NOTICE REGARDING CODE CASES OF THE ASME B31 CODE FOR PRESSURE PIPING

All B31 Code Cases in effect as of September 21, 2007 will remain available for use unless annulled by the B31 Standards Committee.

B31 Case 175
ASTM B 16 (UNS C36000) and B 453 (UNS C35300) in ASME B31.1 Construction

ANNULLED

Annulment Date: September 28, 2013

Reason: Requirements incorporated in ASME B31.1 Code.

CASES OF THE CODE FOR PRESSURE PIPING – B31

B31 CASE 180
Leak Testing of Subassemblies of Jacketed Piping for use in ASME B31.3 Piping Systems

Approval Date: January 5, 2007

Inquiry: Does ASME B31.3 permit an alternate leak test for jacketed piping in which it is impracticable to visually examine the welded joints and connections for leaks in accordance with para. 345.2.2(a)?

Reply: Visually observing the joints and connections during the leak test in accordance with para. 345.2.2(a) and 345.3.1 is not required provided all of the following conditions are satisfied:

1. The welded joints and connections are on the inner pipe of jacketed piping.
2. A leak test is performed that otherwise meets the requirements of para. 345.1 except visual examination of joints and connection in accordance with para. 345.2.2(a) and 345.3.1 is not required.
3. A sensitive leak test is performed in accordance with para. 345.8 to demonstrate leak tightness of welded joints and connections that are not visually examined during the leak testing requirements in 2 above.

B31 CASE 181

Use of Alternative Ultrasonic Examination Acceptance Criteria

ANNULLED

Annulment Date: June 25, 2018

Reason: Code Case 181 has been incorporated into Appendix R in B31.3-2016 Edition.

B31 CASE 182
Use of 1.15Ni-0.65Cu-Mo-Cb in ASME B31.1 Construction

ANNULLED

Annulment Date: June 1, 2015

Reason: Requirements incorporated in ASME B31.1 Code.

B31 CASE 183 - 5
Use of 9Cr–2W, UNS No. K92460, in ASME B31.1 Construction

Approval Date: (June 6, 2023)

Inquiry: May 9Cr–2W, UNS No. K92460, material conforming to one of the specifications listed in Table 1, be used for ASME B31.1 construction?

Reply: It is the opinion of the Committee that 9Cr–2W, UNS No. K92460, material conforming to one of the specifications listed in Table 1, may be used for ASME B31.1 construction provided the following additional requirements are met:

(a) ASTM A369 Grade FP92 material shall not exceed a hardness of 250 HBW/265 HV (25 HRC).

(b) The maximum allowable stress values for the material shall be those given in Table 2. The maximum use temperature for the material shall be 1,200°F (649°C).

(c) For the purposes of procedure and performance qualifications, the material shall be considered P-No. 15E, Group 1. The procedure and performance qualifications shall be conducted in accordance with Section IX. Procedure and performance qualifications qualified under previous versions of this Case do not require requalification.

(1) When weld filler metal of nominally matching chemistry (e.g., AWS chemical composition designator B92) is used to make pressure retaining welds in these materials, the nickel plus manganese (Ni + Mn) content of the filler metal shall not exceed 1.2%.

(2) Post-weld heat treatment for this material is mandatory, and the following rules shall apply:

(-a) The PWHT temperature range shall be 1,350°F to 1,470°F (730°C to 800°C).

(-b) All other requirements shall be those given for P-No. 15E, Group 1 materials in Table 132.1.1-1.

(-c) Exemptions to postweld heat treatment for this material shall be in accordance with the rules for P-No. 15E, Group 1 materials in para. 127.4.9.

(d) Repair welding of base material shall be permitted as prescribed by the applicable material product specification or its general requirements specification. All repair welds shall be in accordance with Section IX using one of the following processes: SMAW, SAW, GTAW, or FCAW. The composition of the welding consumables shall meet the chemical composition requirements for the base material and shall be such that the lower critical transformation temperature of the consumables shall exceed the maximum post weld heat treatment temperature in (c) above. If the lower critical transformation temperature is calculated rather than measured, the formula used shall be reported. If requested, data supporting the validity of the formula shall be provided by the material manufacturer. All repair welds to base material shall be normalized and tempered according to the requirements of the applicable material specification. The material manufacturer shall provide a complete report of all repair welds.

(e) If during the manufacturing any portion of the component is heated to a temperature greater than 1,470°F (800°C), then the component must be reaustenitized and retempered in its entirety in accordance with the applicable material specification, or that portion of the component heated above 1,470°F (800°C) and the weld metal and heat-affected zone that exceeded 1470°F (800°C) plus an additional 3 in. (75 mm) of base metal on each side of the joint shall be removed and replaced with new material or the removed section may be reaustenitized and retempered before being reinstalled.

(f) 9Cr – 2W materials subject to forming or bending shall be heat treated in accordance with the following rules.

(1) When the material is cold formed or cold bent, cold forming strains shall be calculated in accordance with para. 129.3.4.1 or 129.3.4.2.

(2) If normalizing and tempering is performed, it shall not be performed locally. The pipe, tube, or component to be normalized and tempered shall either be heat treated in its entirety, or the area (including the transition to the unstrained portion) shall be cut away from the balance of the pipe, tube or component and heat treated separately or replaced.

(3) If hot bending or hot forming is performed, and for all cold swages, flares or upsets, normalizing and tempering of the material is required in accordance with the requirements in the base material specification.

(4) If cold bending or cold forming is performed, the material shall be heat treated as follows:

(-a) For materials with greater than 20% strain with design temperatures exceeding 1115°F (600°C) or for materials with greater than 25% strain with design temperatures between 1000°F (540°C) and 1115°F (600°C) inclusive, the cold strained area of the component shall be normalized and tempered in accordance with the requirements of the base material specification.

(-b) For materials with greater than 5% strain but less than or equal to 20% strain with design temperatures exceeding 1115°F (600°C) or with greater than 5% strain but less than or equal to 25% strain with design temperatures between 1000°F (540°C) and 1115°F (600°C) inclusive, the cold strained areas shall be heat treated at 1350-1425°F (730-775°C) for 1 hr./in. (1 hr./ 25mm.) or 30 minutes minimum. As an alternative, normalization and temper in accordance with the requirements of the base material specification may be substituted for the heat treatment required in this paragraph.

(-c) If only a portion of a cold bent or cold formed piping component is heated above the heat treatment temperature allowed above and the material was subjected to strains greater than 5% but less than or equal to 25% for design temperatures less than or equal to 1115°F (600°C), one of the following actions shall be performed:

(-1) The component in its entirety shall be renormalized and tempered in accordance with the requirements of the base metal specification.

(-2) The allowable stress shall be that for Gr. 9 material (i.e., A335 P9 or equivalent product specification) at the design temperature provided that the portion of the component that was heat treated to a temperature exceeding the maximum holding temperature is subjected to a final heat treatment within the temperature range and for the time required in para. (D)(2) above. For Boiler External Piping, the use of this provision shall be noted on the Manufacturer's Data Report.

(-d) For materials with less than or equal to 5% strain or design temperatures less than 1000°F (540°C), heat treatment is neither required nor prohibited.

(g) This material has demonstrated a susceptibility to creep cavity formation and damage in the time-dependent regime resulting in very low strain before rupture and high sensitivity to multiaxial stresses (e.g. trending to notch weakening behavior). Therefore, the following additional requirements apply.

(1) Definitions

creep cavitation damage: a manifestation of creep damage, typically as a high density of individual voids (cavities) formed during an exposure to stress and elevated temperatures in the time-dependent regime. CSEF steels that are susceptible to creep cavitation are vulnerable to local creep damage and cracking in regions of higher stress because of their limited capacity to withstand tertiary creep degradation (i.e., microfissuring and cracking).

creep intolerant CSEF steels: creep cavitation susceptibility is indicated by the limited amount of deformation at the time of creep rupture failure. Such materials will exhibit a reduction of area value of <70% for specimens which are creep tested at an applied stress that is <60% of the yield strength at the maximum design metal temperature (ASME BPVC, Section II, Part D, Subpart 1, Table Y-1).

lambda, λ, parameter for creep intolerant CSEF steels: creep intolerant CSEF steels have high susceptibility to creep cavity formation (intolerant behavior), little creep deformation before rupture and high sensitivity to multi- axial stresses (e.g., trending to notch weakening behavior). The lambda parameter is calculated using equation (1) in (2), Step 1 for characterizing creep tolerant/intolerant behavior of CSEF steels.

(2) Procedure for Determination of Creep Intolerant Behavior:

Step 1. Where creep strain data is available, a creep intolerant parameter, λ, value may be calculated using the following equation:

$$\lambda = \frac{\varepsilon_f}{\dot{\varepsilon}_{\min} t_r} \qquad (1)$$

Where:

ε_f = elongation strain at failure

$\dot{\varepsilon}_{\min}$ = minimum creep rate. When relevant, the steady state (secondary) creep rate $\dot{\varepsilon}_{ss}$ can be substituted

t_r = time to rupture

Step 2. The lambda, λ, parameter shall be calculated from either creep rupture data of the tested heats of material obtained in accordance with ASME BPVC, Section II, Part D, Mandatory Appendix 5 or from published creep test data for the applicable CSEF steel.

Step 3. Using the data collected from creep rupture testing, calculate the value of λ using equation (1) in Step 1. If the value of λ is less than 5, the material shall be classified as creep intolerant material. When determining the lambda, λ, parameter from test data, the designer shall give consideration to the sensitivity of the λ parameter to the conditions of the creep testing.

Step 4. If creep rupture testing was not able to be conducted to determine the value of lambda, λ, in Step 2 or no published creep rupture data exists for the applicable CSEF steel, the material shall be classified as creep intolerant and shall follow the requirements of this Case for elevated temperature design.

Step 5. Materials identified as creep intolerant with a component design temperature in the time dependent regime shall use a reduced allowable stress. This reduced allowable stress value is dependent on geometry using a *K* factor. The allowable stress value provided in ASME BPVC, Section II, Part D, Table 1A, shall be multiplied by a factor, F, defined by the following equation:

$$F = \frac{1}{1 + 0.2(K - 1)} \qquad (2)$$

where K is a geometry factor defined in Table 3.

Step 6. Given the theoretical basis for K factors in Table 3, a designer may elect to use design-by-analysis methods to calculate the creep redistributed stationary state stress directly and reduce the allowable stress consistent with this Code Case or may use elastic analysis to determine a K factor.

Step 7. The resultant allowable stress multiplier from Step 5 is provided in Table 4.

(h) When utilized for Boiler External Piping, this Case number shall be shown on the Manufacturer's Data Report.

(i)This Case number shall be shown in the material certification and marking of the material.

TABLE 1
MATERIAL SPECIFICATIONS AND GRADES

Flanges, Forged Fittings Valves and Parts	ASTM A182 / A182M – 21 Grade F92
Seamless Tubes	ASTM A213 / A213M – 22 Grade T92
Piping Fittings	ASTM A234 / A234M – 19 Grade WP92
Seamless Pipe	ASTM A335 / A335M – 21a Grade P92
Forgings	ASTM A336 / A336M – 21 Grade F92
Forged and Bored Pipe	ASTM A369 / A369M – 18a Grade FP92
Plate	ASTM A1017 / A1017M – 17 Grade 92

TABLE 2
MAXIMUM ALLOWABLE STRESS VALUES

For Metal Temperature Not Exceeding, °F	ksi	For Metal Temperature Not Exceeding, °C	MPa
-20 to 100	25.7	-30 to 40	177
200	25.7	85	177
300	25.3	100	177
400	24.5	125	177
500	23.8	150	174
600	23.2	200	169
650	22.8	250	165
700	22.4	300	161
750	21.9	325	159
800	21.4	350	156
850	20.8	375	154
900	20.1	400	151
950	19.2	425	148
1000	18.3	450	144
1050	*15.4*	475	140
1100	*11.7*	500	135
1150	*8.3*	525	129
1200	*5.3*	550	123
		575	*97.5*
		600	*75.0*
		625	*54.3*
		650 [Note (1)]	*35.8*

GENERAL NOTE: Stress values in italics are obtained from time dependent properties

NOTES: (1) The maximum use temperature is 649 °C. The value at 650 °C is provided for interpolation purposes only.

Table 3 Geometry Factors

Geometry/Feature	*K*
Cylindrical welded components under internal pressure	1.0
Longitudinal seam welds	1.5
Dished heads	1.5
Unstayed flat heads and covers	2.5
Openings in shells, headers, and heads (with or without compensation)	2.5
Ligaments	2.5
Supports and attachment lugs	2.0

GENERAL NOTE: Use of the above geometry factors does not reduce the risk of failure from creep intolerant behavior. Implementation of the geometry factors simply increases thickness of the component and reduces the allowable stress to increase creep life.

Table 4 Allowable Stress Multiplier

Geometry/Feature	*F*
Cylindrical welded components under internal pressure	1.000
Longitudinal seam welds (Note 1)	0.909
Dished heads	0.909
Unstayed flat heads and covers	0.**769**
Openings in shells, headers, and heads (with or without compensation)	0.769
Ligaments	0.769
Supports and attachment lugs	0.833

Note 1 - The F factor is independent of the Weld Strength Reduction Factor in B31.1 Table 102.4.7-1.

B31 CASE 184

Use of Ultrasonic Examination of Welds as an Alternative to Radiographic Examination in ASME B31.3, Chapter IX

ANNULLED

Annulment Date: 03/31/2011 (Date of Issuance of B31.3-2010 Edition)

Reason: Code Case 184 shall expire upon the publication of ASME B31.3–2010 Edition.

CASES OF THE CODE FOR PRESSURE PIPING – B31

ASME B31.3 CODE CASE 185

Title: Use of Standard Helium Leak Test for a Vacuum-only Piping System (Paragraph 345)

Approval Date: December 22, 2009

Inquiry:

Under what circumstances does ASME B31.3 permit the use of helium mass spectrometer leak tests performed under a vacuum as a substitute for the leak test requirements specified in ASME B31.3, para. 345?

Reply:

In the opinion of the Committee, the qualified helium leak tests under vacuum conditions in the ASME BPV Code, Section V, Article 10, Appendix V and Appendix IX are acceptable substitutes for the testing requirements identified in para. 345 of ASME B31.3 provided the following conditions are met:

1. The piping system is expected to operate only under vacuum (i.e., sub-atmospheric pressure) conditions.

2. Any leakage into the piping system that could result in an internal reaction (e.g., combustion or explosion) that increases the pressure above atmospheric shall be prevented.

3. All system joints and connections shall be leak tested. Piping welds and joints to be tested shall be uninsulated and exposed, and shall not be primed, painted or otherwise coated.

4. Helium leak testing is performed at vacuum conditions sufficient for the mass spectrometer helium leak tests of ASME BPV Code, Section V, Article 10, Appendices V and IX, or at pressures below 10 millibars absolute (<1% of atmospheric pressure), whichever is lower.

5. ASME B31.3, para. 345.2 applies, except for the minimum "10 min" leak test period, the leak test pressure requirements and the limitation of the need for access for jacketed piping to "visual access." Para. 345.3 also applies, except for the leak test pressure requirements. All other inspection, examination and records requirements of ASME B31.3 Chapter VI must still be satisfied (i.e., paras. 340, 341, 342, 343, 344 and 346).

6. Written procedures shall be qualified, in accordance with BPV Code, Section V, Article 10.

7. Test personnel shall have training and certification consistent with ASME B31.3, para. 342.

8. Test reports, including records of personnel qualifications, shall meet the requirements of ASME BPV Code, Section V, Article 10, Item T-1091 and shall be retained for at least five years.

9. Options of the ASME BPV Code, Section V, Article 10 test methods, which allow the engineering design to modify specified requirements of the Appendix V and Appendix IX test methods (such as acceptability limits for system leak tightness), may only be exercised so as to make these requirements more sensitive or more conservative.

10. The use of the vacuum leak test instead of the pressurized leak test of ASME B31.3, para. 345 shall be specified in the engineering design and shall be accepted by the Owner.

B31 CASE 186
Use of Alternative Ultrasonic Examination Acceptance Criteria in ASME B31.12

Approval Date: November 26, 2010

Inquiry: Under what conditions and limitations may alternative UT acceptance criteria apply in lieu of those described in para. IP-10.4.5.6 of ASME B31.12?

Reply: It is the opinion of the Committee that alternative UT acceptance criteria as described in this Case may be applied in lieu of those described in para. IP-10.4.5.6 of ASME B31.12, provided that all of the following requirements are met:

(a) The ultrasonic examination area shall include the volume of the weld, plus the lesser of 25 mm (1 in.) or t on each side of the weld.

(b) A documented examination strategy or scan plan shall be provided, showing transducer placement, movement, and component coverage, that provides a standardized and repeatable methodology for weld acceptance. The scan plan shall also include ultrasonic beam angle used, beam directions with respect to weld centerline, and pipe volume examined for each weld. The documentation shall be made available to the owner's Inspector.

(c) The ultrasonic examination shall be performed in accordance with a written procedure conforming to the requirements of Section V, Article 4.[1] The procedure shall have been demonstrated to perform acceptably on a qualification block(s). Qualification block(s) shall be in accordance with Section V, Article 4, T-434.1.2 through T-434.1.6. The qualification block(s) shall be prepared by welding or the hot isostatic process (HIP) and shall contain a minimum of three flaws, oriented to simulate flaws parallel to the production weld's fusion line as follows:

(1) one surface flaw on the side of the block representing the pipe O.D. surface

(2) one surface flaw on the side of the block representing the pipe I.D. surface

(3) one subsurface flaw

If the block can be flipped during UT examination, then one flaw may represent both the I.D. and O.D. surfaces. Thus, only two flaws may be required.

Flaw size shall be no larger than the flaw in Table 1 or Table 2 for the thickness to be examined. Acceptable performance is defined as response from the maximum allowable flaw and other flaws of interest demonstrated to exceed the reference level. Alternatively, for techniques that do not use amplitude recording levels, acceptable performance is defined as demonstrating that all imaged flaws with recorded lengths, including the maximum allowable flaws, have an indicated length equal to or greater than the actual length of the flaws in the qualification block.

(d) The ultrasonic examination shall be performed using a device employing automatic computer-based data acquisition. The initial straight beam material examination (T-472 of Section V, Article 4) for reflectors that could interfere with the angle beam examination shall be performed

(1) manually

(2) as part of a previous manufacturing process, or

(3) during the automatic UT examination

provided detection of these reflectors is demonstrated as described in (c) above.

(e) Data is recorded in unprocessed form. A complete data set with no gating, filtering, or thresholding for response from the examination volume in

Table 1 Flaw Acceptance Criteria for Weld Thickness Less Than 25 mm (1 in.)

	a/t	ℓ
Surface flaw	≤0.087	≤6.4 mm (0.25 in.)
Subsurface flaw	≤0.143	≤6.4 mm (0.25 in.)

GENERAL NOTES:
(a) t = thickness of the weld excluding any allowable reinforcement. For a butt weld joining two members having different thicknesses at the weld, t is the thinner of these two thicknesses. If a full penetration weld includes a fillet weld, the thickness of the throat of the fillet weld shall be included in t.
(b) A subsurface indication shall be considered as a surface flaw if the separation (S in Fig. 1) of the indication from the nearest surface of the component is equal to or less than half the through dimension [$2d$ in Fig. 1, sketch (b)] of the subsurface indication.

[1] Sectorial scans (S-scans) with phased arrays may be used for the examination of welds, provided they are demonstrated satisfactorily in accordance with (c). S-scans provide a fan beam from a single emission point, which covers part or all of the weld, depending on transducer size, joint geometry, and section thickness. While S-scans can demonstrate good detectability from side-drilled holes, because they are omnidirectional reflectors, the beams can be misoriented for planar reflectors (e.g., lack of fusion and cracks). This is particularly true for thicker sections, and it is recommended that multiple linear passes with S-scans be utilized for components greater than 25 mm (1 in.) thick. An adequate number of flaws should be used in the demonstration block to ensure detectability for the entire weld volume.

Table 2 Flaw Acceptance Criteria for 25 mm (1 in.) to 300 mm (12 in.) Thick Weld

	25 mm (1 in.) ≤ t ≤ 64 mm (2½ in.)		100 mm (4 in.) ≤ t ≤ 300 mm (12 in.)	
Aspect Ratio, a/ℓ	Surface Flaw, a/t	Subsurface Flaw, a/t	Surface Flaw, a/t	Subsurface Flaw, a/t
0.00	0.031	0.034	0.019	0.020
0.05	0.033	0.038	0.020	0.022
0.10	0.036	0.043	0.022	0.025
0.15	0.041	0.049	0.025	0.029
0.20	0.047	0.057	0.028	0.033
0.25	0.055	0.066	0.033	0.038
0.30	0.064	0.078	0.038	0.044
0.35	0.074	0.090	0.044	0.051
0.40	0.083	0.105	0.050	0.058
0.45	0.085	0.123	0.051	0.067
0.50	0.087	0.143	0.052	0.076

GENERAL NOTES:

(a) t = thickness of the weld excluding any allowable reinforcement. For a butt weld joining two members having different thicknesses at the weld, t is the thinner of these two thicknesses. If a full penetration weld includes a fillet weld, the thickness of the throat of the fillet weld shall be included in t.

