P.W.H.T

Post Weld Heat Treatment

ASME B31.3

PROCESS PIPING

Rev.:

1990 - 2004

Rev.:

2006 - 2012

Rev.:

2014 - 2022

Revision - 1990 ~ 2004

TABLE 331.1.1 REQUIREMENTS FOR HEAT TREATMENT

Base Metal P-No. or S-No. [Note (1)]	Weld Metal Analysis A-Number [Note (2)]	Base Metal Group	Nominal Wall Thickness		Specified Min. Tensile Strength, Base Metal		Metal Temperature Range		Holding Time Nominal Wall [Note (3)]		Holding Time Min. Time, hr	Brinell Hardness, Max. [Note (4)]
			mm	in.	Mpa	ksi	°C	°F	min/mm	hr/in		
1	1	Carbon Steel	≤ 19	≤ 3/4	All	All	None	None	...	...	...	...
			> 19	> 3/4	All	All	593 - 649	1100 - 1200	2.4	1	1	...
3	2, 11	Alloy Steels, Cr ≤ 1/2%	≤ 19	≤ 3/4	≤ 490	≤ 71	None	None	...	...	...	...
			> 19	> 3/4	All	All	593 - 718	1100 - 1325	2.4	1	1	225
			All	All	> 490	> 71	593 - 718	1100 - 1325	2.4	1	1	225
4 [Note (5)]	3	Alloy Steels, 1/2% < Cr ≤ 2%	≤ 13	≤ 1/2	≤ 490	≤ 71	None	None	...	...	...	...
			> 13	> 1/2	All	All	704 - 746	1300 - 1375	2.4	1	2	225
			All	All	> 490	> 71	704 - 746	1300 - 1375	2.4	1	2	225
5A, 5B, 5C [Note (5)]	4 , 5	Alloy Steels (2,1/4% < Cr < 10%)										
		< 3% Cr and ≤ 0.15% C	≤ 13	≤ 1/2	All	All	None	None	...	...	...	...
		< 3% Cr and < 0.15% C	> 13	> 1/2	All	All	704 - 760	1300 - 1400	2.4	1	2	241
		> 3% Cr or > 0.15% C	All	All	All	All	704 - 760	1300 - 1400	2.4	1	2	241
6	6	High Alloy Steels Martensitic A240 Gr. 429	All	All	All	All	732 - 788	1350 - 1450	2.4	1	2	241
			All	All	All	All	621 - 663	1150 - 1225	2.4	1	2	241
7	7	High Alloy Steels Ferritic	All	All	All	All	None	None	...	...	...	...
8	8, 9	High Alloy Steels Austenitic	All	All	All	All	None	None	...	...	...	...
9A, 9B	10	Nickel Alloy Steels	≤ 19	≤ 3/4	All	All	None	None	...	...	...	...
			> 19	> 3/4	All	All	593 - 635	1100 - 1175	1.2	1/2	1	...
10	...	Cr-Cu Steel	All	All	All	All	760 - 816 [Note (6)]	1400 - 1500 [Note (6)]	1.2	1/2	1/2	...
10H	...	Duplex Stainless Steel	All	All	All	All	Note (7)	Note (7)	1.2	1/2	1/2	...
10 I	...	27 Cr Steel	All	All	All	All	663 - 704 [Note (8)]	1225 - 1300 [Note (8)]	2.4	1	1	...
11A SG 1	...	8Ni, 9Ni Steel	≤ 51	≤ 2	All	All	None	None	...	...	...	...
			> 51	> 2	All	All	552 - 585 [Note (9)]	1025 - 1085 [Note (9)]	2.4	1	1	...
11A SG 2	...	5Ni Steel	> 51	> 2	All	All	552 - 585 [Note (9)]	1025 - 1085 [Note (9)]	2.4	1	1	...
62	...	Zr R60705	All	All	All	All	538 - 593 [Note (10)]	1000 - 1100 [Note (10)]	Note (10)	Note (10)	1	...

NOTES:

(1) P-Number or S-Number from BPV Code, Section IX, QW/QB-422.

(2) A-Number from Section IX, QW-442.

(3) For holding time in SI metric units, use min/mm (minutes per mm thickness). For U.S. units, use hr/in. thickness.

(4) See para. 331.1.7.

(5) See Appendix F, para. F331.1.

(6) Cool as rapidly as possible after the hold period.

(7) Postweld heat treatment is neither required nor prohibited, but any heat treatment applied shall be as required in thematerial specification.

(8) Cooling rate to 649°C (1200°F) shall be less than 56°C (100°F)/hr; thereafter, the cooling rate shall be fast enough to prevent embrittlement.

(9) Cooling rate shall be > 167°C (300°F)/hr to 316°C (600°F).

