Agenda Item: 620-1022

Title: **Allowable Tensile Stress API 620 Annexure Q A645 Grade A**

Date: November 14, 2023

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Purpose: To update allowable tensile stress values for ASTM A645 Grade A material in API 620 Annexure Q, Table Q-3.

Source: Email D. Miller June 02, 2021, to M. Shores and R. Challa

Revision: **1 (November 14, 2023)**

Impact: Neutral

Rationale: API 620 lists ASTM A645 Grade A material as a plate material for low pressure welded cryogenic storage tanks. API 620 currently, in 12th Edition Addendum 3, Annexure Q, Table Q-3, lists 31,700 psi as allowable design stress and 42,000 psi as allowable test stress, with a note 'b' identified for ASTM A645 Grade A material.

Similar 5% Nickel Steel material, ASTM A645 Grade B, is indicated to have allowable stress values in accordance with note 'a' of Table Q-3.

Table Q-3 Note 'a':

> *The allowable stresses for these materials are based on the lower yield and tensile strength of the weld metal or base metal, as determined by Q.4.2.1 and Q.4.2.2, and the design rules in Q.3.3.2 and Q.3.3.3. Further, the allowable stresses shall be considered joint by joint as limits on the stress acting across that joint considering the weld metal used at that joint. The minimum measured tensile strength shall be 95,000lbf/in^2 and minimum measured yield strength shall be 52,500 lbf/in^2, except that for circumferential seams only in the sidewall of a cylindrical tank, the minimum measured tensile strength shall be 80,000 lbf/in^2 and the minimum measured yield strength shall be 42,000 lbf/in^2. For all seams, the maximum permitted values to be used for determining the allowable stress are 100,000 lbf/in^2 for tensile strength and 58,000 lbf/in^2 for yield strength.*

Table Q-3 Note 'b':

> *Based on the yield and tensile strength of the weld metal, as determined by Q.4.2. The minimum measured tensile strength shall be 95,000 lbf/in^2 and the minimum measured yield strength shall be 52,500 lbf/in^2.*

ASTM A645 Grade A and Grade B differ only slightly in chemical composition, with the following basic differences as per ASTM A645 specification (2022 edition) Table 1 (appendix A of this agenda item).

- Lower Manganese content in Grade A (0.30%-0.60%) compared to that of Grade B (0.90%-1.50%) in heat analysis.
- No Chromium in Grade A compared to 0.10% to 1.00% in Grade B
- Slightly higher tempering temperature for grade A (

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Proposal: Annex Q - Table Q-3

The following section to include updated ASTM A 645 Grade A allowable stress values. Please refer to modifications as shown in the subsequent parts of this item.

1. Annex Q - Table Q-3, Page Q-9

PROPOSAL 620-1022 ASTM A645 Grade A FOR BALLOT

Table Q-3—Maximum Allowable Stress Values

ASTM Specifications	Stress Value (lbf/in.^{2})				
	Specified Minimum		Allowable Stress		
	Tensile Strength	Yield Strength	Design	Test	
Plate and Structural Members					
A353	100,000	75,000	[a]	[a]	
A553, Type 1	100,000	85,000	[a]	[a]	
A553, Type III	100,000	85,000	[a]	[a]	18
A844	100,000	85,000	[a]	[a]	18
A841, Grade G, Class 9	100,000	85,000	[a]	[a]	18
A645, Grade B	100,000	85,000	[a]	[a]	
A645, Grade A	95,000	65,000	~~31,700[b]~~ [a]	~~42,000[b]~~ [a]	18
A240, Type 304	75,000	30,000	22,500	27,000	
A240, Type 304L	70,000	25,000	18,750	22,500	
A240, Type 201LN (UNS-S20153)	95,000	45,000	31,700	40,500	
A240, Type 316	75,000	30,000	22,500	27,000	
A240, Type 316L	70,000	25,000	18,750	22,500	
A276, Type 304, Condition A[d]	75,000[d]	30,000[d]	22,500	27,000	
A276, Type 304L, Condition A[d]	70,000[d]	25,000[d]	18,750	22,500	
A276, Type 316, Condition A[d]	75,000[d]	30,000[d]	22,500	27,000	
A276, Type 316L, Condition A[d]	70,000[d]	25,000[d]	18,750	22,500	
A479, Type 304, Condition A[d]	75,000[d]	30,000[d]	22,500	27,000	
A479, Type 304L, Condition A[d]	70,000[d]	25,000[d]	18,750	22,500	
A479, Type 316, Condition A[d]	75,000[d]	30,000[d]	22,500	27,000	
A479, Type 316L, Condition A[d]	70,000[d]	25,000[d]	18,750	22,500	
B209, Alloy 3003-0	14,000	5,000	3,750	4,500	
B209, Alloy 5052-0	25,000	9,500	7,100	8,550	
B209, Alloy 5083-0	40,000[g]	18,000[g]	13,300[g]	16,200[g]	
B209, Alloy 5086-0	35,000	14,000	10,500	12,600	
B209, Alloy 5154-0	30,000	11,000	8,250	9,900	
B209, Alloy 5456-0	42,000[g]	19,000[g]	14,000[g]	17,100[g]	
B221, Alloy 3003-0	14,000	5,000	3,750	4,500	
B221, Alloy 5052-0	25,000	10,000	7,500	9,000	
B221, Alloy 5083-0	39,000	16,000	12,000	14,400	
B221, Alloy 5086-0	35,000	14,000	10,500	12,600	
B221, Alloy 5154-0	30,000	11,000	8,250	9,900	
B221, Alloy 5456-0	41,000	19,000	13,650	17,100	
B221, Alloys 6061-T4 and T6 (welded)	24,000		8,000	10,000	
B308, Alloys 6061-T4 and T6 (welded)	24,000		8,000	10,000	
Piping and Tubing					
A333, Grade 8	100,000	75,000	[a]	[a]	
A334, Grade 8	100,000	75,000	[a]	[a]	
A213, Grade TP, Type 304	75,000	30,000	22,500	27,000	
A213, Grade TP, Type 304L	70,000	25,000	18,750	22,500	
A312, Grade TP, Type 304[c]	75,000	30,000	22,500	27,000	
A312, Grade TP, Type 304L[c]	70,000	25,000	18,750	22,500	