(b) A subsurface indication shall be considered as a surface flaw if separation (S in Fig. 1) of the indication from the nearest surface of the component is equal to or less than half the through-thickness dimension [$2d$ in Fig. 1, sketch (b)] of the subsurface indication.

(c) If the acceptance criteria in this Table result in a flaw length, ℓ, less than 6.4 mm (0.25 in.), a value of 6.4 mm (0.25 in.) may be used.

(d) For intermediate flaw aspect ratio, a/ℓ, and thickness, t [64 mm (2½ in.) < t < 100 mm (4 in.)], linear interpolation is permissible.

subparagraph (a) above shall be included in the data record.

(f) Personnel performing and evaluating UT examinations shall be qualified and certified in accordance with their employer's written practice. ASNT SNT-TC-1A or CP-189 shall be used as a guideline. Only Level II or III personnel shall analyze the data or interpret the results.

(g) Qualification records of certified personnel shall be approved by the owner's Inspector per para. 342.1.

(h) In addition, personnel who acquire and analyze UT data shall be qualified and certified in accordance with (f) above, trained using the equipment in (d) above, and participate in the demonstration of (c) above.

(i) Data analysis and acceptance criteria shall be as follows:

(1) Data Analysis Criteria. Reflectors exceeding the limits in either (a) or (b) below, as applicable, shall be investigated to determine whether the indication originates from a flaw or is a geometric indication in accordance with (i)(2) below. When a reflector is determined to be a flaw, it shall be evaluated for acceptance in accordance with (i)(4).

(a) For amplitude-based techniques, the location, amplitude, and extent of all reflectors that produce a response greater than 20% of the reference level shall be investigated.

(b) For nonamplitude-based techniques, the location and extent of all images that have an indicated length greater than the limits in (1) or (2) below, as applicable, shall be investigated.

(1) For welds in material equal to or less than 38 mm (1½ in.) thick at the weld, images with indicated lengths greater than 3.8 mm (0.150 in.) shall be investigated.

(2) For welds in material greater than 38 mm (1½ in.) thick but less than 64 mm (2½ in.) thick at the weld, images with indicated lengths greater than 5 mm (0.200 in.) shall be investigated.

(2) Geometric. Ultrasonic indications of geometric and metallurgical origin shall be classified as follows:

(a) Indications that are determined to originate from the surface configurations (such as weld reinforcement or root geometry) or variations in metallurgical structure of materials (such as cladding to base metal interface) may be classified as geometric indications and

(1) need not be characterized or sized in accordance with (i)(3) below

(2) need not be compared to allowable flaw acceptance criteria of Table 1 or 2

(3) the maximum indication amplitude and location shall be recorded, e.g., internal attachments, 200% DAC maximum amplitude, 25 mm (1 in.) above

the weld centerline, on the inside surface, from 90 deg to 95 deg

(b) The following steps shall be taken to classify an indication as geometric:

(1) Interpret the area containing the reflector in accordance with the applicable examination procedure.

(2) Plot and verify the reflector coordinates. Provide a cross-sectional display showing the reflector position and surface discontinuity such as root or counterbore.

(3) Review fabrication or weld prep drawings.

(c) Alternatively, other NDE methods may be applied to classify an indication as geometric (e.g., alternative UT beam angles, radiography). The method employed is for information only to classify the indication as geometric, and ASME B31.12 requirements for examination techniques are only required to the extent that they are applicable.

(3) Flaw Sizing. Flaws shall be sized in accordance with a procedure demonstrated to size similar flaws at similar material depths. Alternatively, a flaw may be sized by a supplemental manual technique so long as it has been qualified by the demonstration above. The dimensions of the flaw shall be determined by the rectangle that fully contains the area of the flaw. (Refer to Figs. 1 through 5.)

(a) The length, ℓ, of the flaw shall be drawn parallel to the inside pressure-retaining surface of the component.

(b) The depth of the flaw shall be drawn normal to the inside pressure-retaining surface and shall be denoted as a for a surface flaw or $2a$ for a subsurface flaw.

(4) Flaw Evaluation and Acceptance Criteria. Flaws shall be evaluated for acceptance using the applicable criteria of Table 1 or Table 2 and with the following additional requirements:

(a) Surface Connected Flaws. Flaws identified as surface flaws during the UT examination may or may not be surface connected. Therefore, unless the UT data analysis confirms that the flaw is not surface connected, it shall be considered surface connected or a flaw open to the surface, and is unacceptable unless a surface examination is performed in accordance with (1) or (2) below. If the flaw is surface connected, the requirements above still apply; however, in no case shall the flaw exceed the acceptance criteria in ASME B31.12 for the method employed. Acceptable surface examination techniques are

(1) magnetic particle examination (MT) in accordance with applicable para. IP-10.4.5.5 of ASME B31.12 or

(2) liquid penetrant examination (PT) in accordance with applicable para. IP-10.4.5.4 of ASME B31.12

(b) Multiple Flaws

(1) Discontinuous flaws shall be considered a singular planar flaw if the distance between adjacent flaws is equal to or less than S as shown in Fig. 2.

(2) Discontinuous flaws that are oriented primarily in parallel planes shall be considered a singular planar flaw if the distance between the adjacent planes is equal to or less than 13 mm ($\frac{1}{2}$ in.). (Refer to Fig. 3.)

(3) Discontinuous flaws that are coplanar and nonaligned in the through-wall thickness direction of the component shall be considered a singular planar flaw if the distance between adjacent flaws is equal to or less than S as shown in Fig. 4.

(4) Discontinuous flaws that are coplanar in the through-wall direction within two parallel planes 13 mm ($\frac{1}{2}$ in.) apart (i.e., normal to the pressure-retaining surface of the component) are unacceptable if the additive flaw depth dimension of the flaws exceeds those shown in Fig. 5.

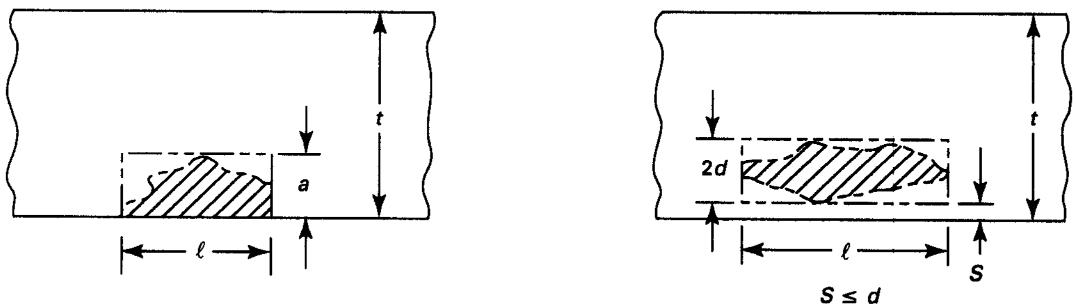
(c) Subsurface Flaws. Flaw length, ℓ, shall not exceed $4t$.

(d) Criteria for Wall Thickness Less Than 25 mm (1 in.). With the owner's approval, the flaw acceptance criteria in Table 2 for wall thicknesses between 25 mm (1 in.) and 64 mm ($2\frac{1}{2}$ in.) may be used for wall thicknesses of less than 25 mm (1 in.). The maximum allowable flaw depth for qualification purposes shall be specified.

(j) Examination data, including the data record of (c) above and data analysis or interpretation of (i) above, shall be reviewed by a UT Level III individual. When flaw evaluation or characterization of (i) above is performed by another qualified Level II or III individual, the review may be performed by another individual from the same organization. Examination data review shall include verification that the records indicated in Section V, Article 4, T-491 and T-492, and records noted in the applicable Article 4 appendices, are available. ASME B31.12 para. IP-10.12 applies.

Alternatively, the review may be achieved by arranging for a data acquisition and initial interpretation by a Level II individual qualified in accordance with (f) and (h) above, and a final interpretation and evaluation shall be performed by a Level III individual qualified similarly. The Level III individual shall have been qualified in accordance with (f) above, including a practical examination of flawed specimens.

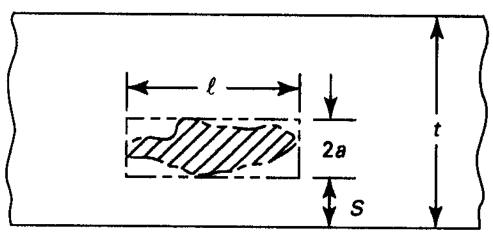
Fig. 1 Single Indications



(a)

(b)

Surface Indications



$S > a$

(c) Subsurface Indications

Fig. 2 Multiple Planar Flaws Oriented in Plane Normal to Pressure-Retaining Surface

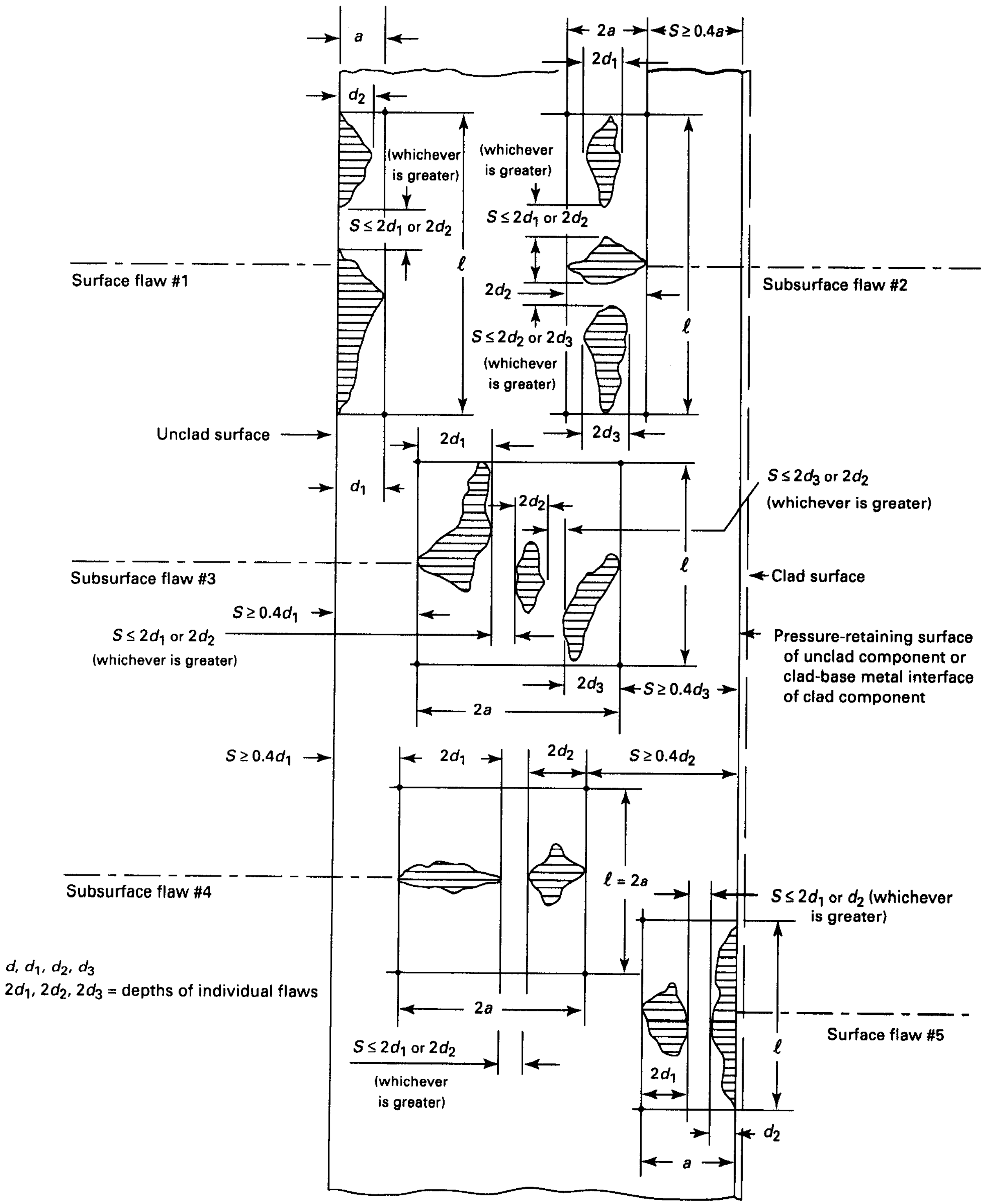


Fig. 3 Discontinuous Flaws Oriented Primarily in Parallel Planes

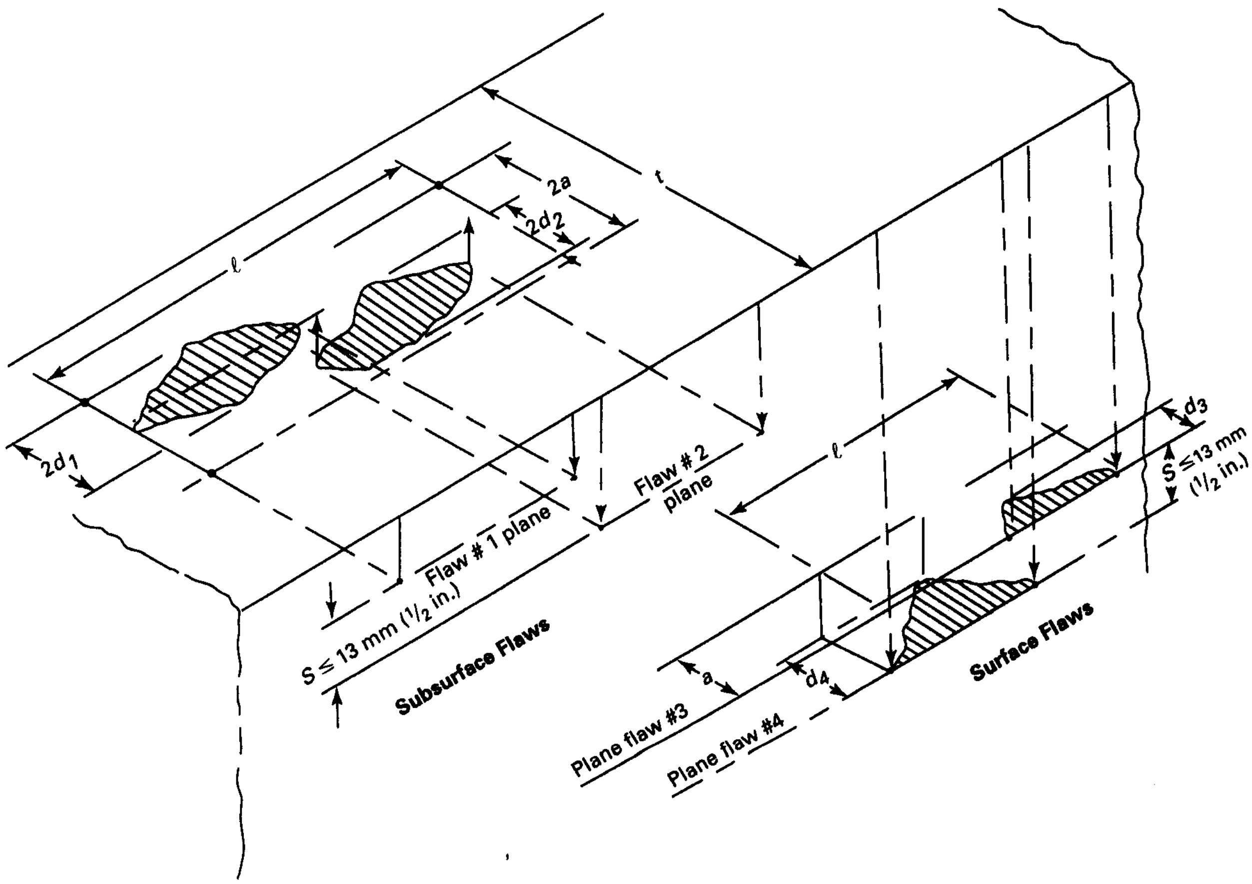


Fig. 4 Nonaligned Coplanar Flaws in Plane Normal to Pressure-Retaining Surface (Illustrative Flaw Configurations)

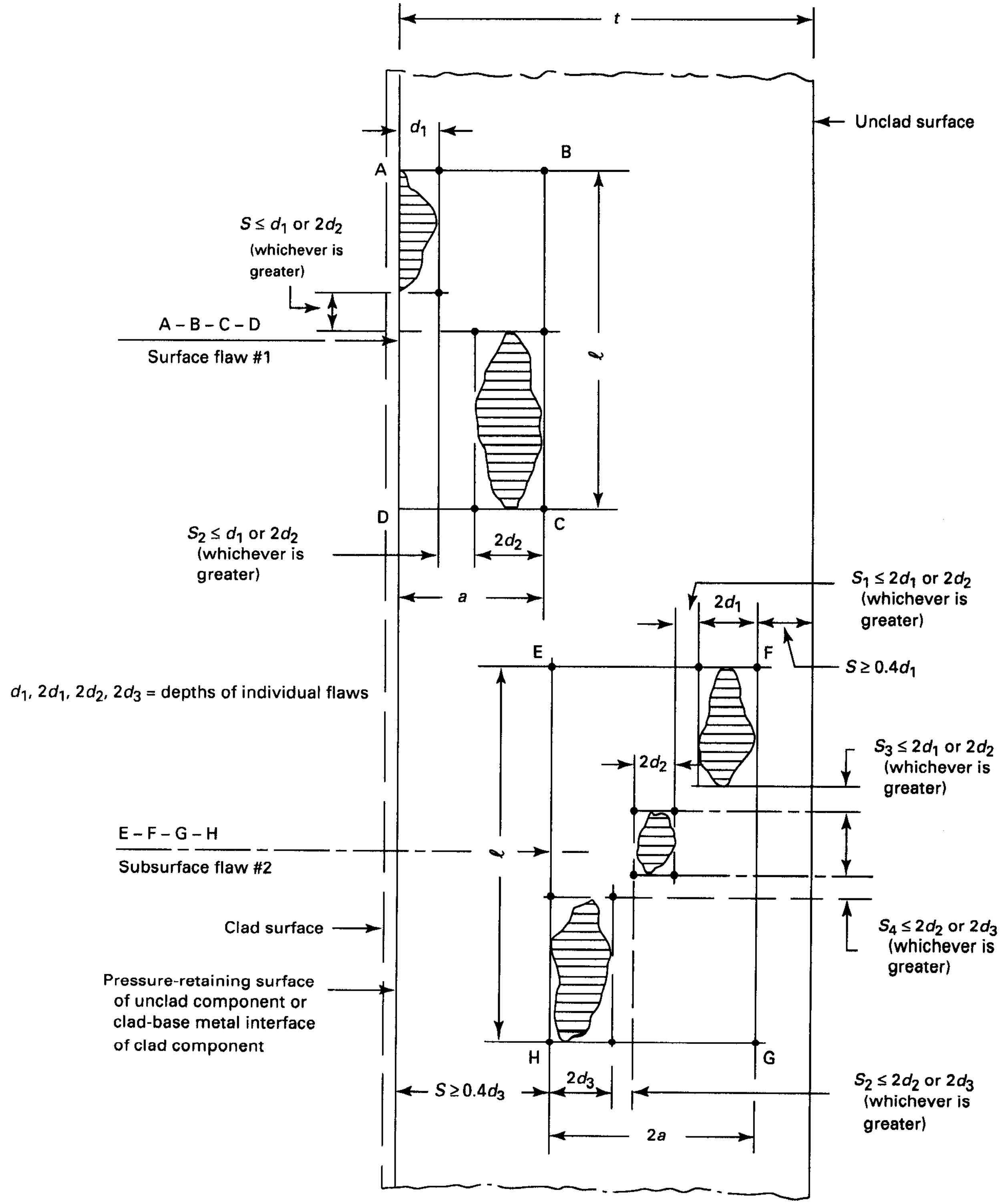
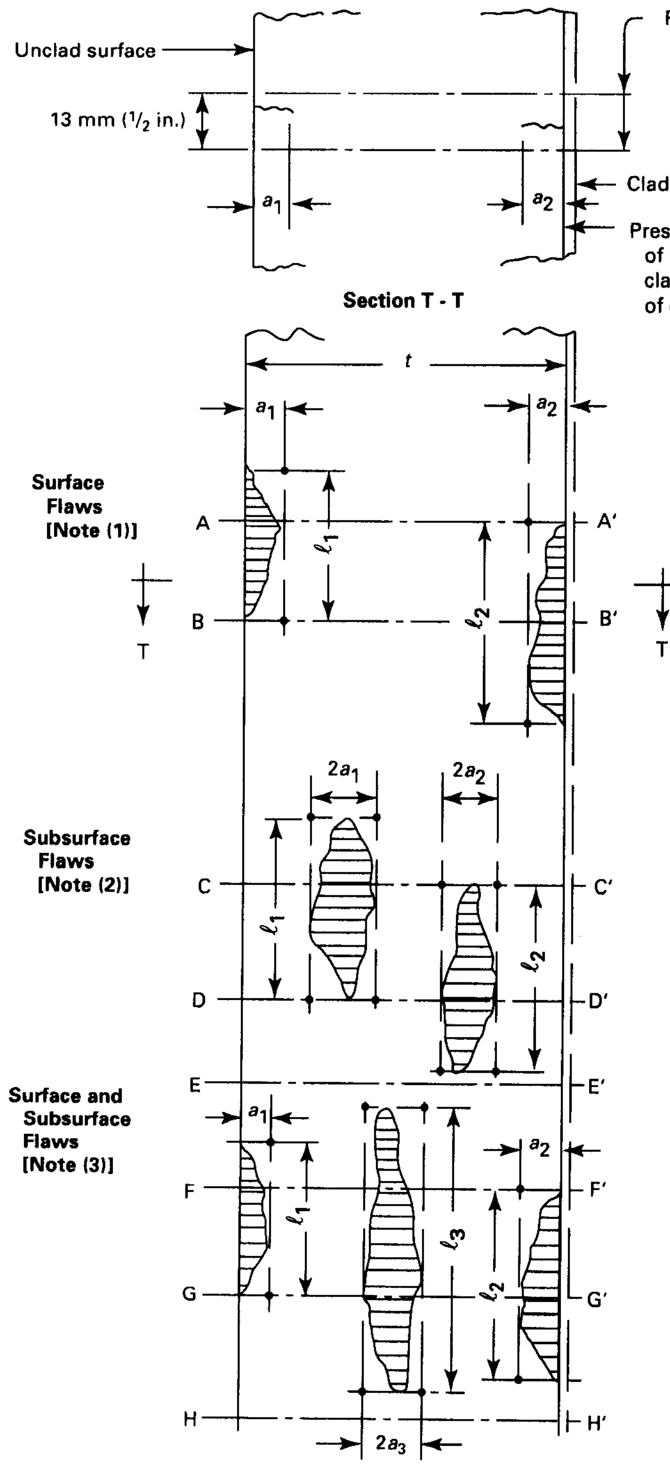


Fig. 5 Multiple Aligned Planar Flaws



GENERAL NOTE: The flaw depth dimensions a_s and a_e are the allowable flaw standards for surface and subsurface flaws, respectively.

