.95	0.89	0.89	4.1	8.8	8.8
A516-70	20	0.95	0.88	0.88	3.9	9.8	9.8
A662 C	20	0.95	0.86	0.78	3.9	11.2	17.1
A537 CL1	20	0.95	0.87	0.71	3.9	10.5	21.5
A537 CL2	22.8	0.95	0.85	0.68	3.7	10.4	21.1

Table of Stress Ratios and Temperature Reductions at 250 °F
(stress ratio at 75% per API 620)

Material	Actual Tensile Stress (ksi)	620 Stress Ratio	ASME-23 CL 1 Stress Ratio	ASME-23 CL 2 Stress Ratio	620 Temp Red (°F)	ASME CL 1 Temp Red (°F)	ASME CL 2 Temp Red (°F)
A36	12	0.75	0.62 (0.68) *	0.56 (0.60) *	18.9	27.7 (23.9) *	32.2 (28.9) *
A516-60	13.5	0.75	0.70	0.70	18.9	22.1	22.1
A516-70	15.8	0.75	0.69	0.69	18.7	22.8	22.8
A662 C	15.8	0.75	0.68	0.61	18.7	23.8	28.3
A537 CL1	15.8	0.75	0.69	0.56	18.7	23.3	31.7
A537 CL2	18	0.75	0.67	0.54	17.1	21.7	29.9

Table of Stress Ratios and Temperature Reductions at 250 °F
(stress ratio at 50% per API 620)

Material	Actual Tensile Stress (ksi)	620 Stress Ratio	ASME CL 1 Stress Ratio	ASME CL 2 Stress Ratio	620 Temp Red (°F)	ASME CL 1 Temp Red (°F)	ASME CL 2 Temp Red (°F)
A36	8	0.50	0.41 (0.45) *	0.37 (0.40) *	35.9	41.9 (39.4) *	45.1 (42.8) *
A516-60	9	0.50	0.47	0.47	35.9	38.1	38.1
A516-70	10.5	0.50	0.46	0.46	35.9	38.7	38.7
A662 C	10.5	0.50	0.45	0.41	35.9	39.3	42.5
A537 CL1	10.5	0.50	0.46	0.37	35.9	39.0	44.9
A537 CL2	12	0.50	0.45	0.39	32.3	35.4	40.8

The below shows examples of the lowest R_{ts} .

In ASME VIII Div 2 (2023), Figure 3.12 required the minimum R_{ts} to be 0.3 for Class 1 and 0.24 for Class 2. In comparison to the stress ratios with API 620 allowable stresses, the minimum R_{ts} is approximately 0.33 on average.

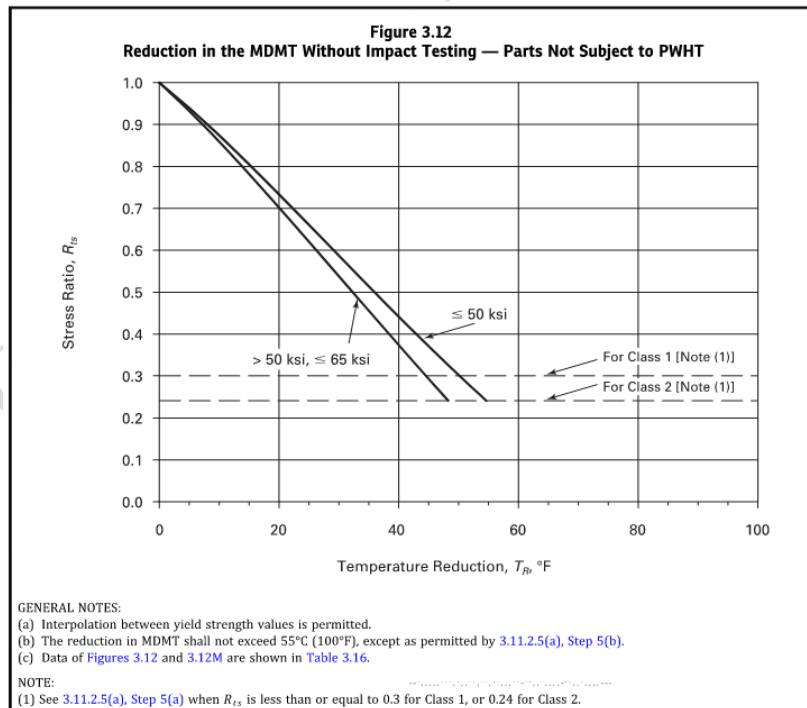


Table of Stress Ratios and Temperature Reductions at 250 °F
(stress ratio at lowest per ASME CL1 or CL2)

Material	Actual Tensile Stress (ksi)	620 Stress Ratio	ASME CL 1 Stress Ratio	ASME CL 2 Stress Ratio	620 Temp Red (°F)	ASME CL 1 Temp Red (°F)	ASME CL 2 Temp Red (°F)
A36	5.7	0.36	0.30 (0.32) *	0.26 (0.29) *	46.1	50.5 (48.6) *	52.9 (51.2) *
A516-60	5.8	0.32	0.30	0.30	48.6	50.1	50.1
A516-70	6.9	0.33	0.30	0.30	48.1	50.0	50.0
A662 C	6.9	0.33	0.30	0.27	48.1	50.5	52.6
A537 CL1	6.9	0.33	0.30	0.25	48.1	50.3	54.3
A537 CL2	8.1	0.34	0.30	0.24	42.2	44.4	48.2

In all cases, API 620 allowable stress to be used as the denominator for computing stress ratio is conservative when compared to ASME.