(10) Heat treat within 14 days after welding. Hold time shall be increased by 1/2 hr for each 25 mm (1 in.) over 25 mm thickness. Cool to 427°C (800°F) at a rate ≤ 278°C (500°F)/hr, per 25 mm (1 in.) nominal thickness, 278°C (500°F)/ hr max. Cool in still air from 427°C (800°F).

Revision - 2006 ~ 2012

TABLE 331.1.1 REQUIREMENTS FOR HEAT TREATMENT

Base Metal P-No. or S-No. [Note (1)]	Weld Metal Analysis A-Number [Note (2)]	Base Metal Group	Nominal Wall Thickness		Specified Min. Tensile Strength, Base Metal		Metal Temperature Range		Holding Time Nominal Wall [Note (3)]		Holding Time Min. Time, hr	Brinell Hardness, Max. [Note (4)]
			mm	in.	Mpa	ksi	°C	°F	min/mm	hr/in		
1	1	Carbon Steel	≤ 20	≤ 3/4	All	All	None	None	. . .	. . .	. . .	. . .
			> 20	> 3/4	All	All	593 - 649	1100 - 1200	2.4	1	1	. . .
3	2, 11	Alloy Steels, Cr ≤ 1/2%	≤ 20	≤ 3/4	≤ 490	≤ 71	None	None	. . .	. . .	. . .	. . .
			> 20	> 3/4	All	All	593 - 718	1100 - 1325	2.4	1	1	225
			All	All	> 490	> 71	593 - 718	1100 - 1325	2.4	1	1	225
4 [Note (5)]	3	Alloy Steels, 1/2% < Cr ≤ 2%	≤ 13	≤ 1/2	≤ 490	≤ 71	None	None	. . .	. . .	. . .	. . .
			> 13	> 1/2	All	All	704 - 746	1300 - 1375	2.4	1	2	225
			All	All	> 490	> 71	704 - 746	1300 - 1375	2.4	1	2	225
5A, 5B, 5C [Note (5)]	4 , 5	Alloy Steels (2,1/4% < Cr < 10%)										
		< 3% Cr and ≤ 0.15% C	≤ 13	≤ 1/2	All	All	None	None	. . .	. . .	. . .	. . .
		< 3% Cr and < 0.15% C	> 13	> 1/2	All	All	704 - 760	1300 - 1400	2.4	1	2	241
		> 3% Cr or > 0.15% C	All	All	All	All	704 - 760	1300 - 1400	2.4	1	2	241
6	6	High Alloy Steels Martensitic A240 Gr. 429	All	All	All	All	732 - 788	1350 - 1450	2.4	1	2	241
			All	All	All	All	621 - 663	1150 - 1225	2.4	1	2	241
7	7	High Alloy Steels Ferritic	All	All	All	All	None	None	. . .	. . .	. . .	. . .
8	8, 9	High Alloy Steels Austenitic	All	All	All	All	None	None	. . .	. . .	. . .	. . .
9A, 9B	10	Nickel Alloy Steels	≤ 20	≤ 3/4	All	All	None	None	. . .	. . .	. . .	. . .
			> 20	> 3/4	All	All	593 - 635	1100 - 1175	1.2	1/2	1	. . .
10	. . .	Cr-Cu Steel	All	All	All	All	760 - 816 [Note (6)]	1400 - 1500 [Note (6)]	1.2	1/2	1/2	. . .
10H	. . .	Duplex Stainless Steel	All	All	All	All	Note (7)	Note (7)	1.2	1/2	1/2	. . .
10 I	. . .	27 Cr Steel	All	All	All	All	663 - 704 [Note (8)]	1225 - 1300 [Note (8)]	2.4	1	1	. . .
11A SG 1	. . .	8Ni, 9Ni Steel	≤ 51	≤ 2	All	All	None	None	. . .	. . .	. . .	. . .
			> 51	> 2	All	All	552 - 585 [Note (9)]	1025 - 1085 [Note (9)]	2.4	1	1	. . .
11A SG 2	. . .	5Ni Steel	> 51	> 2	All	All	552 - 585 [Note (9)]	1025 - 1085 [Note (9)]	2.4	1	1	. . .
62	. . .	Zr R60705	All	All	All	All	538 - 593 [Note (10)]	1000 - 1100 [Note (10)]	Note (10)	Note (10)	1	. . .

NOTES:

(1) P-Number or S-Number from BPV Code, Section IX, QW/QB-422.

(2) A-Number from Section IX, QW-442.

(3) For holding time in SI metric units, use min/mm (minutes per mm thickness). For U.S. units, use hr/in. thickness.

(4) See para. 331.1.7.

(5) See Appendix F, para. F331.1.

(6) Cool as rapidly as possible after the hold period.

(7) Postweld heat treatment is neither required nor prohibited, but any heat treatment applied shall be as required in thematerial specification.

(8) Cooling rate to 649°C (1200°F) shall be less than 56°C (100°F)/hr; thereafter, the cooling rate shall be fast enough to prevent embrittlement.