NOTES:

(1) This illustration indicates two surface flaws. The first, a_1, is on the outer surface of the component, and the second, a_2, is on the inner surface:
$(a_1 + a_2) \leq (a_s + a'_s)/2$ within planes A-A′ and B-B′

(2) This illustration indicates two subsurface flaws:
$(a_1 + a_2) \leq (a_e + a'_e)/2$ within planes C-C′ and D-D′

(3) This illustration indicates two surface flaws and one subsurface flaw:
- (a) $(a_1 + a_3) \leq (a_s + a'_e)/2$ within planes E–E′ and F-F′
- (b) $(a_1 + a_2) \leq (a_s + a_e + a'_s)/3$ within planes F–F′ and G-G′
- (c) $(a_2 + a_3) \leq (a'_s + a_e)/2$ within planes G–G′ and H-H′

B31 CASE 187
Alternate Postweld Heat Treatment Holding Temperature Range Requirements for P-No. 5A and P-No. 5B Group 1 Materials

ANNULLED

Annulment Date: November 24, 2015

Reason: Requirements incorporated in ASME B31.1 Code.

B31 CASE 188

Minimum Hydrostatic Test Pressure for ASME B31.3, Chapter IX (Para. K345.4.2)

ANNULLED

Annulment Date: February 27, 2015

Reason: Requirements incorporated in ASME B31.3 Code.

Original Inquiry: Under what conditions and limitations may alternative UT acceptance criteria apply in lieu of those described in para. 136.4.6 of ASME B31.1?

When specified by the owner, the ultrasonic examination acceptance criteria included below may be applied for welds in accordance with B31.1 provided the following requirements are met:

1) General/Scope:
   a) The examination shall be conducted using automated or semi-automated techniques utilizing computer based data acquisition.
   b) The examination shall be performed in accordance with a written procedure approved by an NDE Level III and conforming to the requirements of ASME Section V, Article 4 Mandatory Appendix VIII and:
      i) For Phased Array – ASME Section V, Article 4, Mandatory Appendix V
      ii) For Time of Flight Diffraction (TOFD) - ASME Section V, Article 4, Mandatory Appendix III
   c) Procedure qualification shall meet the requirements of ASME Section V, Article 4, Mandatory Appendix IX.
2) Equipment
   a) A mechanical guided scanner capable of maintaining a fixed and consistent search unit position relative to the weld centerline shall be used.
3) Personnel
   a) Set-up and scanning of welds shall be performed by personnel certified as NDE Level II or III (or by Level I personnel under the direct supervision of Level II or Level III personnel).
   b) Interpretation and evaluation of data shall be performed by NDE Level II or III personnel.
   c) Examination personnel shall be qualified and certified following a procedure or program as described in BPV Code, Section V, Article 1, T-120 (e), (f), (h) or (i).
   d) Personnel demonstration requirements shall be as stated in ASME Section V, Article 4 Mandatory Appendix VIII and all additional Owner stipulated demonstration requirements.
4) Examination
   a) The initial straight beam scan for reflectors that could interfere with the angle beam examination shall be performed (a) manually, (b) as part of a previous manufacturing process, or (c) during the weld examination, provided detection of these reflectors is included in the demonstration as required in 1(c) above.
   b) The examination area shall include the volume of the weld, plus the lesser of 25mm (1.0 in.) or *t* of adjacent base metal. Alternatively, the examination volume may be reduced to include the actual heat affected zone (HAZ) plus 6mm (0.25 in.) of base material beyond the heat affected zone on each side of the weld, provided the extent of the weld HAZ is measured and documented.
   c) Scanning may be peformed at reference level provided the procedure qualification was performed at reference level.
5) Data Recording

   Data shall be recorded in the unprocessed form with no thresholding. The data record shall include the complete examination area as specified in (4)(b) above.
6) Data Analysis
   a) Reflectors exceeding the limits below shall be investigated to determine whether the indication originates from a discontinuity or is a geometric indication in accordance with 6(b) below.
      i) For amplitude based techniques, the location, amplitude, and extent of all reflectors that produce a response

greater than 20% of the reference level shall be evaluated.

ii) For non-amplitude based techniques, the location and extent of all images that have an indicated length greater than 4.0mm (0.16 in.) shall be investigated.

b) Ultrasonic indications of geometric and/or metallurgical origin shall be classified as specified in ASME Section V, Article 4 Paragraph T-481.

i) Alternatively, other techniques or NDE methods may be used to classify an indication as geometric (e.g., alternative beam angles, radiography). The method employed is for information only to classify the indication as geometric, and ASME B31.1 requirements for examination techniques are only required to the extent they are applicable.

7) Discontinuity Evaluation

a) The dimension of the discontinuity(s) shall be determined by the rectangle that fully contains the area of the discontinuity(s). (Refer to Fig. 1)

i) The length, ℓ, of the discontinuity shall be drawn parallel to the inside pressure retaining surface of the component.

ii) The height, *h*, of the discontinuity shall be drawn normal to the inside pressure retaining surface of the component.

iii) The discontinuity shall be characterized as a surface or subsurface discontinuity, as shown in Figure 1.

iv) A subsurface indication shall be considered as a surface discontinuity if the separation (*S* in Figure 1) of the indication from the nearest surface of the component is equal to or less than half the through wall dimension (*h* in Figure 1, sketch [b]) of the subsurface indication.

b) Multiple Discontinuities

i) Discontinuous indications that are oriented primarily in parallel planes shall be considered to lie in a single plane if the distance between the adjacent planes is equal to or less than 13mm (0.50 in.) or 0.5t, whichever is less.

ii) If the space between two indications aligned along the axis of weld is less than the height of the indication of greater height, the two discontinuities shall be considered a single discontinuity.

iii) If the space between two indication aligned in the through-thickness dimension is less than the height of the indication of greater height, the two indications shall be considered a single discontinuity.

8) Discontinuity Acceptance Criteria

Discontinuities shall be evaluated using the applicable criteria of Table 1, 2, or 3, with the following additional requirement:

a) Regardless of discontinuity height or aspect ratio, discontinuity length shall not exceed 4*t*.

9) Documentation

a) This Case number shall be referenced in the documentation and marking of the material and recorded on the Manufacturer's Data Report, as applicable.

TABLE 1
Discontinuity Acceptance Criteria for Weld Thickness <25mm (1.0 in.)

	h/t	**ℓ**
Surface discontinuity	≤ 0.100	≤ 6.4 mm (0.25 in.)
Subsurface discontinuity	≤ 0.286	≤ 6.4 mm (0.25 in.)

GENERAL NOTES:

(a) *t* = thickness of the weld excluding any allowable reinforcement. For a butt joint joining two members having different thickness at the joint, *t* is the thinner of the two thicknesses joined. If a full penetration weld includes a fillet weld, the effective throat dimension of the fillet weld shall be included in *t*.

(b) A discontinuity is considered rejectable if its dimensions exceed the *h/t* value or the ℓ value in the Table above.

TABLE 2

Surface Discontinuity Acceptance Criteria for Weld Thickness ≥ 25mm (1.0in.)

Aspect Ratio, h/ℓ	**Weld Thickness**		
	≥ 25mm to 64mm (1.0 in. to 2.5 in.)	*> 64mm to < 100mm (2.5 in. to 3.9 in.)*	*100mm to 300mm (3.9 in. to 11.8 in.)*
	h/t		***h/t***
0.00	≤ 0.031		≤ 0.019
0.05	≤ 0.033		≤ 0.020
0.10	≤ 0.036		≤ 0.022
0.15	≤ 0.041		≤ 0.025
0.20	≤ 0.047		≤ 0.028
0.25	≤ 0.055	***(See Note C)***	≤ 0.033
0.30	≤ 0.064		≤ 0.038
0.35	≤ 0.074		≤ 0.044
0.40	≤ 0.083		≤ 0.050
0.45	≤ 0.085		≤ 0.051
0.50	≤ 0.087		≤ 0.052

General Notes:

(a) *t* = thickness of the weld excluding any allowable reinforcement. For a butt joint joining two members having different thickness at the joint, *t* is the thinner of the two thicknesses joined. If a full penetration weld includes a fillet weld, the effective throat dimension of the fillet weld shall be included in *t*.

(b) Aspect Ratio (*h/ℓ*) used may be determined by rounding the calculated *h/ℓ* down to the nearest 0.05 increment value within the column, or by linear interpolation.

(c) Regardless of discontinuity height or aspect ratio, discontinuity length shall not exceed 4*t*.

(d) For intermediate thickness *t* (weld thicknesses between 64mm and 100mm [2.5 in. and 3.9 in.]) linear interpolation is required to obtain *h/t* values.

TABLE 3

Subsurface Discontinuity Acceptance Criteria for Weld Thickness ≥ 25mm (1.0in.)

Aspect Ratio, h/ℓ	**Weld Thickness**		
	≥ 25mm to 64mm (1.0 in. to 2.5 in.)	*> 64mm to < 100mm (2.5 in. to 3.9 in.)*	*100mm to 300mm (3.9 in. to 11.8 in.)*
	h/t		***h/t***
0.00	≤ 0.068		≤ 0.040
0.10	≤ 0.076		≤ 0.044
0.20	≤ 0.086		≤ 0.050
0.30	≤ 0.098		≤ 0.058
0.40	≤ 0.114		≤ 0.066
0.50	≤ 0.132	***(See Note C)***	≤ 0.076
0.60	≤ 0.156		≤ 0.088
0.70	≤ 0.180		≤ 0.102
0.80	≤ 0.210		≤ 0.116
0.90	≤ 0.246		≤ 0.134
1.00	≤ 0.286		≤ 0.152

General Notes:

(a) *t* = thickness of the weld excluding any allowable reinforcement. For a butt joint joining two members having different thickness at the joint, *t* is the thinner of the two thicknesses joined. If a full penetration weld includes a fillet weld, the effective throat dimension of the fillet weld shall be included in *t*.

b) Aspect Ratio (*h/ℓ*) used may be determined by rounding the calculated *h/ℓ* down to the nearest 0.05 increment value within the column, or by linear interpolation.

c) Regardless of discontinuity height or aspect ratio, discontinuity length shall not exceed 4*t*.

d) For intermediate thickness *t* (weld thicknesses between 64mm and 100mm [2.5 in. and 3.9 in.]) linear interpolation is required to obtain *h/t* values.

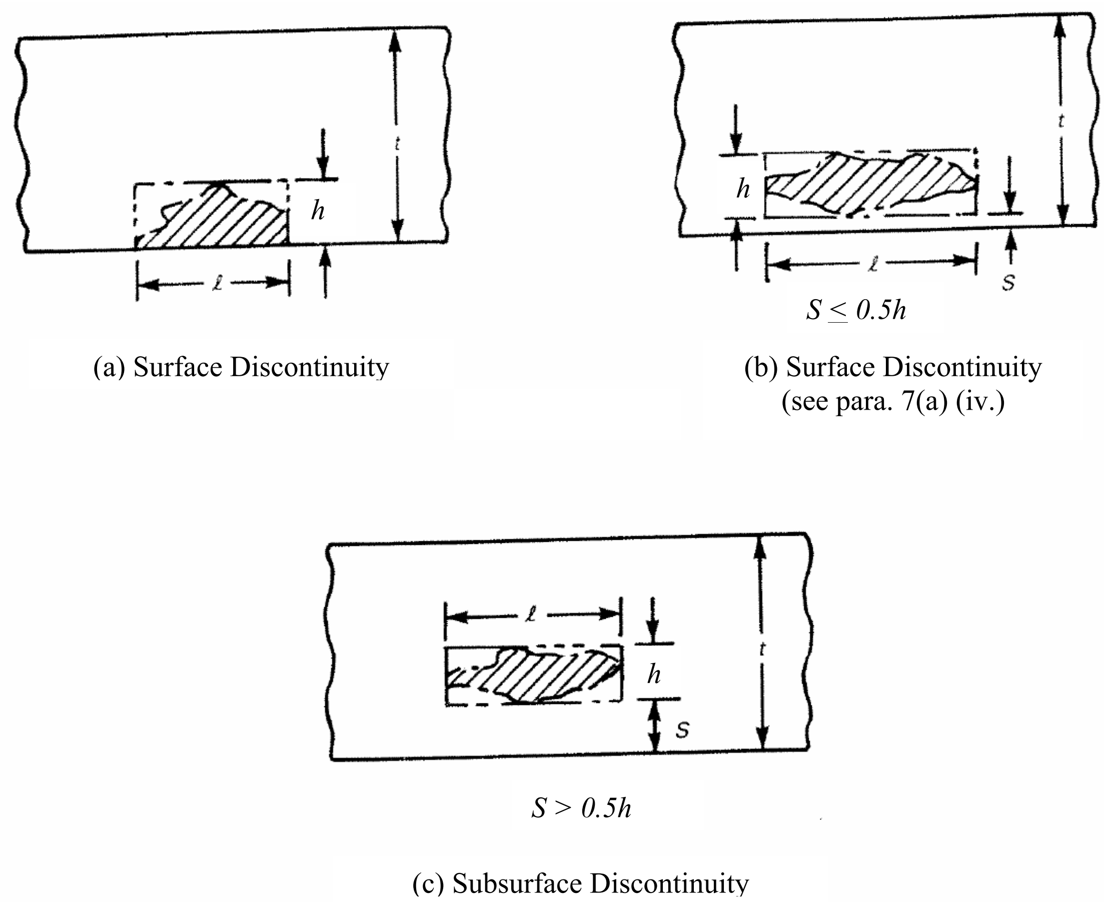


Figure 1: Surface and Subsurface Indications

B31 Case 190-3
Seamless Ni-25Cr-20 Co Material UNS N07740
B31.1
Approval Date: March 16, 2021

Inquiry: May precipitation-hardenable Ni-25Cr-20Co alloy (UNS N07740) ASTM B983-16 seamless pipe and tube; ASTM B637-16 bar, forgings and forging stock; ASTM B1007-17 cold-worked tube; and ASTM B872-19 plate sheet and strip; and fittings material conforming to the chemical requirements shown in Table 1, the mechanical properties listed in Table 2, and otherwise conforming to the applicable requirements in the specification listed in Table 3 be used under ASME B31.1 rules?

Reply: In the opinion of the committee, yes, provided the following additional rules are met:

(a) Material shall be supplied in the solution heat treated and aged condition. ASTM B983-16, ASTM B637-16, ASTM B1007-17 and ASTM B872-19 contain their own heat treatment, however, for the product forms listed in Table 3, the Solution heat treatment shall be performed at 2010°F (1100°C) minimum for 0.5 hr. per 1 in. (25 mm) of thickness, but not less than 5 minutes and water quenched or rapid air cooled. Aging shall be performed at 1400°F to 1500°F (760°C to 816°C) for 4 hours minimum up to 2 inches (50 mm) of thickness, plus an additional 0.5 hour per additional in. (25 mm) of thickness. Aging shall be followed by air cooling.

(b) As an alternative to the delivery conditions of (a), where the material is to be subjected to additional fabrication operations, the material may be supplied in the solution annealed condition provided:

1. The marking shall include the suffix "Y" immediately following the ASTM Specification number and preceding any other suffix. The "Y" suffix shall not be removed until the material specification requirements have been completed and the material test report supplemented;
2. Material supplied in the solution annealed condition shall meet 105 ksi (724 MPa) min. tensile strength, 60 ksi (414 MPa) minimum yield strength and 30% minimum elongation in 2 in. (50mm) or 4D (refers to diameter of the tensile specimen);
3. The material supplier shall carry out the full heat treatment requirements of (a) on a sample from the lot to demonstrate compliance with the delivery conditions of this Code Case; and
4. On completion of all fabrication operations, the entire component shall be heat in accordance with the requirements of (a) to obtain the mechanical properties in Table 2. Local solution annealing is not permitted.

(c) The maximum allowable stress values for the material shall be those given in Tables 4 and 4M.

(d) Separate weld procedure and performance qualifications shall be required. Qualifications shall be performed with material that is first annealed and aged in accordance with (a) above. When welding this alloy to itself, the weld filler metal shall be of matching chemical composition and welding shall be limited to either solid bare wire GTAW or GMAW processes. The welding procedure qualification shall be conducted as prescribed in Section IX except that the guided bend test required by QW-160 may use a 4t minimum bend radius.

(e) Postweld heat treatment for this material is mandatory. The postweld heat treatment shall be performed at 1400°F – 1500°F (760°C – 815°C) for a minimum of 4 hours for thickness up to 2 inches (50 mm), plus an additional 1 hour per additional inch (25 mm) of thickness. If a longitudinal weld seam is required in the construction of a component, a weld strength reduction factor of 0.70 shall apply in accordance with rules in para. and Table 102.4.7 for applications at temperatures above 1112°F (600°C).

(f) Resistance welding may be used to join non-load-bearing attachments to precipitation hardened Ni-25Cr-20Co alloy (UNS N07740). Postweld heat treatment in accordance with (e) is not mandatory for electric resistance welds used to attach extended heat-absorbing fins to pipe and tube products listed in the *Inquiry* above, provided the following requirements are met:

1. The maximum pipe size shall be NPS 4 (DN100); the maximum tube size shall be 4.500 in. (114.3 mm);
2. The maximum fin thickness or other non-load-bearing attachments shall be 0.125 in. (3 mm);
3. Prior to using the welding process, the manufacturer shall demonstrate that the heat-affected zone does not encroach upon the minimum wall thickness; and
4. Fins or other non-load-bearing attachments can be of any austenitic stainless steel.

(g) After cold forming to strains in excess of 5%; after any swages, upsets, or flares; or after any hot forming of this material, the component shall be heat treated in accordance with the requirements specified in (a) above. No local solution annealing may be performed. The entire affected component or part that includes the cold strained area and transition to unstrained material must be included in both heat treatments. Forming strains shall be calculated as listed in ASME-B31.1 2018 Edition paragraph 129.3.4.1. When forming strains cannot be calculated as noted above, the manufacturer shall have the responsibility to determine the maximum forming strain.