Table Q-3—Maximum Allowable Stress Values (Continued)

ASTM Specifications	Stress Value (lbf/in.^{2})			
	Specified Minimum		Allowable Stress	
	Tensile Strength	Yield Strength	Design	Test
Bolting[e]				
F468, Alloy 6061-T6	42,000	35,000	14,000	
A320 (strain-hardened: Grade B8, B8C, B8M and B8T)				
≤ ¾ in.	125,000	100,000	30,000	
> ¾ to 1 in.	115,000	80,000	26,000	
> 1 to 1¼ in.	105,000	65,000	21,000	
> 1¼ to 1½ in.	100,000	50,000	16,000	
A320 (solution-treated and strain-hardened grades when welded)				
Grades B8, B8M, and B8T-all sizes	75,000	30,000	15,000	

[a] The allowable stresses for these materials are based on the lower yield and tensile strength of the weld metal or base metal, as determined by Q.4.2.1 and Q.4.2.2, and the design rules in Q.3.3.2 and Q.3.3.3. Further, the allowable stresses shall be considered joint by joint as limits on the stress acting across that joint considering the weld metal used at that joint. The minimum measured tensile strength shall be 95,000 lbf/in.^{2} and minimum measured yield strength shall be 52,500 lbf/in.^{2}, except that for circumferential seams only in the sidewall of a cylindrical tank, the minimum measured tensile strength shall be 80,000 lbf/in.^{2} and the minimum measured yield strength shall be 42,000 lbf/in.^{2}. For all seams, the maximum permitted val Not Used the allowable stress are 100,000 lbf/in.^{2} for tensile strength and 58,000 lbf/in.^{2} for yield strength.

[b] ~~Based on the yield and tensile strength of the weld metal, as determined by Q.4.2. The minimum measured tensile strength shall be 95,000 lbf/in.^{2} and the minimum measured yield strength shall be 52,500 lbf/in.^{2}.~~

[c] For welding piping or tubing, a joint efficiency of 0.80 shall be applied to the allowable stresses for longitudinal joints in accordance with 5.23.3.

[d] Based on hot finish. Where cold finish is permitted, allowable stresses for hot finish shall still be used. 14

[e] See 5.6.6.

[f] Not to be used for opening reinforcement when used with A353, A 553, A645, A841, and A844. 18

[g] These allowable stresses are for thicknesses up to and including 1.5 in. For thicknesses over 1.5 in., determine allowable stresses per Q.3.3.2 using ASTM minimum tensile strength and minimum yield strength for these thicknesses. 18

Appendix A: ASTM A645 (2022 edition) reference – excerpt Table 1

TABLE 1 Chemical Requirements

Element	Composition, %	
	Grade A	Grade B
Carbon, max		
Heat Analysis	0.13	0.13
Produce Analysis	0.15	0.15
Manganese		
Heat Analysis	0.30–0.60	0.90–1.50
Product Analysis	0.25–0.66	0.84–1.59
Phosphorus, max		
Heat Analysis	0.025	0.020
Product Analysis	0.025	0.025
Sulfur, max		
Heat Analysis	0.025	0.010
Product Analysis	0.025	0.015
Silicon		
Heat Analysis	0.20–0.40	0.15–0.30[A]
Product Analysis	0.18–0.45	0.13–0.33[A]
Nickel		
Heat Analysis	4.8–5.2	5.0–6.0
Product Analysis	4.7–5.3	4.9–6.1
Chromium		
Heat Analysis	...	0.10–1.00
Product Analysis	...	0.06–1.05
Molybdenum		
Heat Analysis	0.20–0.35	0.10–0.30
Product Analysis	0.17–0.38	0.09–0.33
Aluminum, total		
Heat Analysis	0.02–0.12	0.02–0.05
Product Analysis	0.01–0.16	0.015–0.06
Nitrogen, max		
Heat Analysis	0.020	0.010
Product Analysis	0.025	0.010

[A] The specified minimum limit does not apply if the total aluminum is 0.030 % or more, ore if the acid soluble aluminum content is 0.025 % or more.

TABLE 2 Tensile Requirements

	Grade A	Grade B
Yield strength, min, ksi [MPa][A]	65 [450]	85 [590]
Tensile strength, ksi [MPa]	95–115 [655 to 795]	100–120 [690–830]
Elongation in 2 in. [50 mm], min, %[B]	20.0	20

[A] At 0.2 % offset, or, if agreed between the purchaser and the manufacturer, at 0.5 % extension under load.
[B] See Specification A20/A20M for elongation adjustment.