(9) Cooling rate shall be > 167°C (300°F)/hr to 316°C (600°F).

(10) Heat treat within 14 days after welding. Hold time shall be increased by 1/2 hr for each 25 mm (1 in.) over 25 mm thickness. Cool to 427°C (800°F) at a rate ≤ 278°C (500°F)/hr, per 25 mm (1 in.) nominal thickness, 278°C (500°F)/ hr max. Cool in still air from 427°C (800°F).

Revision - 2014 ~ 2022

TABLE 331.1.1 POST WELD HEAT TREATMENT

P-No. and Group No. (ASME BPVC, Section IX, QW /QB-420)	Holding Temperature Range, °C (°F) [Note (1)]	Minimum Holding Time at Temperature for Control Thickness [Note (2)]	
		Up to 50 mm (2 in.)	Over 50 mm (2 in.)
P-No. 1, Group Nos. 1-3	595 to 650 (1,100 to 1,200)	1 h/25 mm (1 hr/in.); 15 min min.	2 hr plus 15 min for each additional 25 mm (in.) over 50 mm (2 in.)
P-No. 3, Group Nos. 1 and 2	595 to 650 (1,100 to 1,200)		
P-No. 4, Group Nos. 1 and 2	650 to 705 (1,200 to 1,300)		
P-No. 5A, Group No. 1	675 to 760 (1,250 to 1,400)		
P-No. 5B, Group No. 1	675 to 760 (1,250 to 1,400)		
P-No. 6, Group Nos. 1-3	760 to 800 (1,400 to 1,475)		
P-No. 7, Group Nos. 1 and 2 [(Note (3)]	730 to 775 (1,350 to 1,425)		
P-No. 8, Group Nos. 1-4	PWHT not required unless required by WPS		
P-No. 9A, Group No. 1	595 to 650 (1,100 to 1,200)		
P-No. 9B, Group No. 1	595 to 650 (1,100 to 1,200)		
P-No. 10H, Group No. 1	PWHT not required unless required by WPS. If done, see Note (4).		
P-No. 10I, Group No. 1 [Note (3)]	730 to 815 (1,350 to 1,500)		
P-No. 11A	550 to 585 (1,025 to 1,085) (Note (5)]		
P-No. 15E, Group No. 1	705 to 775 (1,300 to 1,425) (Notes (6), (7)]	1 h/25 mm (1 hr/in.); 30 min min.	1 h/25 mm (1 hr/in.) up to 125 mm (5 in.) plus 15 min for each additional 25 mm (in.) over 125 mm (5 in.)
P-No. 62	540 to 595 (1,000 to 1,100)		See Note (8)
All other materials	PWHT as required by WPS	In accordance with WPS	In accordance with WPS

GENERAL NOTE: The exemptions for mandatory PWHT are defined in Table 331.1.3.

NOTES:

(1) The holding temperature range is further defined in para. 331.l.6(c) and Table 331.1.2.

(2) The control thickness is defined in para. 331.1.3.

(3) Cooling rate shall not be greater than 55° C (100° F) per hour in the range above 650° C (1,200° F), after which the cooling rate shall be sufficiently rapid to prevent embrittlement.

4) If PWHT is performed after welding, it shall be within the following temperature ranges for the specific alloy, followed by rapid cooling:

Alloys S31803 and S32205 - 1 020° C to 1 100° C (1,870° F to 2,010° F)

Alloy S32550 - 1 040° C to 1 120° C (1,900° F to 2,050° F)

Alloy S32750 - 1 025° C to 1 125° C (1,880° F to 2,060° F)

All others - 980° C to 1 040° C (1,800° F to 1,900° F)

(5) Cooling rate shall be >165° C (>300° F)/h to 315° C (600° F)/h.

(6) The minimum PWHT holding temperature may be 675° C (1,250° F) for nominal material thicknesses [see para. 331.l.3(c)] ,;;13 mm (,;;Y2 in.).

(7) The Ni+ Mn content of the filler metal shall not exceed 1.2% unless specified by the designer, in which case the maximum temperature to be reached during PWHT shall be the lower transformation temperature of the filler metal, as determined by analysis and calculation or by test, but not exceeding 800° C (1,470° F). If the 800° C (1,470° F) limit was not exceeded but the lower transformation temperature of the filler metal was exceeded or if the composition of the filler metal is unknown, the weld must be removed and replaced. It shall then be rewelded with compliant filler metal and subjected to a compliant PWHT. If the 800° C (1,4 70° F) limit was exceeded, the weld and the entire area affected by the PWHT will be removed and, if reused, shall be renormalized and tempered prior to reinstallation. The lower transformation temperature is the steady-state temperature at which the austenite phase transformation occurs.

(8) Heattreat within 14 days after welding. Hold time shall be increased by 1.2 h for each 25 mm (1 in.) over 25 mm (1 in.) thickness.
Cool to 425° C (800° F) at a rate $280° C (,;;500° F)/h.