(h) The maximum use temperature is 1472°F (800°C).

(i) For the temperature-dependent parameter, *y*, as noted in Table 104.1.2(A) shall be as follows;

(1) 1150°F (621°C) and below: 0.4

(2) 1200°F (649°C): 0.5

(3) above 1200°F (649°C): 0.7

(j) External pressure design is prohibited.

(i) For ASTM B983-16, ASTM B637-16, ASTM B1007-18 and ASTM B872-19 material, this Case number shall appear on the Manufacturer's Data Report. For all other product forms listed in Table 3, this Case number shall appear in the marking and certification for the material and on the Manufacturer's Data Report.

TABLE 1
CHEMICAL REQUIREMENTS

Element	Chemical Composition Limits, %
Chromium	23.5 – 25.5
Cobalt	15.0 – 22.0
Aluminum	0.2 – 2.0
Titanium	0.5 – 2.5
Columbium+Tantalum	0.50 – 2.5
Iron	3.0 max
Carbon	0.005 – 0.08
Manganese	1.0 max
Molybdenum	2.0 max
Silicon	1.0 max
Copper	0.50 max
Phosphorous	0.03 max
Sulfur	0.03 max
Boron	0.0006 – 0.006
Nickel	remainder

TABLE 2
MECHANICAL PROPERTIES REQUIREMENTS

Tensile strength, min., ksi (MPa)	150 (1035)
Yield strength, min., ksi (MPa)	90 (620)
Elongation in 2 in., min., %	20

TABLE 3
SPECIFICATION

Wrought fittings	SB-366

TABLE 4
MAXIMUM ALLOWABLE STRESS VALUES

For Metal Temperature Not Exceeding, °F	Stress Values, ksi [Note (1)]
-20 to 100	42.9
200	42.9
300	42.9
400	42.6
500	41.1
600	40.3
650	40.1
700	40.0
750	40.0
800	40.0
850	40.0
900	40.0
950	40.0
1000	40.0
1050	40.0
1100	39.8
1150	39.1
1200	*33.1*
1250	*26.2*
1300	*20.2*
1350	*15.1*
1400	*10.7*
1450	*6.9*
1500	*3.2 [Note (2)]*

NOTES:

(1) Stress values shown in italics are obtained from time-dependent properties.

(2) The maximum use temperature shall be 1472ºF. Datum for 1500ºF temperature is provided for interpolation purposes.

TABLE 4M
MAXIMUM ALLOWABLE STRESS VALUES

For Metal Temperature Not Exceeding, °C	Stress Values, MPa [Note (1)]
-30 to 40	295
65	295
100	295
150	295
200	294
250	285
300	279
325	277
350	276
375	276
400	276
425	276
450	276
475	276
500	276
525	276
550	276
575	276
600	274
625	269
650	*226*
675	*183*
700	*146*
725	*113*
750	*84.1*
775	*59.1*
800	*34.5*

NOTE:
(1) Stress values shown in italics are obtained from time-dependent properties.

B31 Code Case 191
Cu-13Zn-1.1Ni-Si-Al Alloy Seamless Pipe and Tube
ASME B31.3
Approval Date: January 21, 2015

Inquiry: May precipitation-hardened (Temper Designation TF00) Cu-13Zn-1.1Ni-Si-Al alloy (UNS No. C69100) seamless pipe and tube conforming to the requirements of ASTM B706-00 (R2011) be used under the rules of ASME B31.3?

Reply: Yes, provided:

(a) The maximum allowable stress values for the material shall be those given in Table 1;

(b) Welded and brazed construction is not permitted;

(c) The maximum use temperature shall be 204ºC (400ºF);

(d) Certification to the ASTM B706-00 (R2011) specification requirements shall be mandatory.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Stress, ksi		For Metal Temperature Not Exceeding, °C	Stress, MPa
100	20.0		40	*138*
150	20.0		65	*138*
200	20.0		100	*138*
250	20.0		125	*138*
300	20.0		150	*138*
350	19.9		175	*137*
400	19.5		200	*135*
			225	*132*

Note: The maximum use temperature for this alloy is 204ºC (400ºF). The value listed at 225ºC is provided for interpolation purposes only.

B31 Case 192-1
Approval Date: September 3, 2015
Cu-13Zn-1.1Ni-Si-AI Alloy Seamless Pipe and Tubing
ASME B31.1

Inquiry: May precipitation-hardened Cu-13Zn-1.1Ni-Si-Al alloy (UNS No. C69100), seamless pipe and tubing conforming to the requirements of ASTM B706-00 (reapproved 2011) be used for non-welded construction under the rules of ASME B31.1?

Reply: It is the opinion of the Committee that precipitation-hardened Cu-13Zn-1.1Ni-Si-Al alloy (UNS No. C69100), seamless pipe and tubing conforming to the requirements of ASTM B706-00 may be used for non-welded construction under the rules of ASME B31.1, provided the following additional requirements are met:

(a) The tubing shall be in the precipitation-hardened condition; temper TF00 in B706.
(b) The maximum allowable stress values for the material shall be those given in Table 1. The maximum design temperature shall be 400ºF (204ºC).
(c) This Case number shall be referenced in the documentation and marking of the material and shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Stress, ksi	For Metal Temperature Not Exceeding, °C	Stress, MPa
100	17.1	40	118
150	17.1	65	118
200	17.1	100	118
250	17.1	125	118
300	17.1	150	118
350	17.1	175	118
400	17.1	200	118
		225	117

Note: The maximum use temperature for this alloy is 400°F (204°C); the value listed at 225°C is provided for interpolation purposes only.

Case 193
Approval Date: October 9, 2014
Cu-5.5Zn-4Si Casting Alloy UNS No. C87600
ASME B31.3

Inquiry: May Cu-5.5Zn-4Si Casting Alloy UNS No. C87600 conforming to the requirements of ASTM B584 be used for construction under the rules of ASME B31.3?

Reply: Yes, provided:

(a) The basic allowable stress values for the material shall be those given in Table 1. A Casting Quality Factor, E_c, needs to be applied;
(b) The maximum use temperature shall be 177ºC (350ºF);
(c) Separate weld procedure and performance qualifications shall apply to this material. The welding procedure qualifications shall be in accordance with ASME Section IX.

Table 1
Basic Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Stress, ksi		For Metal Temperature Not Exceeding, °C	Stress, MPa	
100	20.0		40	138	
150	20.0		65	138	
200	20.0		100	138	
250	20.0		125	138	
300	20.0		150	138	
350	20.0		175	138	
			200	137	

Note: The maximum use temperature for this alloy is 177ºC (350ºF):
The value listed at 200ºC is provided for interpolation purposes only.

B31 Case 194
Approval Date: December 2, 2014
ASTM B584 (UNS No. C87600) in ASME B31.1 Construction
ASME B31.1

Inquiry: May silicon bronze alloy UNS No. C87600 casting to ASTM B584 be used for ASME B31.1 Construction?

Reply: Yes, provided the following requirements are met:

(a) This material shall not be used for boiler external piping except where specifically permitted by ASME B&PV I. See Para. 100.1.2(A)

(b) The maximum permissible design temperature shall not exceed 149ºC (300ºF).

(c) Limitations for use of this material for flammable liquids and gases shall be in accordance with paragraphs 122.7, 122.8 and 124.7.

(d) The allowable stress values are shown in Table 1.

(e) This Case number shall be referenced in the documentation and marking of the material.

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Stress, ksi		For Metal Temperature Not Exceeding, °C	Stress, MPa	
100	13.7		40	94.6	
150	13.7		65	94.6	
200	13.7		100	94.6	
250	13.7		125	94.6	
300	13.7		150	94.6	

Note: The maximum use temperature for this alloy is 149ºC (300ºF):
The value listed at 150ºC is provided for interpolation purposes only.

General Note: The casting quality factor of 0.8 is included in the allowable stress value in Table 1.

B31 Case 195
Approval Date: July 23, 2014
Use of UNS S32003 Stainless Steel for ASME ASME B31.1

Inquiry: May ferritic/austenitic duplex stainless steel UNS No. S32003 seamless and welded pipe and tube, and plate, sheet and strip conforming to the requirements of ASTM A240, A789 and A790 as applicable, be used in ASME B31.1 construction?

Reply: It is the opinion of the Committee that the materials described in the Inquiry may be used in ASME B31.1 construction provided that all applicable requirements of ASME B31.1 and the following additional requirements are met:

(a) This material shall not be used for Boiler External Piping. See para. 100.1.2 (A).
(b) The design temperature shall not exceed 650°F (343°C).
(c) The maximum allowable design stress values shall be those listed in Tables 1 or 1M. For welded pipe and tube, a joint efficiency factor of 0.85 shall be used.
(d) Welding procedure and performance qualifications shall be performed in accordance with Section IX of the ASME Boiler and Pressure Vessel Code. The material shall be considered as P-No. 10H.
(e) Heat treatment after welding is neither required nor prohibited. However, if heat treatment is applied, the solution annealed heat treatment shall be as noted in the corresponding specification.
(f) This Case number shall be included in the material documentation and marking of the material.

TABLE 1

MAXIMUM ALLOWABLE STRESS VALUES (U. S. Customary)

For Metal Temperature Not Exceeding, °F	Stress Values, ksi Sheet and Strip ≤0.187 in.	Plate >0.187 in.	Tube	Pipe
100	28.6	27.1	28.6	27.1
200	27.7	26.3	27.7	26.3
300	26.1	24.8	26.1	24.8
400	25.8	24.5	25.8	24.5
500	25.8	24.5	25.8	24.5
600	25.8	24.5	25.8	24.5
650	25.8	24.5	25.8	24.5

TABLE 1M
MAXIMUM ALLOWABLE STRESS VALUES (Metric)

For Metal Temperature Not Exceeding, °C	Stress Values, MPa Sheet and Strip ≤5 mm	Plate >5 mm	Tube	Pipe
40	197	187	197	187
65	197	187	197	187
100	189	180	189	180
150	180	171	180	171
200	178	169	178	169
250	178	169	178	169
300	178	169	178	169
325	178	169	178	169
350 [Note (1)]	178	169	178	169

NOTES:
(1) The value at 350°C is for interpolation only. The maximum use temperature is 343°C.

Precautionary Note: This material may be expected to develop embrittlement after exposure at moderately elevated temperatures. See ASME Boiler and Pressure Vessel Code, Section II, Part D, Nonmandatory Appendix A, Paragraph A-211 Thermal Aging Embrittlement.

B31 Case 196

Ductile Iron Casting UNS No. F33100

ANNULLED

Annulment Date: January 24, 2022

Reason: Incorporated in ASME B31.3-2016 Edition.

B31 Case 197
Approval Date: September 3, 2015
Grade 1 Ni-Cr-Mo-Cb alloy (UNS N06625)
ASME B31.1

Inquiry: May annealed Grade 1 Ni-Cr-Mo-Cb alloy (UNS N06625) seamless pipe and tube (SB-444); welded pipe (SB-705); welded tube (SB-704); plate, sheet, strip (SB-443); rod and bar (SB-446); and forgings (SB-564) be used in water wetted Boiler External Piping (BEP) welded construction for temperatures up to 1100°F (593°C).

Reply: Yes, providing the following requirements are met:

(a) The maximum allowable stress shall be as listed in Tables 1 and 1M and Tables 2 and 2M.
(b) Welding procedures and performance qualifications shall be conducted as prescribed in ASME Section IX.
(c) The value of y for this material [see Table 104.1.2(A)] shall be 0.4 for all temperatures.
(d) For plate, sheet, strip, bar and forgings, the minimum tensile strength of reduced tension specimens in accordance with QW-462.1 of ASME Section IX shall not be less than 110,000 psi (758 MPa)
(e) All other requirements of ASME B31.1 shall be followed.
(f) When utilized for Boiler External Piping, this Case number shall be shown on the Manufacturer's Data Report.
(g) This Case number shall be shown in the material certification and marking of the material.

NOTE: Alloy UNS N06625 is subject to severe loss of impact strength at room temperature after exposure in the range of 1000°F to 1400°F (538°C to 760°C).

CAUTIONARY NOTE: Austenitic alloys are subject to stress corrosion cracking, intergranular attack, pitting and crevice corrosion when used in boiler applications in aqueous environments. Factors that affect the susceptibility of these materials are applied or residual stress, water chemistry and deposition of solids, and material condition. Susceptibility to attack is enhanced when the material is used in a sensitized condition or with residual cold work. Concentration of corrosive agents (e.g., chlorides, caustic, or reduced sulfur species) can occur under deposits formed on the surface of these materials, and can result in severe underdeposit wastage or cracking. For successful operation in water environments, careful attention must be paid to continuous control of water chemistry.

TABLE 1
MAXIMUM ALLOWABLE STRESS VALUES FOR SEAMLESS PIPE AND TUBE, PLATE, SHEET, STRIP, BARS, RODS, SHAPES AND FORGINGS

For Metal Temperature Not Exceeding,° F	Values, ksi
-20 to 100	34.3
200	34.3
300	34.3
400	33.6
500	32.9
600	32.4
650	32.1
700	31.8
750	31.5
800	31.2
850	30.9
900	30.6
950	30.3
1000	29.9
1050	29.5
1100	29.0

TABLE 1M
MAXIMUM ALLOWABLE STRESS VALUES FOR SEAMLESS PIPE AND TUBE, PLATE, SHEET, STRIP, BARS, RODS, SHAPES AND FORGINGS

For Metal Temperature Not Exceeding, °C	Values, MPa
-30 to 40	236
65	236
100	236
125	236
150	236
175	234
200	232
225	230
250	228
275	226
300	224
325	222
350	221
375	219
400	217
425	215
450	213
475	212
500	210
525	207
550	205
575	202
600 [Note1]	192

Note 1: The value at 600°C is given for interpolation only; the maximum use temperature is 593°C

TABLE 2
MAXIMUM ALLOWABLE STRESS VALUES FOR WELDED PIPE AND TUBE

For Metal Temperature Not Exceeding, °F	Values, ksi
-20 to 100	29.1
200	29.1
300	29.1
400	28.5
500	28.0
600	27.5
650	27.3
700	27.0
750	26.8
800	26.5
850	26.3
900	26.0
950	25.7
1000	25.4
1050	25.1
1100	24.7

TABLE 2M
MAXIMUM ALLOWABLE STRESS VALUES FOR WELDED PIPE AND TUBE

For Metal Temperature Not Exceeding, °C	Values, MPa
-30 to 40	201
65	201
100	201
125	201
150	201
175	199
200	197
225	196
250	194
275	192
300	190
325	189
350	188
375	186
400	184
425	183
450	181
475	180
500	179
525	176
550	174
575	172
600 [Note 1]	163

Note 1: The value at 600°C is given for interpolation only; the maximum use temperature is 593°C

B31 Case 198
Approval Date: January 21, 2015
Grade 91 Steel-- 9%Cr-1%Mo (K90901)
ASME B31.1

Inquiry: May normalized and tempered UNS K90901 material that meets the specification requirements of ASTM A989 / A989M-13 for hot isostatically-pressed alloy steel powder metallurgy parts for high temperature service be used for ASME B31.1 components for welded construction?

Reply: Yes, provided the following additional requirements are met:

(a) For purposes of welding procedure and performance qualification, this material shall be considered P-No. 15E Group 1.

(b) The material shall be normalized within the temperature range of 1900°F to 1975°F (1040°C to 1080°C), followed by air or accelerated cooling, and tempered within the range of 1350°F to 1470°F (730°C to 800°C).

(c) The maximum allowable stress values for the material shall be those given in Tables 1/1M

(d) The maximum design temperature is 1200°F (649°C). Temperature excursions as permitted with ASME B31.1-2014 paragraph 102.2.4 are not permitted.

(e) The maximum allowable powder size is 0.019 in (0.5 mm) and the powder shall be produced by the gas atomization process.

(f) Following atomization, powders shall be stored under a positive nitrogen or argon atmosphere to minimize potential oxidation or contamination.

(g) In addition to a chemical composition analysis of the final blend powder, an analysis of a sample (component or compact) from each lot of parts shall be required.

(h) The material shall be examined using either the magnetic particle or liquid penetrant inspection method in accordance with ASTM A989/A989 M 13, Supplementary Requirements S4—Magnetic Particle Examination or S5—Liquid Penetrant Examination.

(i) Weld repairs to the material shall be made with one of the following welding processes and consumables:

1. SMAW: A5.5/A5.5M or SFA-5.5/SFA-5.5M E90XX-B9
2. SAW: A5.23/A5.23M or SFA-5.23/SFA-5.23M EB9 + neutral flux
3. GTAW: A5.28/A5.28M or SFA-5.28/SFA-5.28M ER90S-B9
4. FCAW: A5.29/A5.29M or SFA-5.29/SFA-5.29M E91T1-B9

In addition, the Ni + Mn content of all welding consumables shall not exceed 1.0%. (See ASME Section I-2013, Table PW-39-5, NOTE 3 for further explanation.)

(j) Weld repairs to the material as a part of the original manufacture shall be made with welding procedures and welders qualified in accordance with Section IX.

(k) Repair by welding shall not exceed 10% of the part surface area and 33-1/3% of wall thickness of the finished part or 3/8 in. (9.5 mm), whichever is less, without prior approval of the purchaser.

(l) After any repair welding, the welded area shall be ground smooth to the original contour and shall be free of defects as verified by magnetic particle or liquid penetrant inspections.

(m) If during the manufacturing any portion of the component is heated to a temperature greater than 1470°F (800°C), then the component shall berenormalized and retempered in its entirety in accordance with (b) above.

(n) For external pressure design, Figure CS-3 and Table CS-3 of Section II, Part D shall be used.

(o) Physical properties can be found in Table B-1 of ASME B31.1-2014.

(p) The Code Case number shall be shown on the Manufacturer’s Data Report when used for boiler external piping (BEP).

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding , °F	Maximum Allowable Stress Values, ksi
-20 to 100	24.3
200	24.3
300	24.3
400	24.2
500	24.1
600	23.7
650	23.4
700	22.9
750	22.2
800	21.3
850	20.3
900	19.1
950	17.8
1,000	16.3
1,050	14.0 [Note(1)]
1,100	10.3 [Note(1)]
1,150	7.0 [Note(1)]
1,200	4.3 [Note(1)]

Note:
(1) These stress values are obtained from time dependent properties

Table 1M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Maximum Allowable Stress Values, MPa
-30 to 40	168
65	168
100	168
125	168
150	168
200	167
250	166
300	164
325	163
350	161
375	157
400	153
425	147
450	141
475	134
500	126
525	117
550	107
575	88.5 [Note(1)]
600	65.0 [Note(1)]
625	45.5 [Note(1)]
650	28.9 [Note(1), (2)]

Note:
(1) These stress values are obtained from time dependent properties
(2) The maximum use temperature shall be 649°C. Datum for 650°C temperature is provided for interpolation purposes

B31 Case 199-2

Approval Date: October 10, 2023

ASTM A351 Grade HG10MnN, UNS J92604

ASME B31.1

Inquiry: May austenitic stainless steel castings conforming to ASTM A351 Grade HG10MnN (UNS J92604) be used in welded and non-welded construction under ASME B31.1?

Reply: In the opinion of the committee, yes, provided the following additional requirements to the published ASME B31.1 Code book are met:

a) The physical properties for UNS J92604 are found in ASME BPVC or ASME B31.1 as follows:
   1. Thermal Expansion properties shall be taken from austenitic stainless steels in ASME B31.1 Table B-1;
   2. Thermal Conductivity and Thermal Diffusivity shall be taken from Material Group K in Table TCD of ASME Section II Part D;
   3. Elastic Moduli shall be taken from austenitic stainless steels in ASME B31.1 Table C-1;
   4. Poisson's Ratio and Density Values shall be the same as shown for high alloy steels (300-Series) in Table PRD of ASME Section II Part D.

b. The maximum allowable stress values for the material shall be those given in Tables 1 and 1M. The maximum design temperature shall be 1500°F (816°C). A casting quality factor in accordance with paragraph 102.4.6 shall be applied to these allowable stresses.

c. The casting shall be inspected in accordance with the requirements of Supplementary Requirements S5 of ASTM A351 (Radiographic Inspection).

d. The casting shall not require any additional heat treatment.

e. Separate welding procedure qualifications conducted in accordance with ASME Section IX shall be required for this material. For the purposes of performance qualification, the material shall be considered P-No.8 material.

f. Weld repairs to castings or cast pipe shall be made with the following welding process and consumable:
   1) Welding Process – SMAW
      a. Specification - A5.11/A5.11M
      b. AWS Classification - ENiCrCoMo-1
      c. UNS Number - W86117
   2) Welding Process – GMAW and GTAW
      a. Specification - A5.14/A5.14M
      b. AWS Classification – ERNiCrCoMo-1
      c. UNS Number – N06617

g. Weld repairs to castings as part of materials manufacture shall be made following welding procedures and welders qualified in accordance with ASME Section IX.

h. All weld repairs shall be recorded with respect to their location on the casting. Supplementary Requirement S12 of ASTM A703 shall apply. For weld repairs performed as part of materials manufacture, the documentation shall be included with the Materials Test Report. For weld repairs performed by the Manufacturer, documentation shall be included with the Manufacturer's Data Report.

i. Postweld heat treatment is neither required nor prohibited

j. A manufacturer's test report meeting certification requirements of ASTM A703 shall be provided.

k. This Case number shall be shown in the material certification and marking of the material.

l. This Case number shall be shown on the Manufacturer's Data Report.