It can be seen from the table that it would be too extreme to use the allowable stress from ASME/BPVC VIII Div 2 Class 2 when stress ratios are near maxed out per API 620. However, as the stress ratio lowers then the gap between CL1 and CL2 temp reductions narrows down considerably between which stress ratio is used. The gap between CL1 and CL2 is lesser when stress ratios are at or lower than 50%.

The assumption is that most stress ratios will be higher than 50% in most cases, which would suggest that the CL 2 stress ratio may provide too much temperature reduction than intended. Whereas, with using API 620 stress ratios, there will be lesser benefit with temperature reduction.

In consideration of establishing allowable stress to use in the stress ratio, the following are the three options:

- 1) Using API 620 allowable stresses (most conservative option).
- 2) Using Class 1 allowable stress.
- 3) Using Class 2 allowable stresses.

Though Class 1 stress values are still accessible in ASME Section II Part D, it is proposed not to use either Class 1 or Class 2 allowable stresses for stress ratios but use only API 620 allowable stresses and limit the actual 620 stress ratio to be not lower than 0.33.

Since these materials are ordered as non-ASME materials (i.e., A36 vs SA36), it is advised to apply the quality factors that API 620 has in Table 5-1 that will lower the allowable stress to use on certain materials.

Also, the low temperature/low provision rules would only apply to materials that can be found in ASME Section II Part D. If the API 620 material of choice is not found in ASME II-D, then these design rules to lower the MDMT are not permitted.

Summary of Recommendations:

- 1) Material must be listed in ASME Section II Part D
- 2) Allowable stress from API 620, including the applicable notes in Table 5-1.
- 3) R_{ts} to be greater of (0.33 or Actual/Allowable)

PROPOSAL 4.2.2 Low-stress/Low-temperature Design Provisions

Either of the following a) or b) may be used:

- a) The following design criteria, relative to the use of Table 4-1, apply when the actual stress under design conditions does not exceed one-third of the allowable tensile stress.
 - 1) Consideration of the design metal temperature is not required in selecting material from Table 4-1 for tank components that are not in contact with the liquid or vapor being stored and are not designed to contain the contents of an inner tank (see Q.2.4 and R.2.3).
 - 2) The design metal temperature may be increased by 30 °F in selecting material from Table 4-1 for tank components conforming to any of the following:
 - i) components exposed to the vapor from the liquid or vapor being stored and are not designed to contain the contents of the inner tank.
 - ii) components located within, but not welded directly to, a primary liquid container, a secondary liquid container, or a warm product vapor container (see R.2.4).
 - 3) Excluding bottom plates welded to the cylindrical sidewall of flat-bottom tanks, the plates of a non-refrigerated flat-bottom tank, counterbalanced in accordance with 5.11.2, may be constructed of any material selected from Table 4-1.
- b) Except for lap-welded bottoms, lap-welded suspended decks, lap-welded roofs, and lap-welded liner plates for concrete walls, the provisions of ASME *Boiler and Pressure Vessel Code (BPVC)* Section VIII Division 2 issue year ~~2017~~ **2025** (hereinafter referred to as *BPVC VIII-2-~~2017~~ 2025*) Sections 3.11.2.1 (general); 3.11.2.3 (Exemption From Impact Testing based on the MDMT, Thickness, and Material Specification); 3.11.2.5 (Exemption From Impact Testing Based on Design Stress Values); 3.11.2.6 (Adjusting the MDMT for Impact Tested Materials); 3.11.2.9 (PWHT); and 3.11.2.10 (weld procedure impact testing) together with any referenced paragraphs or sections may be used for material design of components, including but not limited to the allowable stresses, material specifications, locations requiring post weld heat treat, impact test temperatures, impact test exemption temperatures, and impact energy

value requirements, with the following clarifications:

- 1) NDE methods and acceptance criteria may follow Section 7 of this standard.
- 2) The use of *BPVC* VIII-2-~~2017~~ 2025 may be by individual components, but for connected components which are materially different, such as annular plate attached to first shell ring, the most stringent criteria of the connected components apply to both parts.
- 3) Allowable stresses from API 620 still applies to component design, even when using *BPVC* VIII-2-~~2017~~ 2025. When determining stress ratios for the purpose of entering a table or figure in *BPVC* VIII-2-~~2017~~ 2025, *API 620 allowable stresses in Tension per Table 5-1, including associated notes, shall be used. ASME allowable stresses per ASME BPVC.II.D.C-2017 for Class 1 Vessels (no fatigue analysis) are applicable.* Additional criteria that apply are that the selected material shall be listed in ASME *BPVC.II. Part D*, and stress ratio (R_{ts}) shall be the greater of 0.33 or the ratio of the actual stress over the allowable stress.

Attachment A – Comparison of *BPVC* VIII-2 2025 version to 2017 version