TABLE 1 -
MAXIMUM ALLOWABLE STRESS VALUES

For Metal	Allowable Stress Values,	Allowable Stress Values,
Temperature	Max., ksi	Max., ksi
Not Exceeding, °F		
100	21.7	21.7
200	17.7	21.7 (1)
300	15.5	20.8 (1)
400	14.1	19.1 (1)
500	13.2	17.9 (1)
600	12.6	17.0 (1)
650	12.4	16.7 (1)
700	12.2	16.5 (1)
750	12.0	16.2 (1)
800	11.9	16.0 (1)
850	11.7	15.8 (1)
900	11.6	15.6 (1)
950	11.5	15.5 (1)
1000	11.3	15.3 (1)
1050	11.2	15.2 (1)
1100	11.1	15.0 (1)
1150	11.1	12.5 (2)
1200	10.0 (2)	10.0 (2)
1250	7.8 (2)	7.8 (2)
1300	6.0 (2)	6.0 (2)
1350	4.5 (2)	4.5 (2)
1400	3.3 (2)	3.3 (2)
1450	2.2 (2)	2.2 (2)
1500	1.4 (2)	1.4 (2)

NOTES:

(1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of this alloy where slightly greater deformation is acceptable. These higher stress values exceed 66 2/3% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for applications where slight amounts of distortion can cause leakage or malfunction.

(2) Time-dependent values

TABLE 1M -
MAXIMUM ALLOWABLE STRESS VALUES

For Metal	Allowable Stress Values	Allowable Stress Values
Temperature	Max., MPa	Max., MPa
Not Exceeding, °C		
40	150	150
65	132	150 (1)
100	120	150 (1)
150	107	143 (1)
200	98	133 (1)
250	92	124 (1)
300	88	119 (1)
325	86	117 (1)
350	85	115 (1)
375	84	113 (1)
400	83	112 (1)
425	82	111 (1)
450	81	109 (1)
475	80	108 (1)
500	79	107 (1)
525	79	106 (1)
550	78	105 (1)
575	77	104 (1)
600	77	102 (2)
625	76	84 (2)
650	68 (2)	68 (2)
675	55 (2)	55 (2)
700	43 (2)	43 (2)
725	34 (2)	34 (2)
750	25 (2)	25 (2)
775	19 (2)	19 (2)
800	13 (2)	13 (2)
825	7.9 (3)	7.9 (3)

NOTES:

(1) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of this alloy where slightly greater deformation is acceptable. These higher stress values exceed 66 2/3% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for applications where slight amounts of distortion can cause leakage or malfunction.

(2) Time-dependent Values

(3) These values are provided at 825°C for interpolation use only. The maximum use temperature is 816°C

B31 Case 200
Approval Date: October 31, 2016
Composite Piping for Hydrogen Service
ASME B31.12 Hydrogen Piping

Inquiry: Under what conditions may composite piping be used in gaseous hydrogen service in accordance with the requirements of B31.12?

Reply: It is the opinion of the Committee that composite piping may be used in gaseous hydrogen service provided all of the following additional requirements are met:

1. Scope

1.1. Product Form

This piping product form consists of a nonmetallic, multi-layer system, capable of being made in long continuous lengths and can be

1. Manufactured, spooled for transportation, and installed on site or
2. Manufactured and installed on site.

This product form incorporates a nonmetallic liner that provides the leakage boundary. Fiber reinforcement is placed, over the nonmetallic liner, which is the structural layer that provides pressure integrity and resists applied external loads. An external protective layer is provided to protect the structural layer from damage.

Two types of piping are addressed by this Code Case. Both of these types are spoolable composite piping. The thermosetting composite piping shall meet the requirements of ASTM D2996. The thermoplastic composite piping shall meet the requirements of ASTM F2896. Both piping types shall comply with the requirements of API 15HR and API 15S where applicable in addition to the requirements of this Code Case.

The composite piping shall not have any outlets except at the manufacturer's supplied metallic fittings.

The application of the piping defined in this Code Case is allowed for both Industrial Piping (Part IP) and Pipelines (Part PL).

1.2. Service Limitations

1.2.1. The manufacturer's pressure rating of the pipe shall not exceed 2500 psi (17 MPa).

1.2.2. The maximum material usage temperature of the piping shall not be warmer than the lesser of 140°F (60°C) or 35°F (19°C) colder than the maximum material usage temperature or glass transition temperature of any material used in the layer system. The minimum material usage temperature of the piping shall not be colder than -20ºF (–29ºC).

1.2.3. The design life shall be limited to fifty (50) years from the date of manufacture. The pipe shall be marked with the date of manufacture in accordance with the requirement of API 15HR.

1.2.4. Non-metallic piping in hydrogen service is restricted to underground service. Risers for underground sections of composite piping shall be metallic.

2. Code and Standards Referenced

ASME

2.1. Boiler and Pressure Vessel Code, Section V, Nondestructive Examination, 2015

2.2. Boiler and Pressure Vessel Code, Section IX, Welding Brazing and Fusing Qualifications, 2015

ASTM

2.3. D1598-2009, *Test Method for Time-To-Failure of Plastic Pipe under Constant Internal Pressure*

2.4. D1599-2014, *Test Method for Resistance to Short-Time Hydraulic Pressure of Plastic Pipe, Tubing, and Fittings*

2.5. D2412-2011, *Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading*

2.6. D2657-2007, *Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings*

2.7. D2774-2012, *Standard Practice for Underground Installation of Thermoplastic Pressure Piping*

2.8. D2992-2012, *Practice for Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings*

2.9. D2996-2015 Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe

2.10. D3839-2014, *Standard Guide for Underground Installation of "Fiberglass" (Glass-Fiber Reinforced Thermosetting-Resin) Pipe*

2.11. D3350-2014, *Specification for Polyethylene Pipe and Fittings Materials*

2.12. F1668-2008, *Standard Guide for Construction Procedures for Buried Plastic Pipe*

2.13. F2619-2013, *Standard Specification for High-Density Polyethylene (PE) Line Pipe*

2.14. F2896-2011, *Standard Specification for Reinforced Polyethylene Composite Pipe For The Transport Of Oil And Gas And Hazardous Liquids*

API

2.15. *Specification* 15HR, *High Pressure Fiberglass Line Pipe,* 2001

2.16. Recommended Practice 15S, *Qualification of Spoolable Reinforced Plastic Line Pipe,* 2006

3. Materials

3.1. Material Identification All materials used in the manufacture of the piping shall be traceable to material test reports or certificates of compliance.

3.2. Reinforcement

3.2.1. Glass, aramid, and polyester reinforcements are acceptable for the piping product. Additional material as allowed by API 15S are allowed if agreed to by the owner.

3.2.2. The reinforcement material supplier shall certify that the reinforcement conforms to the manufacturer's specifications for the product.

3.3. Resin System

3.3.1. When a resin system is used, the resin system shall consist of epoxy, polyester, or vinyl ester plus the resin manufacturer's recommended promoters and curing agents. No filler, pigment, thixotrope, or dye that will interfere with the natural color of the resin shall be used except as permitted by the resin manufacturer.

3.3.2. The resin system material supplier shall certify that the resin conforms to the manufacturer's specifications for the product.

3.4. Liner material

3.4.1. The liner shall be manufactured from a High Density Polyethylene (HDPE) meeting ASTM D3350 density cell classification 4 or higher. When standard High Density Polyethylene Pipe is used as the liner, it shall be specified to ASTM F2619.

3.4.2. The liner material supplier shall certify that each batch of liners has the specified material chemistry and mechanical properties and conforms to the manufacturer's specifications for the product.

3.4.3. When requested by the owner, the pipe manufacturer shall provide the liner permeability rates.

3.4.4. Fusion joints in the HDPE liner may be used. The location of all fusion joints shall be recorded by the manufacturer and provided to the owner.

3.5. Metallic Parts (End Fitting and Coupling Components)

3.5.1. Metallic components and fittings used in construction shall meet the requirements of ASME B31.12 and recognized good engineering practices to withstand all specified loadings without failure, impairment of their serviceability, or leakage detectable by the code required test. When manufacture's supplied fittings are used that do not meet listed standards they shall be qualified as unlisted components in accordance with IP-3.8.2 for Industrial Piping or PL-2.2.5 for Pipelines.

3.5.2. All required elastomer seals used in metallic end-fittings and couplings shall be specified by the piping manufacturer. The piping manufacturer shall specify the required material, the seal dimensions, and the required durometer hardness for any elastomer seals.

3.5.3. At all joints connecting the composite piping and metallic fitting and components, the manufacturer of the composite piping shall also supply the metallic fitting and components. Mixing of different manufacturers' products is not allowed.

4. Design

4.1. Design Basis The hydrostatic design basis for the composite piping sections shall be in accordance with ASTM D2992.

4.2. Design Pressure

4.2.1. The design pressure of Industrial Piping (Part IP) shall not exceed the maximum pressure rating (MPR) of the composite section of the piping as defined by API 15S (Section 5.3) for nonmetallic reinforced pipe.

4.2.2. The maximum allowable operating pressure (MAOP) for Pipelines (Part PL) shall not exceed the maximum pressure rating (MPR) of the composite section of the piping as defined by API 15S (Section 5.1.4) for nonmetallic reinforced pipe multiplied by the design factor (F) as defined in B31.12, Option B, Tables PL 3.7.1-2.

4.2.3. In evaluation of the MAOP for location class changes as prescribed in paragraph PL-3.6, Option B shall be used when evaluating changes to location class using Table PL-3.6.1 for composite piping sections. The value of S_m for the composite piping shall not exceed the maximum pressure rating (MPR) of the composite section of the piping as defined by API 15S (Section 5.1.4).

4.3. Structural Layer

4.3.1. The qualification testing required in Section 7 substantiates the design of the structural layer.

4.3.2. Re-qualification shall be required when the piping manufacturer makes changes to the materials or manufacturing process for the product. The changes to the material and manufacturing process described in Table 4.1 shall be accompanied by a technical justification of the effect of the change, together with partial requalification according to Section 12 of ASTM D2992. Failure to pass the test defined in Section 12 of ASTM D2992 shall require full qualification in accordance with Section 7.

4.3.3. Changes not described in Table 4.1 shall be subject to full qualification in accordance with Section 7.

4.3.4. All qualification or re-qualification shall be approved by the owner prior to installation of the piping.

4.4. Protective Layer An external layer shall be provided to protect the structural layer from damage due to impact, ultraviolet radiation, or other environmental exposure or abrasive conditions, and in-service degradation for the life of the piping under the service conditions.

Table 4.1 System Variable Changes Acceptable with Technical Justification and for Partial Requalification

Pipe System Element	Variable
Reinforcement Material	Reinforcement manufacturer Grade and specification Filament diameter Tow size / configuration
Resin	Resin manufacturer Resin Grade Curing system manufacturer Curing system grade Glass transition temperature Maximum use Temperature
Adhesive	Adhesive manufacturer Adhesive grade Maximum use Temperature
Joint Sealing Element	Manufacturer Grade and specification Durometer hardness Seal dimensions
Manufacturing	Cure temperature and time schedule Reinforcement angle Reinforcement Stacking sequence Transfer of manufacturing from one plant to another.

5. Fabrication

5.1. Manufacturing Specification

5.1.1. The manufacturing specification shall specify all pertinent material properties data, the process by which the structural layer is applied to the liner, and all other significant process data associated with the product design. The Manufacturing Specification shall include tolerance limits for all appropriate material properties, process conditions such as time and temperature, acceptable test result values, compositions of resins, reinforcement, and curing agents, etc.

5.1.2. The manufacturing specification shall address the degree of cure for the laminate. The degree of cure for the piping shall be determined by differential scanning calorimetry and shall meet the requirements of API 15 HR.

5.1.3. The manufacturing specification shall be available to the owner's Inspector for review.

5.2. Fusion Joints All fusion joints in the liner shall meet the requirements of ASME Section IX, Part QF.

5.3. Installation Requirements

5.3.1. The piping manufacturer shall specify the installation requirements for the piping product. The requirements in ASTM D3839, ASTM D2774, and ASTM F1668 shall be followed where applicable.

5.3.2. The cover, clearance, and casing requirements shall be in accordance with B31.12 Paragraph PL-3.7.3.

5.3.3. The requirements of PL-3.7.3 (d) (1) for providing physical barriers and markers are required for composite piping.

5.3.4. A means to locate the composite piping (e.g. a copper wire) shall be provided during installation of all buried piping.

5.3.5. The piping manufacturer shall specify an assembly procedure for all end-fittings and couplings connected to the plastic piping. The manufacturer shall identify all essential variables required to be controlled during assembly of the joint and provide an acceptable range for the essential variables. The manufacturer shall also provide the training requirements for assemblers.

6. Examination

6.1. Manufacturing Examination Requirements The manufacturer of the piping shall be responsible for conducting the examinations required by paragraph 6.1 - 6.6 and the B31.12 Code during the manufacturing process. The piping shall be examined as required during winding, or prior to application of the protective layer to ensure that there are no unacceptable imperfections or defects.

6.2. Qualification of Nondestructive Testing Personnel The manufacturer shall certify that each examiner performing visual examinations has been qualified to the requirements of Section V, Article 9.

6.3. Visual Examination The piping shall be visually examined, using a suitable light source, to determine whether there are any imperfections of the type specified in Table 6.1.

6.4. Design Dimensions Examination The piping shall be examined for conformance with dimensions and tolerances as required in the design. Visual evidence of variation in thickness shall be evaluated and the thickness shall be verified to meet the minimum required thickness by the design. Thickness less than the value specified by the design shall not be permitted.

6.5. Degree of Cure When laminates are used, examination for the degree of cure for all piping shall be determined by differential scanning calorimetry and examined to the requirements of API 15 HR.

6.6. Fusion Joints The piping manufacturer shall perform 100% visual examination of all fusion joints. The acceptance criteria for the visual examinations are provided in Table 6.2.

6.7. Installation Examination Requirements The installer of the piping system shall be responsible for conducting the supplemental examinations in paragraphs 6.8-6.9 in addition to the examinations required by the B31.12 Code.

6.8. End Fitting and Coupling Components

6.8.1. The assembly of all end-fittings and couplings to the piping shall receive 100% visual examination. The examiner shall witness the assembly process and verify each joint is assembled properly.

6.8.2. Any elastomer used to form a seal for the end-fittings and couplings shall receive 100% visual examination by the examiner to verify that the material, dimensions, and durometer hardness of the elastomer meet the specified requirements.

6.9. Final Visual Examination All piping shall have a final visual examination after construction and prior to being buried. No defects that exceed 20% of the wall thickness of the protective layer are allowed. Defects that exceed 20% of the wall thickness of the protective layer may be repaired. The method of repair shall be approved by the owner. No defect is allowed that cuts the structural layer.

Table 6.1 Imperfection Acceptance Criteria

Imperfection	Description	Criteria
Burn	Thermal decomposition evidenced by distortion or discoloration of the surface.	None permitted that affect the structural layer.
Chip	Small piece broken from edge or surface.	Permitted if structural layer has not been fractured.
Crazing	Fine cracks at or under the surface as seen by the unaided eye.	None permitted.
Cut Fiber	Broken or cut fiber in the structural layer	None permitted.
Dry Spot	Area where reinforcement was not thoroughly wet with resin	None permitted
Fracture	Rupture of structural layer without complete penetration. Visible as lighter colored area of layer separation.	None permitted
Pits (pinholes)	Small craters in the surface	Maximum 1/16 in. (1.5 mm) deep, no limit on number.
Resin Drip	Resin protrusion	Maximum 1/8 in. (3 mm) high, no limit on number
Restriction	Any restriction: foreign material in I.D. of pipe.	None permitted
Scratch	Shallow mark caused by improper handling.	No limit on number if the structural layer is not exposed. If reinforcement is exposed, use cut fiber criterion
Inclusions	Foreign material into structural layer	None Permitted

Table 6.2 Acceptance Criteria for Butt Fusion Joints

Type of Defect	Criteria
Cracks	None Permitted
Unfilled areas in joint	None Permitted
Unbonded areas in joint	None Permitted

Protrusion of fused material into pipe bore	≤25 % of pipe wall thickness
Angular misalignment	None Permitted
Outside diameter mismatch	<10% of pipe wall thickness

7. Testing

7.1. Installation Leak Test All piping shall be tested after construction and before being placed in operation. The test fluid shall be by agreement between the piping manufacturer and the owner. The minimum test pressure shall be in accordance with ASME B 31.12 IP10.6 for Industrial Piping or PL-3.10 for Pipelines. The details of the leak test procedure shall be by agreement between the owner and the manufacturer.

7.2. Pipe Qualification Test Requirements The pressure rating of the piping shall be determined using the qualification methodology specified in API 15S Paragraph 5.0 with the following supplemental requirements.

1. Field end fittings (API 15S Paragraph 5.1.2.1 & 5.2.2T) are required for all short term and long term pressure qualification testing.
2. Fatigue testing (API 15S Paragraph 5.1.5.1) shall be completed using the procedure described below. Fatigue testing is not required if the fatigue loading spectra is less than 200 equivalent full pressure cycles.
3. The fluid service factor (API 15S Paragraph 5.1.5.2) for hydrogen shall be 0.67.
4. The leak test described below shall be substituted for the Gas and Multiphase Service test (API 15S Paragraph 5.3.1).
5. Re-Qualification (API 15S Paragraph 5.4) shall follow the requirement in the design section above.

7.3. Fatigue Testing

7.3.1. Procedure

1. Multiple test samples shall be subjected to pressure cycle testing with a minimum test pressure equal to the maximum operating pressure of the piping.
2. The test specimen shall be subjected to the required number of pressure cycles (N) as calculated using Equation 1 below or until failure occurs.
3. The test media shall be specified by the piping manufacturer. Either hydraulic testing using water, pneumatic testing using air, or an inert gas is acceptable. Testing in hydrogen gas is not required.
4. If not specified by the Owner, the cyclic test shall be carried out using an R ratio of 0.1. If a fatigue loading spectra is specified by the owner, a minimum of 20% of the cycles shall be at an R ratio of 0.1.
5. The total number of required test cycles is a function of the number of tests being performed as shown in Table 7.1 below.
6. The frequency of pressure reversals shall not exceed 2 cycles/min.

7. The length of the test samples shall be a minimum of 5 times the nominal diameter ($D_{nominal}$) for piping with $D_{nominal} \leq 6$" (150mm) and. 3 times the nominal diameter for piping with $D_{nominal} > 6$" (150mm).
8. The test samples shall contain field end fittings. At the owner's option a coupling shall be included in the fatigue test sample.
9. The temperature on the outside surface of the piping shall not exceed 100°F (38°C) during the test.

$N = K_n$ X Service Life (years) X C **Equation 1**

Table 7.1 Fatigue Design Margin vs Fatigue Samples

n	2	3	4	5
K_n	4	3.5	3	2.6

7.3.2 Nomenclature

N = required test cycles
K_n = Fatigue design margin
C = required cycles per year as defined by the Owner
n = Number of fatigue samples tested (Minimum value = 2.0)
R = Pressure Ratio = P_{min}/P_{max}
P_{max}=Maximum Operating Pressure
P_{min}=Minimum Operating Pressure

7.3.3 Parameters to monitor and record

1. Temperature of the piping surface
2. Number of cycles achieving upper cyclic pressure
3. Minimum and maximum cyclic pressures
4. Cycle frequency
5. Mode of failure
6. Test fluid

7.3.4 Acceptance Criteria The piping shall withstand N pressurization cycles to design pressure without failure by burst or leakage.

7.4 Leak Test

7.4.1 Procedure

1. The piping shall be subjected to a leak test at the rated pressure.
2. The test media for the leak test shall be hydrogen or a 5% Hydrogen-95% Nitrogen mixture. At the owner's option helium gas may be used.
3. The length of the test samples shall be a minimum of 6 times the nominal diameter or 4 feet.
4. The testing shall be performed on one sample cut at random from piping that will be shipped for the specific hydrogen piping project.
5. The test sample shall contain field end fittings. At the owner's option, a coupling shall be included in the leak test sample.

6. The test sample may be filled with a solid material to limit the required amount of test media. The filler material shall not limit the test media from wetting or escaping through the pipe wall.
7. The temperature on the outside surface of the piping shall not exceed 100°F (38°C) during the test.
8. A sensitive leak test shall be conducted using any method from ASME Section V Article 10, which will meet the required sensitivity.

7.4.2 Parameters to monitor and record

1. Temperature of the piping surface
2. Piping internal pressure
3. Test fluid
4. Leakage Rates

7.4.3 Acceptance Criteria The test sensitivity and acceptable leak rate shall be by agreement between the piping manufacturer and the owner. The minimum sensitivity of the test shall not be less than that specified in ASME B31.12 Paragraph IP-10.10.

7.5 Production Test requirements The production tests for quality assurance shall be in accordance with API 15S Paragraph 6.3 with the following supplemental requirements.

1. The test shall be the ASTM D1599 Short-Term Burst Test as defined in API 15S Paragraph 6.3.1.1.
2. The testing shall be performed on samples cut from the end of each section of piping that will be supplied for the specific hydrogen piping project.
3. The retest option in API 15S Paragraph 6.3.1.3 is not allowed.

8 Inspection In addition to the required B31.12 inspection, the owner's Inspector shall have access to review all manufacturing data and tests associated with the production of the piping.

9 Operation and Maintenance

9.1 If at any time a flaw is found that penetrates through the protective layer into the structural layer of the composite piping the damaged section shall be replaced. The replacement composite piping section shall meet the same requirement as the original piping. The replacement piping section shall be installed in accordance with the composite piping manufacturer's qualified procedures. The replacement section shall be tested at available system pressure.

9.2 Repairs to the protective layer can be made using nonmetallic composite wraps in accordance with the piping manufacturer's qualified procedures.

B31 Case 201

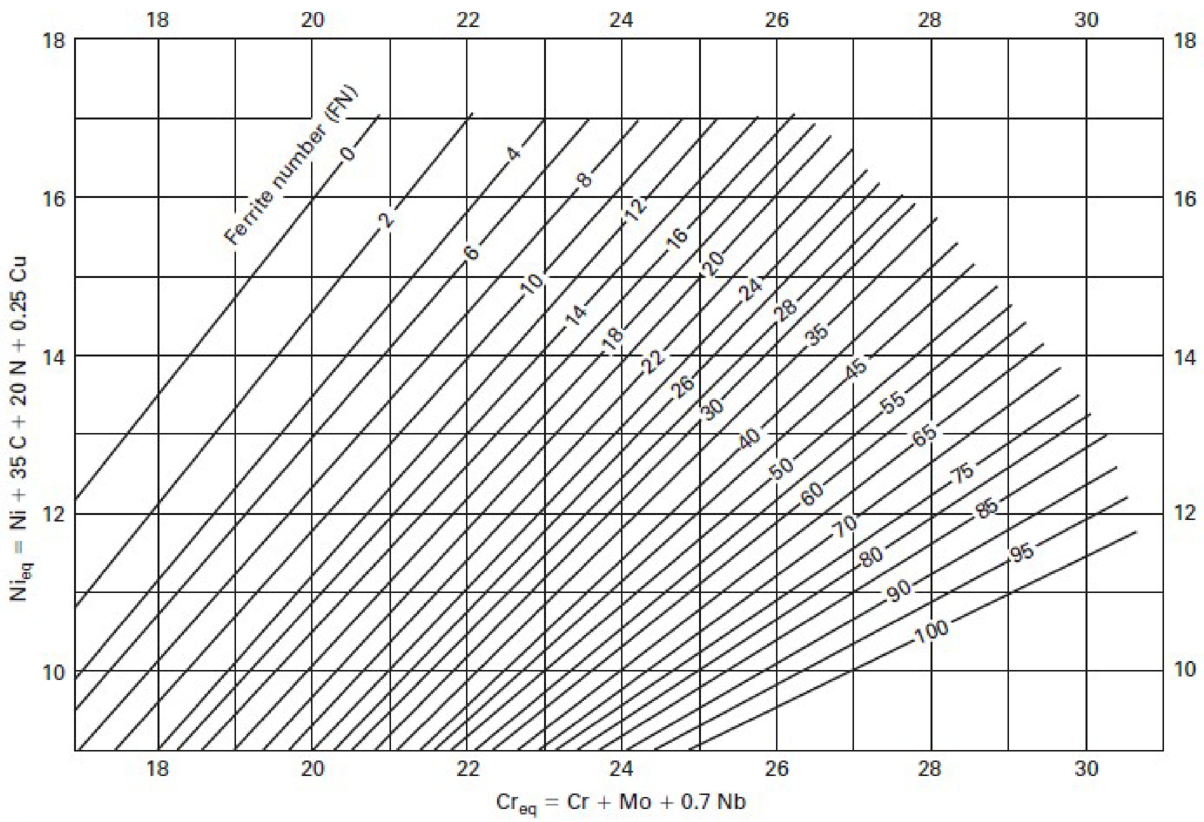
Piping for Hydrogen Service ASME

B31.12 Hydrogen Piping

Inquiry: Under what condition may Types 304, 304L, 316, and 316L stainless steels be used at design minimum temperatures colder than -320 F using Charpy V-notch impact toughness criteria in Section VIII Division 1 UHA-51 rules in B31.12 construction?

Reply: It is the opinion of the Committee that Types 304, 304L, 316 and 316L stainless steels may be used for design minimum temperatures colder than -320 F using Charpy V-notch impact toughness criteria in Section VIII Division 1 UHA-51 rules in B31.12 construction provided the following requirements are met:

a) The base metal shall be limited to Types 304, 304L, 316 and 316L stainless steels listed in Table GR-2.1.1-1.
b) The weld filler metal shall be limited to Type 316L/316LSi and Type 308L/308LSi conforming to SFA-5.4, SFA-5.9 or SFA 5.22. Weld metal deposited from each heat of Type 316L/316LSi filler metal shall have a Ferrite Number (FN) not greater than 10, and a weld metal deposited from each heat of Type 308L/308LSi filler metal shall have a FN in the range of 4 to 14, as measured by a ferritescope or magna gauge calibrated in accordance with AWS A4.2, or as determined by applying the chemical composition from the test weld to Figure 1.
c) Welding processes shall be limited to gas metal arc welding (GMAW), flux cored arc welding (FCAW) or gas tungsten arc welding (GTAW).
d) The Welding Procedure Qualification shall include impact tests of welds and heat affected zones (HAZs) made in accordance with GR 3.2 and with the requirements in (e) except as exempted in (f) and (g).
e) Charpy impact tests shall be conducted at −320°F (−196°C) on three sets of three specimens: one set from the base metal, one set from the weld metal, and one set from the HAZ. Each of the three specimens from each test set shall have a lateral expansion opposite the notch not less than 0.021 in. (0.53 mm).
f) Charpy impact tests are not required where the maximum obtainable Charpy specimen has a width along the notch less than 0.098 in. (2.5 mm).
g) Charpy impact tests are not required when the coincident ratio of design stress in tension to allowable stress is less than 0.3.
h) All other applicable rules regarding Welding Procedure Qualification and non-destructive testing in GR-3, IP-9 and PL-3 shall be satisfied.



GENERAL NOTES:

(a) The actual nitrogen content is preferred. If this is not available, the following applicable nitrogen value shall be used:

(1) GMAW welds — 0.08%, except that when self shielding flux cored electrodes are used — 0.12%

(2) Welds made using other processes — 0.06%.

(b) This diagram is identical to the WRC-1992 Diagram, except that the solidification mode lines have been removed for ease of use.

Figure 1. Weld Metal Delta Ferrite Content

B31 Case 202
Approval Date: November 14, 2017
Heavy Walled Fittings
ASME B31.3 Process Piping

Inquiry: What alternate calculation method for pressure design may be used to determine the required reinforcement for a heavy wall branch connection fitting (lateral, wye, or tee) in accordance with ASME B31.3, Para. 304.3.3?

Reply: It is the opinion of the Committee that the “pressure area” method,[1] as described herein, is an acceptable alternate calculation method to determine the required metal reinforcement for a heavy wall branch connection fitting (lateral, wye, or tee) in accordance with ASME B31.3 Para. 304.3.3.

Nomenclature:

A = Metal areas (see Figures 1, 2, and 3), mm^2 (in.^{2}).

B = Metal areas (see Figures 1 and 2), mm^2 (in.^{2}).

D_1 = Run pipe inside diameter, less corrosion allowance, mm (in.).

D_2 = Branch pipe inside diameter, less corrosion allowance, mm (in.).

E = Pressure areas (see Figures 1, 2, and 3), mm^2 (in.^{2}).

F = Pressure areas (see Figures 1 and 2), mm^2 (in.^{2}).

G = The width of the lateral branch opening at the inside surface of the run pipe (see Figure 1), mm (in.).

P = Design (gage) pressure, kPa (psi).

S = Material allowable stress from B31.3 Table A-1 for the design temperature, kPa (psi). (If a casting is to be qualified for pressure, the material allowable stress shall be multiplied by the appropriate B31.3 casting quality factor.)

t_1 = Thickness in the fitting heel (see Figures 1 and 2) or run radial thickness in the fitting crotch (see Figure 3), mm (in.).

t_2 = Thickness in the fitting crotch (see Figures 1 and 2) or branch radial thickness in the fitting crotch (see Figure 3), mm (in.).

t'_1 = Nominal thickness of the matching run pipe connected to the fitting (see Figures), mm (in.).

t'_2 = Nominal thickness of the matching branch pipe connected to the fitting (see Figures), mm (in.).

α = The angle between the branch pipe centerline and the fitting crotch centerline, deg (see Figures 1 and 2).

β = The angle between the fitting crotch centerline and the run pipe centerline, deg (see Figure 1).

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[1] The “pressure area” method was originally published in the 1956 revised 2nd edition of the MW Kellogg, *Design of Piping Systems*.

General Requirements

1. The fitting shall be manufactured from a single metal casting or forging.

2. The fitting ends shall not be within the envelope of the metal and pressure areas used to qualify the fitting and there shall be sufficient material beyond the envelope to make an acceptable weld end (see ASME B16.25).

3. The t'_1 and t'_2 dimensions of the fitting shall be equal to or greater in thickness than the nominal dimensions of the matching piping. If the fitting is a weaker material than the matching piping, transition pieces may be necessary for the connected piping to match t'_1 and t'_2 dimensions of the fitting determined in accordance with the straight pipe requirements of B31.3, as appropriate.

4. All inside and outside corners of the fittings larger than NPS 2 shall be radiused. It is recommended that inside radii be a minimum t/4 and outside radii be a minimum t/2, where t is the lesser of t'_1 and t'_2, except that these radii shall not be less than 3 mm (1/8 in.) and need not be greater than 25 mm (1 in.).

5. For internally and externally contoured fittings the metal and pressure areas may be represented by quadrilaterals and/or triangles assembled such that they approximate the respective areas:

   (A) for the metal areas: the areas of the largest non-overlapping quadrilaterals and/or triangles may be summed provided all the areas lie within the areas defined by the fitting inside and outside surfaces and side lengths defined in the appropriate figures; and

   (B) for the pressure areas: the areas of the non-overlapping quadrilaterals and/or triangles shall be summed that totally circumscribe and cover the areas defined by the fitting crotch and pipe centerlines, the fitting inside surfaces, and the side lengths defined in the appropriate figures.

6. For laterals (Figure 1) with an $(\alpha + \beta)$ angle greater than or equal to 85 degs, the requirements for the tee (Figure 3) may be used. Otherwise the requirements for the lateral shall be used.

7. Consideration shall be made for required examination of the pipe to fitting joint. A short tangent may improve the reading of a radiograph or facilitate the performance of ultrasonic examination, especially if there is a significant transition from the pipe to the fitting.

8. The fitting's manufacturing tolerance shall be considered.

Calculated Dimensions

The side length dimensions for calculating metal and pressure areas for the various fittings are as follows:

<u>For the lateral (see Figure 1) where (α + β) ≥ 45 deg</u>

Run crotch side length $= \frac{G}{2} + t_2 Cos\frac{\beta}{2}$

Run heel side length $= \frac{G}{2} + t_1 Cos\frac{(\alpha + \beta)}{2}$

Branch crotch side length $= \frac{D_2}{2} + t_2 Cos\frac{\alpha}{2}$

Branch heel side length $= \frac{D_2}{2} + t_1 Cos\frac{(\alpha + \beta)}{2}$

<u>For the wye (see Figure 2) where α ≥ 45 deg</u>

Run heel side length $= \frac{D_1}{2} + t_1 Cos\frac{\alpha}{2}$

Branch crotch side length $= \frac{D_2}{2} + t_2 Cos\,\alpha$

Branch heel side length $= \frac{D_2}{2} + t_1 Cos\frac{\alpha}{2}$

<u>For the tee (see Figure 3)</u>

Run side length $= \frac{D_2}{2} + t_2$

Branch side length $= \frac{D_2}{2} + t_1$

Acceptance Criteria

The following equations shall be met for both the crotch and heel sides of the fitting. For the tee only Equation (1) need be met because of symmetry.

$$S \geq \frac{P\left(E + \frac{A}{2}\right)}{A} \qquad (1)$$

$$S \geq \frac{P\left(F + \frac{B}{2}\right)}{B} \qquad (2)$$

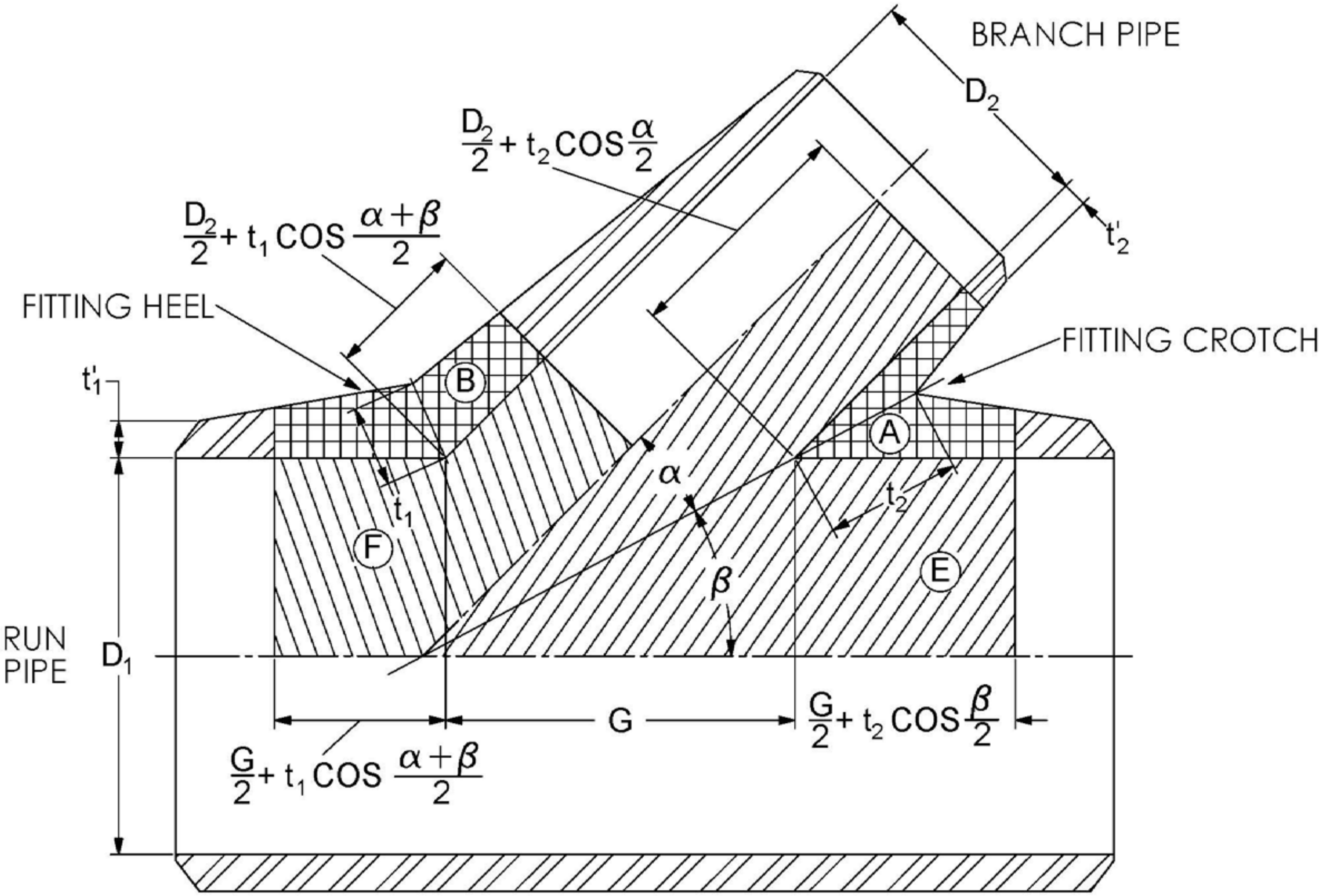


FIGURE 1 - LATERAL FITTING

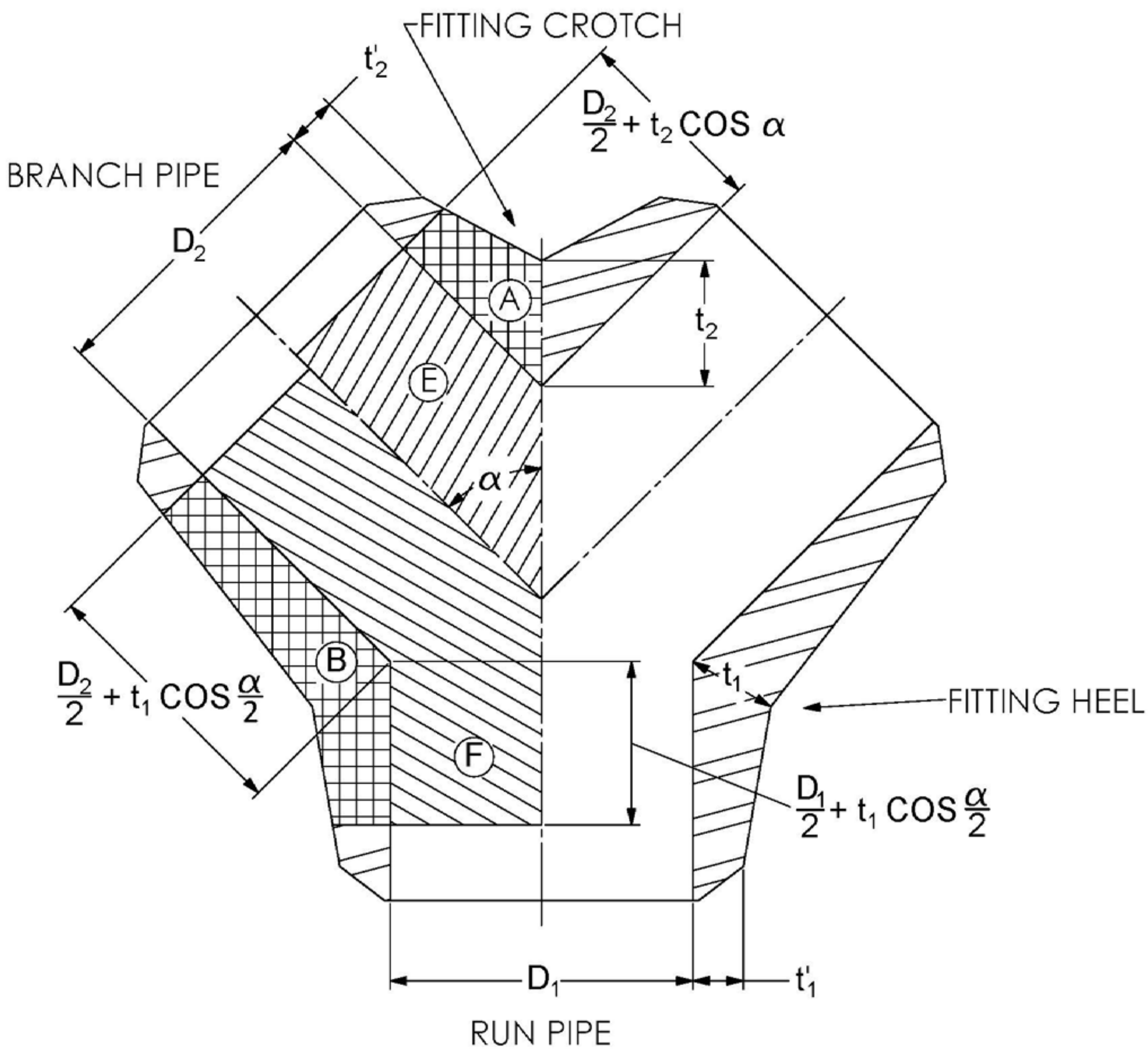


FIGURE 2 - WYE FITTING

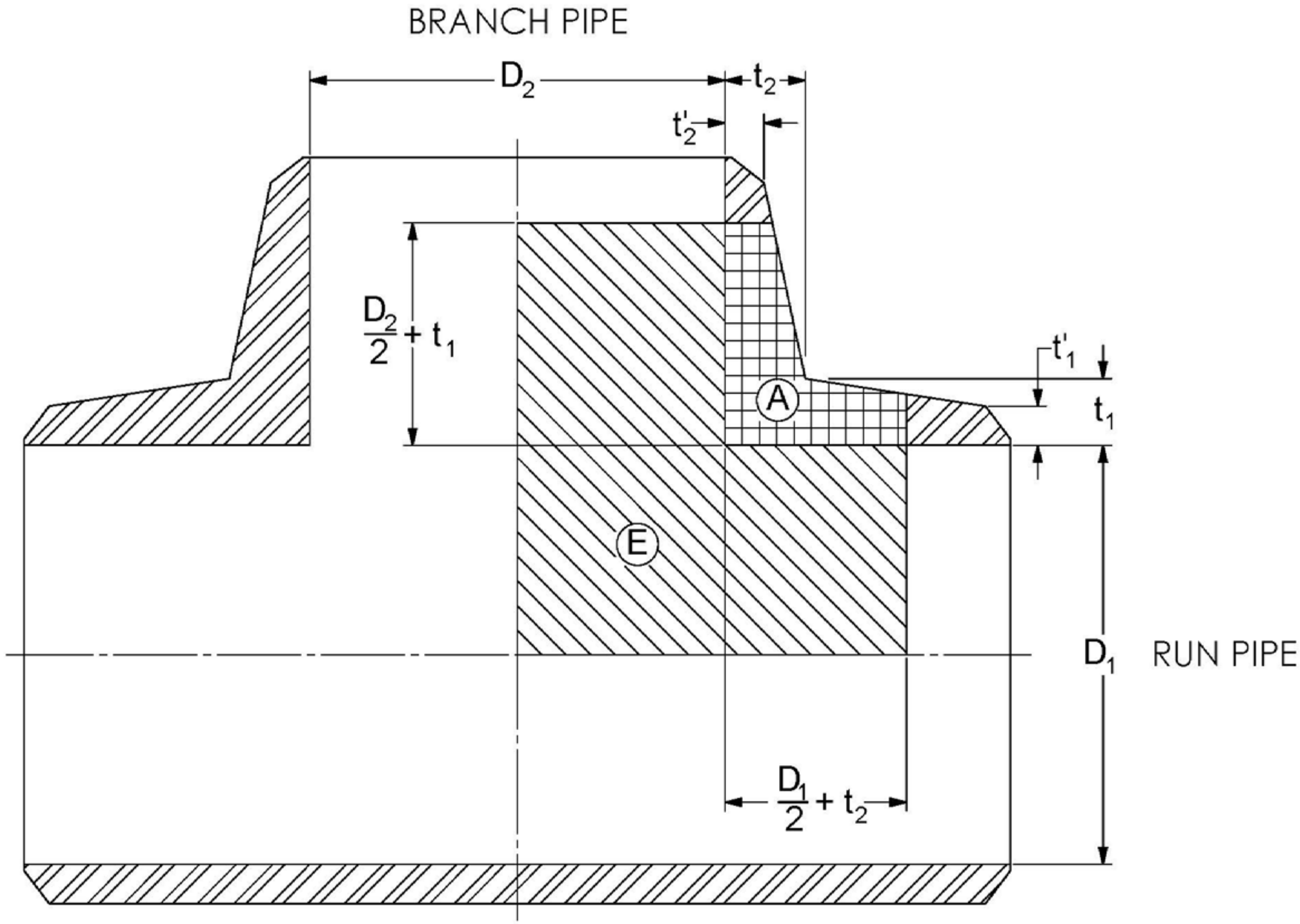


FIGURE 3 - TEE FITTING

B31 CASE 204
Approval Date: April 6, 2018
ASME B31.1 Power Piping

Inquiry: What alternate calculation method for pressure design may be used to determine the required reinforcement for a heavy wall branch connection fitting (lateral, wye, or tee) in accordance with ASME B31.1, Para. 104.3.1(D)?

Reply: It is the opinion of the Committee that the "pressure area" method,[1] as described herein, is an acceptable alternate calculation method to determine the required metal reinforcement for a heavy wall branch connection fitting (lateral, wye, or tee) in accordance with ASME B31.1, Para. 104.3.1(D).

Nomenclature:

A = Metal areas (see Figures 1, 2, and 3), mm^2 ($in.^2$).

B = Metal areas (see Figures 1 and 2), mm^2 ($in.^2$).

D_1 = Run pipe inside diameter, less corrosion allowance, mm (in.).

D_2 = Branch pipe inside diameter, less corrosion allowance, mm (in.).

E = Pressure areas (see Figures 1, 2, and 3), mm^2 ($in.^2$).

F = Pressure areas (see Figures 1 and 2), mm^2 ($in.^2$).

G = The width of the lateral branch opening at the inside surface of the run pipe (see Figure 1), mm (in.).

P = Design (gage) pressure, kPa (psi).

S = Material allowable stress from B31.1 Appendix A for the design temperature, kPa (psi). (If a casting is to be qualified for pressure, the material allowable stress shall be multiplied by the appropriate B31.1 casting quality factor.)

t_1 = Thickness in the fitting heel (see Figures 1 and 2) or run radial thickness in the fitting crotch (see Figure 3), mm (in.).

t_2 = Thickness in the fitting crotch (see Figures 1 and 2) or branch radial thickness in the fitting crotch (see Figure 3), mm (in.).

t'_1 = Nominal thickness of the matching run pipe connected to the fitting (see Figures), mm (in.).

t'_2 = Nominal thickness of the matching branch pipe connected to the fitting (see Figures), mm (in.).

α = The angle between the branch pipe centerline and the fitting crotch centerline, deg (see Figures 1 and 2).

β = The angle between the fitting crotch centerline and the run pipe centerline, deg (see Figure 1).

[1] The "pressure area" method was originally published in the 1956 revised 2nd edition of the MW Kellogg, *Design of Piping Systems*.

General Requirements

1. The fitting shall be manufactured from a single metal casting or forging.

2. The fitting ends shall not be within the envelope of the metal and pressure areas used to qualify the fitting and there shall be sufficient material beyond the envelope to make an acceptable weld end (see ASME B16.25).

3. The t'_1 and t'_2 dimensions of the fitting shall be equal to or greater in thickness than the nominal dimensions of the matching piping. If the fitting is a weaker material than the matching piping, transition pieces may be necessary for the connected piping to match t'_1 and t'_2 dimensions of the fitting determined in accordance with the straight pipe requirements of B31.1, as appropriate.

4. All inside and outside corners of the fittings larger than NPS 2 shall be radiused. It is recommended that inside radii be a minimum t/4 and outside radii be a minimum t/2, where t is the lesser of t'_1 and t'_2, except that these radii shall not be less than 3 mm (1/8 in.) and need not be greater than 25 mm (1 in.).

5. For internally and externally contoured fittings the metal and pressure areas may be represented by quadrilaterals and/or triangles assembled such that they approximate the respective areas:

   (A) for the metal areas: the areas of the largest non-overlapping quadrilaterals and/or triangles may be summed provided all the areas lie within the areas defined by the fitting inside and outside surfaces and side lengths defined in the appropriate figures; and

   (B) for the pressure areas: the areas of the non-overlapping quadrilaterals and/or triangles shall be summed that totally circumscribe and cover the areas defined by the fitting crotch and pipe centerlines, the fitting inside surfaces, and the side lengths defined in the appropriate figures.

6. For laterals (Figure 1) with an $(\alpha + \beta)$ angle greater than or equal to 85 degs, the requirements for the tee (Figure 3) may be used. Otherwise the requirements for the lateral shall be used.

7. Consideration shall be made for required examination of the pipe to fitting joint. A short tangent may improve the reading of a radiograph or facilitate the performance of ultrasonic examination, especially if there is a significant transition from the pipe to the fitting.

8. The fitting’s manufacturing tolerance shall be considered.

9. The wye fitting in Figure 2 is symmetrical .

Calculated Dimensions

The side length dimensions for calculating metal and pressure areas for the various fittings are as follows:

For the lateral (see Figure 1) where (α + β) ≥ 45 deg

Run crotch side length $= \frac{G}{2} + t_2 Cos\frac{\beta}{2}$

Run heel side length $= \frac{G}{2} + t_1 Cos\frac{(\alpha + \beta)}{2}$

Branch crotch side length $= \frac{D_2}{2} + t_2 Cos\frac{\alpha}{2}$

Branch heel side length $= \frac{D_2}{2} + t_1 Cos\frac{(\alpha + \beta)}{2}$

For the wye (see Figure 2) where α ≥ 45 deg

Run heel side length $= \frac{D_1}{2} + t_1 Cos\frac{\alpha}{2}$

Branch crotch side length $= \frac{D_2}{2} + t_2 Cos\,\alpha$

Branch heel side length $= \frac{D_2}{2} + t_1 Cos\frac{\alpha}{2}$

For the tee (see Figure 3)

Run side length $= \frac{D_2}{2} + t_2$

Branch side length $= \frac{D_2}{2} + t_1$

Acceptance Criteria

The following equations shall be met for both the crotch and heel sides of the fitting. For the tee only Equation (1) need be met because of symmetry.

$$S \geq \frac{P\left(E + \frac{A}{2}\right)}{A} \qquad (1)$$

$$S \geq \frac{P\left(F + \frac{B}{2}\right)}{B} \qquad (2)$$

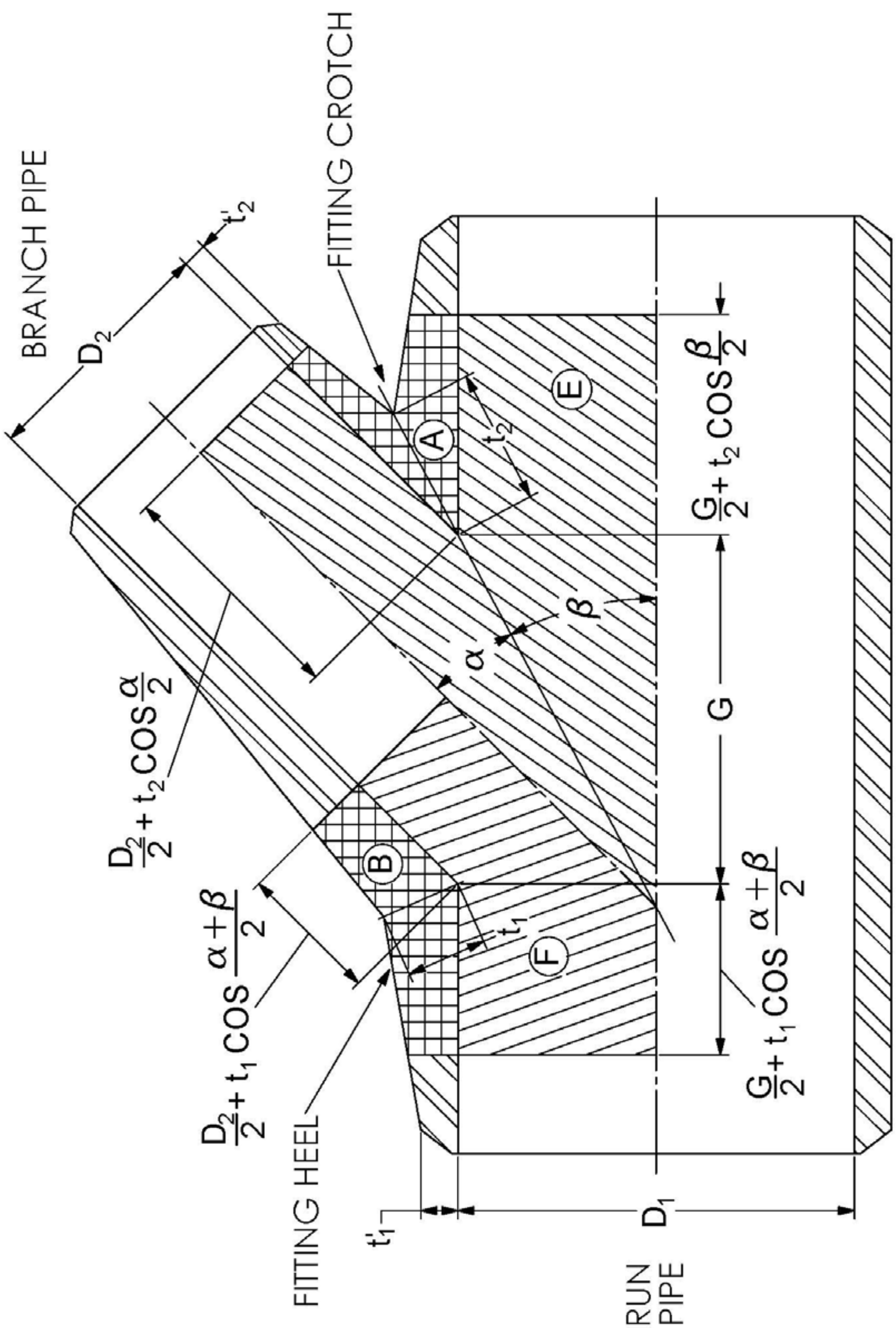


FIGURE 1 - LATERAL FITTING

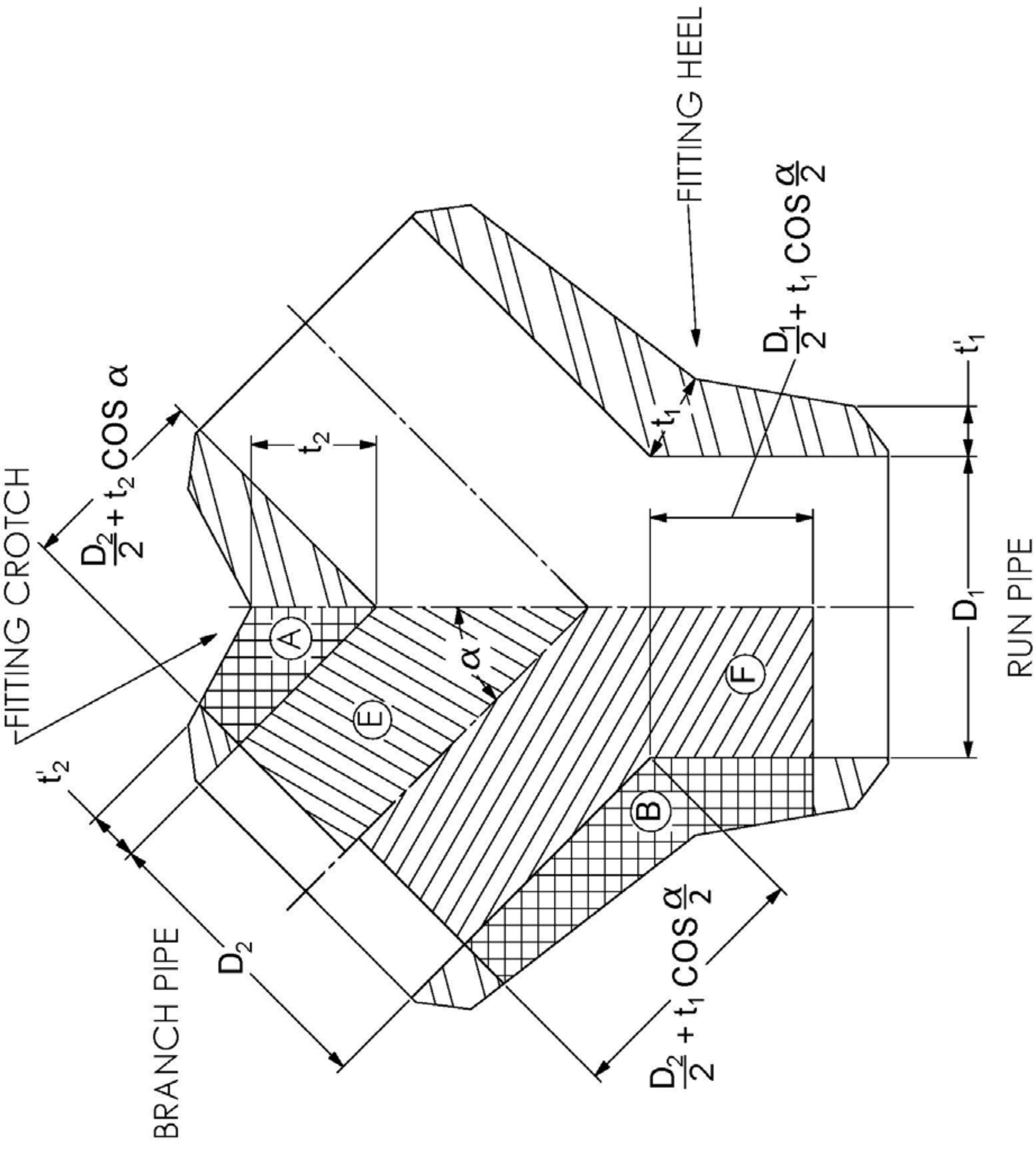


FIGURE 2 - WYE FITTING

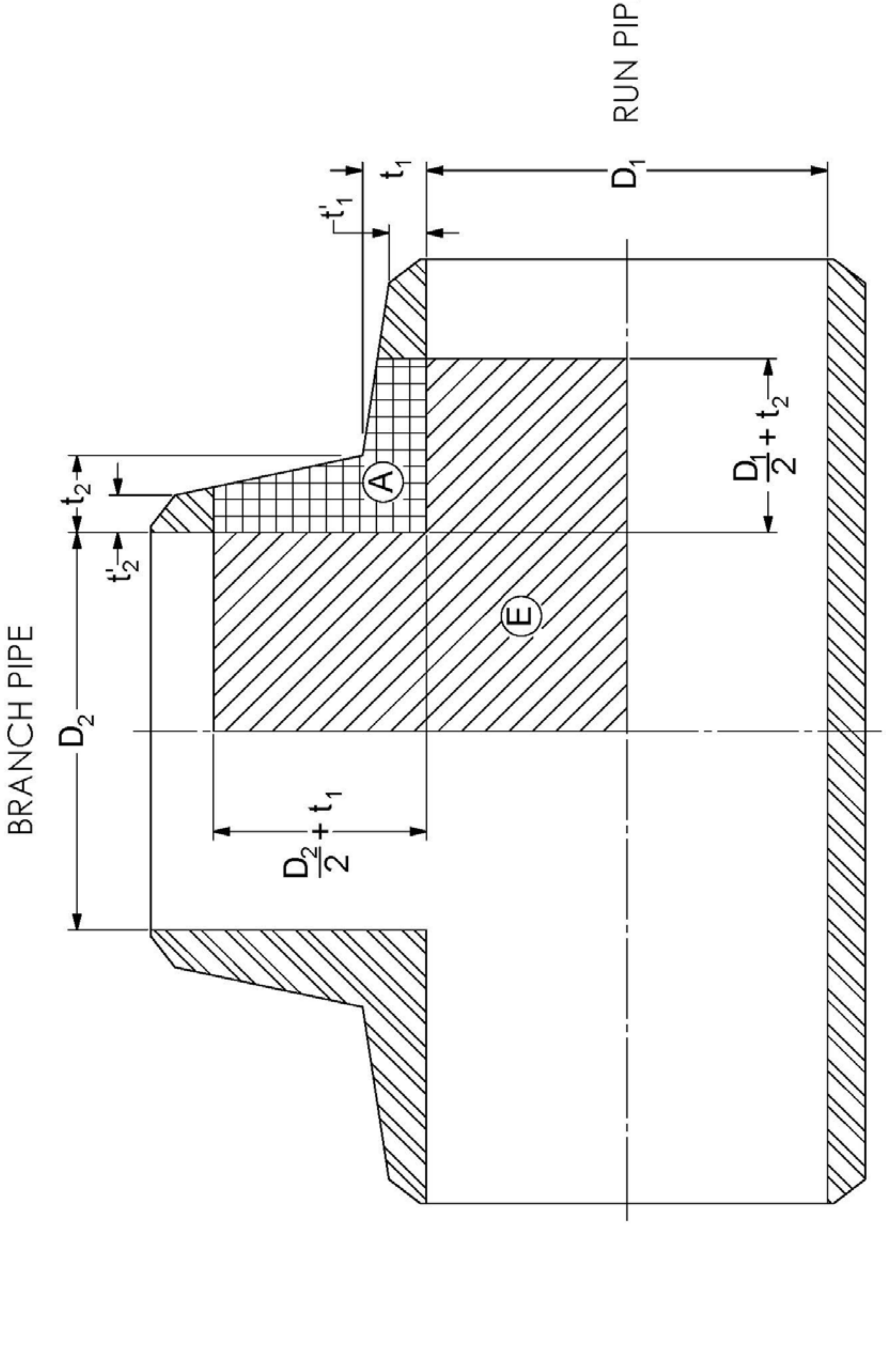


FIGURE 3 - TEE FITTING

B31 Case 205
Approval Date: June 29, 2018
Localized PWHT for CSEF Materials
ASME B31.1 Power Piping

Inquiry: When locally heating welds in P-No. 15E piping materials in accordance with ASME B31.1 paragraph 132.7, is it permissible to use electric resistance heating using the controls described below?

Reply: Yes, provided the following requirements are met.

(a) General Scope.
The rules of this case describe the minimum requirements to be followed during the set-up and application of local controlled heat to weld joints. This case does not address heating the complete weldment in a furnace or oven. This case applies specifically to the heating of P-No. 15E piping materials when using electric resistance heating pads.

(b) Introduction
During the manufacture, fabrication and repair of P-No. 15E piping components, it may be necessary to heat components before welding (preheating), between passes (interpass heating), or after welding (postheating/bakeout or postweld heat treatment [PWHT]). This case is written to provide instruction and give the minimum requirements for performing heating or heat treatment of welds when using electric resistance heating pads.

(c) Terminology for Local Heating
This section defines the terms used in describing local circumferential band heating. See Figures 1 & 2. Minimum requirements for these regions are presented later in this case.

(1) Soak Band (SB).
The soak band is defined as the through-thickness volume of metal, which is required to be heated to within the post weld heat treatment temperature range. As a minimum, it shall consist of the weld metal, the HAZ, and a portion of the base metal adjacent to and on each side of the weld being heated.

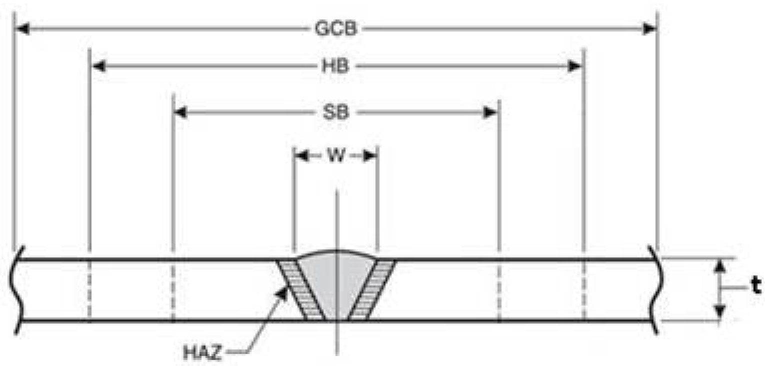
(2) Heated Band (HB).
The heated band is defined as the surface area over which the heat is applied to achieve the required temperature in the soak band. The heated band consists of the soak band width on the outside surface of the component, plus any adjacent base metal necessary to both control the temperature and achieve an acceptable temperature on the inside of the pipe or tube.

(3) Gradient Control Band (GCB).

The gradient control band is defined as the surface area over which insulation and/or supplementary heat source(s) may be placed. The gradient control band encompasses the soak band, the heated band, and sufficient adjacent base metal to ensure that harmful temperature gradients are not generated within the heated band.

(4) Control Zone.

A control zone consists of a grouping of one or more electrical heating pads that are controlled electrically based upon input from a single temperature measuring device (typically a thermocouple). One or more zones may be present in both the circumferential and/or axial directions.



Nomenclature:

W = Widest width of butt or attachment weld.

HAZ = Heat-affected zone.

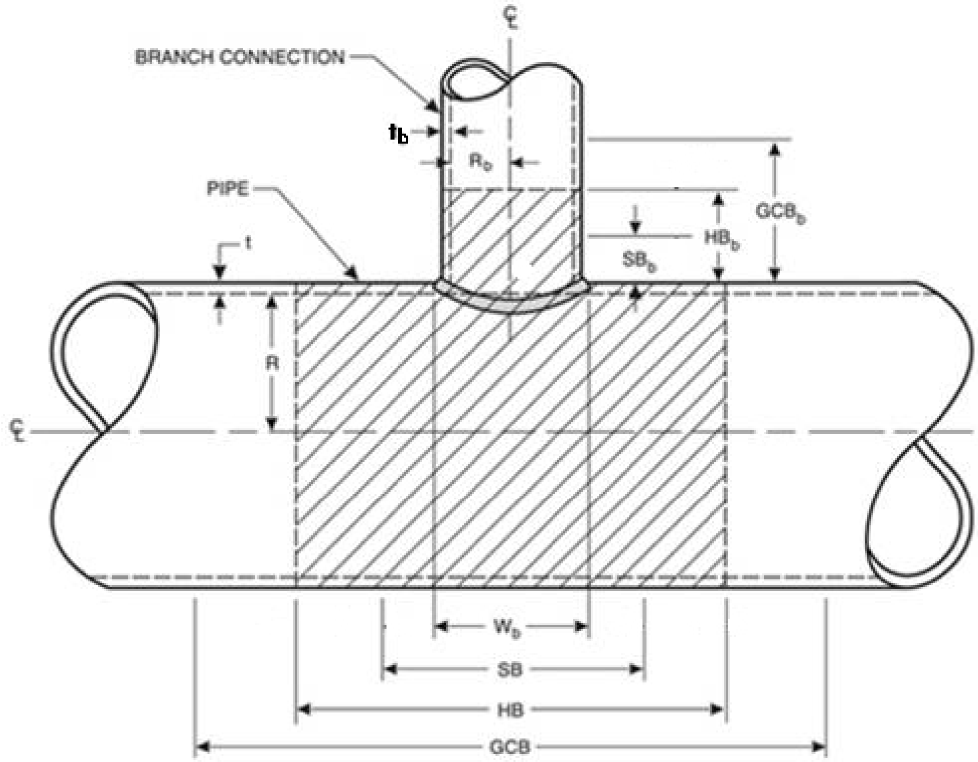
SB = Soak band (width of the volume of the material where the holding temperature equals or exceeds the minimum and equals or is below the maximum required. The minimum width is typically specified as W plus a multiple of t on each side of the weld).

HB = Heated band (width of heat source).

GCB= Gradient control band (minimum width of insulation and/or gradient heat source).

t = Nominal thickness of piping, branch connection, nozzle neck, or attachment.

Figure 1 Definition of Terms for Local Circumferential Band Heating of Pipe Weld.



Nomenclature:

W_b	= Widest width of weld attaching the branch connection to the pipe.
SB	= Soak band on pipe (width of the volume of the material where the holding temperature equals or exceeds the minimum and equals or is below the maximum required. The minimum width is typically specified as W_b plus a multiple of t on each side of the weld attaching the branch connection).
SB_b	= Soak band on branch connection. The minimum width is typically specified as a multiple of t_b beyond the widest width of the weld attaching the branch connection.
HB, HB_b	= Heated band (width of heat source), shown as shaded area.
GCB, GCB_b	= Gradient control band (minimum width of insulation and/or gradient heat source).
t t_b	= Nominal thickness of pipe or branch connection.
R, R_b	= Inside radius of pipe or branch connection.

Figure 2 Definition of Terms for Local Circumferential Band with Branch Connection to Pipe Attachment Weld.

(5) Control Thermocouple
A control thermocouple is a single temperature measuring device that is located within the control zone in order to control the temperature of that control zone.

(6) Monitoring Thermocouple
A monitoring thermocouple is a temperature measuring device used to measure the temperature at the position where it is located.

(7) Axial Temperature Gradient

The axial temperature gradient is the change in temperature along the length of the component. This is usually stated as a maximum temperature difference between two points located a specified distance apart.

(8) Through-thickness Temperature Gradient

The through-thickness temperature gradient is the difference between the temperature on the outside of the weld or component and the temperature on the inside of that same component, on the same radial line, and in the same axial plane.

(9) Component Orientation

For the purposes of this Case, cylindrical components or PWHT in the horizontal position shall mean that the longitudinal axis of the main component lies in the horizontal position, and in the vertical position shall mean that the longitudinal axis of the main component lies in the vertical position

(10) Gradient Control Heaters

Under certain circumstances, extra heaters known as gradient control heaters, or blocking heaters are installed adjacent to the heated band, to add additional heat to control thermal temperature gradients, or to provide thermal biasing to counter increased thermal mass or to counter a vertical bias in the temperature distribution in the heated band during PWHT in the vertical position.

(d) Local Circumferential Band Heating

Local heating of parts or components shall be accomplished by heating circumferential bands. Since local heating of piping is typically from the outside, when designing heat treatment procedures, radial (through-thickness) temperature gradients shall be considered.

(1) Soak Band.

The requirements for soak band width shall as a minimum be equal to the following. Where referenced, t = nominal pipe wall thickness.

(-a) Soak Band Width for Preheat/Interpass Heating.

The minimum requirement for preheat/interpass heating shall be an area 3 in. (75 mm), or 1.5 t whichever is greater, in all directions from the point of welding.

(-b) Soak Band Width for PWHT.

The minimum requirement for PWHT shall be as follows.

(-1) For piping less than or equal to NPS 4 (DN 100) the soak band shall be 1.5 t. on each side of the weld at its greatest width.

(-2) For piping greater than NPS 4 (DN 100), but less than or equal to NPS 8 (DN 200), the soak band shall be 6t on each side of the weld at its greatest width.

(-3) For piping greater than NPS 8 (DN 200), the soak band shall be 10t on each side of the weld at its greatest width.

(-c) Soak Band Width for Postheating.
The minimum requirement for post heating shall be t or 2 in. (50 mm), whichever is less, on each side of the weld at its greatest width.

(2) Heated Band.
The requirements for heated band width shall as a minimum be equal to the following.

(-a) Heated Band Width for PWHT.
Requirements for the heated band width shall be the soak band width plus 4t on each side of the weld. Where t = pipe wall thickness.

(-b) Heated Band Width for Preheating and Postheating.
The heated band width for preheat/interpass heating, and postheating shall be 6 times the wall thickness of the pipe on each side of the weld.

(3) Gradient Control Band.
The primary function of this band is to control the axial temperature gradient at the edges of the heated band. It also serves to minimize heat losses in the heated band. The width of the insulated area directly affects the axial temperature gradient.

The requirements for the Gradient Control Band width shall as a minimum be equal to the following.

(-a) Gradient Control Band Width for Preheating and Postheating.
The insulation may be limited to covering the heaters to protect the welder.

(-b) Gradient Control Band Width for PWHT.
Requirements for the gradient control band width shall be:
The gradient control band width = heated band width + 4 t on each side of the weld. Where t = pipe wall thickness

Note that if the pipe wall thickness changes, attachments are present within the gradient control band, or the pipe is being welded to flanges, valves, etc., the use of supplemental heat source(s) within the gradient control band may be required.

(4) Axial Temperature Gradient.
The axial temperature distribution plays an important role in limiting induced stresses during PWHT. The temperature gradient shall be controlled such as to be reasonably uniform around the component.

(-a) Axial Temperature Gradient for Preheat/Interpass Heating and Postheating.
Control of the axial temperature gradient is not required.

(-b) Axial Temperature Gradient for PWHT.

The maximum axial temperature gradient for PWHT shall be limited such that the temperature at the edge of the heated band shall be no less than one half the temperature at the edge of the soak band during heating, the soak time, and cooling.

(e) Measurement of Temperature.

Measurement of temperature is required during heating operations. When heating above 800°F (425°C), a continuous record of the temperature shall be made during the heating cycle.

(1) Temperature-Indicating Crayons and Paints.

Temperature indicating crayons and paint are only permissible up to 600°F (316°C). Above that temperature, thermocouples shall be used and shall be attached using the capacitor discharge method of welding.

(2) Selection of Thermocouples.

Thermocouples shall be selected based upon their maximum recommended temperature rating.

Type J, Iron-Constantan shall not be used above 1400°F (760°C)

Type K, Chromel-Alumel shall not be used above 2300°F (1260°C)

(-a) The maximum size of thermocouple wire to be used in local heating (with attachment by capacitor discharge welding) shall be #20 American Wire Gage (AWG), which has a diameter of 0.032 in. (0.81 mm).

(3) Installation of Thermocouples.

Thermocouples shall be attached using capacitor discharge welding. Each wire shall be attached separately to the surface of the work piece. The maximum separation of the wires shall be held to 1/4" (6 mm).

(-a) Paragraph 132.3.3 provides a special allowance for attachment of thermocouples by low energy (limited to 125 W-sec [joule]) capacitor discharge welding without requiring a welding procedure, a welder performance qualification or subsequent PWHT.

(-b) After capacitor discharge welding, the thermocouple welds shall be carefully inspected for proper attachment before covering with insulation or application of heat. This shall be accomplished by repositioning the insulation back to the OD surface, then bending the wires flush with the surface. If the weld remains intact, then the thermocouple has been attached securely.

(-c) The thermocouple shall be tied or taped to the work piece approximately 2-3 in. (50-75 mm) away from the attachment point, so as to minimize stress on the point of thermocouple attachment (hot junction).

(-d) The thermocouple wire shall be kept under insulation for at least 4 in. (100 mm) from the welded junction, to minimize heat conduction along the wire, away from the hot junction.

(4) Removal of Thermocouples
During the equipment removal stage, the location of each thermocouple should be adequately identified. This is typically accomplished by circling the attachment area with a marker or chalk.

Light filing or grinding followed by inspection of the thermocouple attachment areas may be required. **Care must always be exercised during filing or grinding to prevent removal of too much metal.**

(5) Control Thermocouples.
Control thermocouple locations shall be based upon the location of the heating pads and the component being heated. Each electrically separate circuit containing heating pads, shall be known as a control zone, and shall be controlled by one control thermocouple. This thermocouple shall be approximately centrally located such that it experiences the greatest expected temperature within the control area. When installing the control thermocouple, an electrically separate, spare control thermocouple shall be installed immediately adjacent to it.

(6) Monitoring Thermocouples.
Monitoring thermocouples shall be placed to insure that all of the parameters specified to control the local heating operation are being achieved. They should be placed to measure the maximum and minimum anticipated metal temperatures. To achieve this, thermocouples shall be placed at the centerline of the weld, the edge of the soak band and at the edge of the heated band

These shall be located as described in section (f). There shall also be at least one thermocouple, either control or monitoring, located under each heating pad.

(f) Design of the Heating Process.
Choice of the sizes, the number, and the electrical configuration of electric heating pads, shall be based upon the geometrical configuration of the parts, the soak band area, and the heated band areas.

All heating pads used in a single heat treatment shall be manufactured from the same materials, and of the same Watt density.

Prior to installation, each heater shall be inspected for broken ceramic beads and frayed heater wires. If found, and judged to be detrimental to the process, the heaters shall be replaced.

(1) Preheat.

(-a) Heating pads shall be symmetrically located on either side of the weld preparation.
The heating pads shall be installed such that the edges of the pads shall be approximately 1 in. (25 mm) away from the edge of the weld preparation.

(-b) Each side of the weld shall be considered as a separate and distinct heated area with its own temperature monitoring and control zones.

(-c) Preheat temperature shall be monitored at a number of locations around the weld, at a location 0.5 in. (13 mm) away from the edge of the weld preparation. As a minimum, the 6 o'clock position shall be monitored to ensure that the minimum preheat has been achieved.

(-1) There shall be at least one control thermocouple installed per control zone, and in the case of horizontally oriented pipe and tube, at least one of these control thermocouples shall be installed at the 12:00 position.
In the case of vertically oriented pipe and tube, there shall also be at least one monitoring thermocouple installed at the upper edge of the uppermost heating pad.

(-2) One control or monitoring thermocouple shall be installed under each heater.

(2) Postheating.
(-a) Heating pads shall be symmetrically located over the centerline of the weld. There shall be at least one control thermocouple installed per control zone, and in the case of horizontally oriented pipe, at least one of these control thermocouples shall be installed at the 12:00 position. In the case of vertically oriented pipe and tube, there shall also be at least one monitoring thermocouple installed at the upper edge of the uppermost heating pad.

(3) Postweld Heat Treatment.
(-a) The heating pads across the soak band shall be installed in such a way that the gaps between the heaters is minimized. When the nominal wall thickness of the pipe is less than or equals 1 in. (25 mm), the gaps between the heaters shall not be greater than 3/8 in. (10 mm). When the nominal wall thickness of the pipe exceeds 1 in. (25 mm), the gaps between the heaters shall not be greater than 1/3 the wall thickness. Where this is not possible, a monitoring thermocouple shall be welded in the center of all such wide gaps.

(-1) There shall be NO OVERLAPPING of heaters.

(-2) Heater tails shall not be allowed to cross any other pad or heater tail.

(-3) Heater tails shall be insulated from the pipe.

(-4) Heater tails shall be brought out through the insulation as close to the edge of the heater as possible.

(-b) Control zones shall as a minimum be laid out as per Table 3 below.

Table 3

Piping Size (NPS) (DN)	Minimum Required Number of Circumferential Control Zones and Control Thermocouple Locations
Up to 6 (150)	One Control Zone, with the control thermocouple at 12 o'clock.
>6 (150) and up to 12 (300)	Two Control Zones, with control thermocouples at 12 o'clock and 6 o'clock.
>12 (300) and up to 30 (750)	Four Control Zones, with control thermocouples at 12 o'clock, 3 o'clock, 6 o'clock, and 9 o'clock.
Over 30 (750)	Number of control zones and associated thermocouples as required by actual heater configuration, circumferential spacing of heaters, control bands etc., but with one control thermocouple at 12 o'clock.

(-c) Location of Thermocouples

At least one thermocouple shall be installed at both the 12:00 and 6:00 positions on the weld centerline. These thermocouples may be either a control thermocouple or a monitoring thermocouple. Additional thermocouples may be necessary depending on the part configuration and size.

Monitoring thermocouples shall also be installed at the outer edges of the soak band, and at the outer edges of the heated band.

(-d) Examples of Thermocouple Locations.

Figures have been provided to show examples of the thermocouple locations for common local circumferential band PWHT applications.

(-1) In some instances, both monitoring and control thermocouples have been shown. Figures 3 through 5 provide required monitoring and control thermocouple locations for PWHT of butt welds in horizontally oriented piping with 1, 2, and 4 zones of control. Figure 6 provides required monitoring thermocouple locations for PWHT of a weld attaching a branch connection to pipe. Control thermocouples shall be attached as required by the control zone layout.

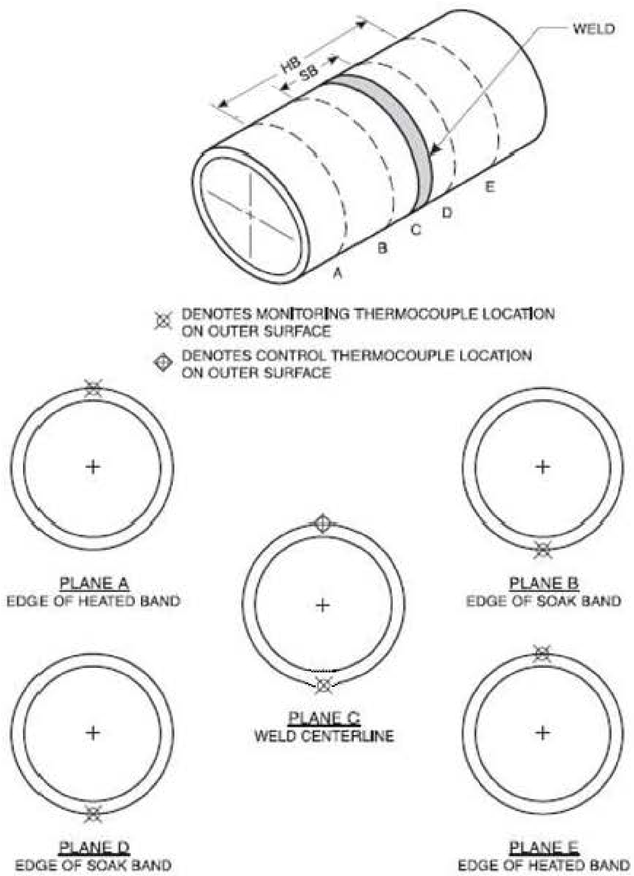


Figure 3 Location of Thermocouples (Monitoring and Control) for Pipe sizes up to NPS 6 (DN 150) and one Control Zone

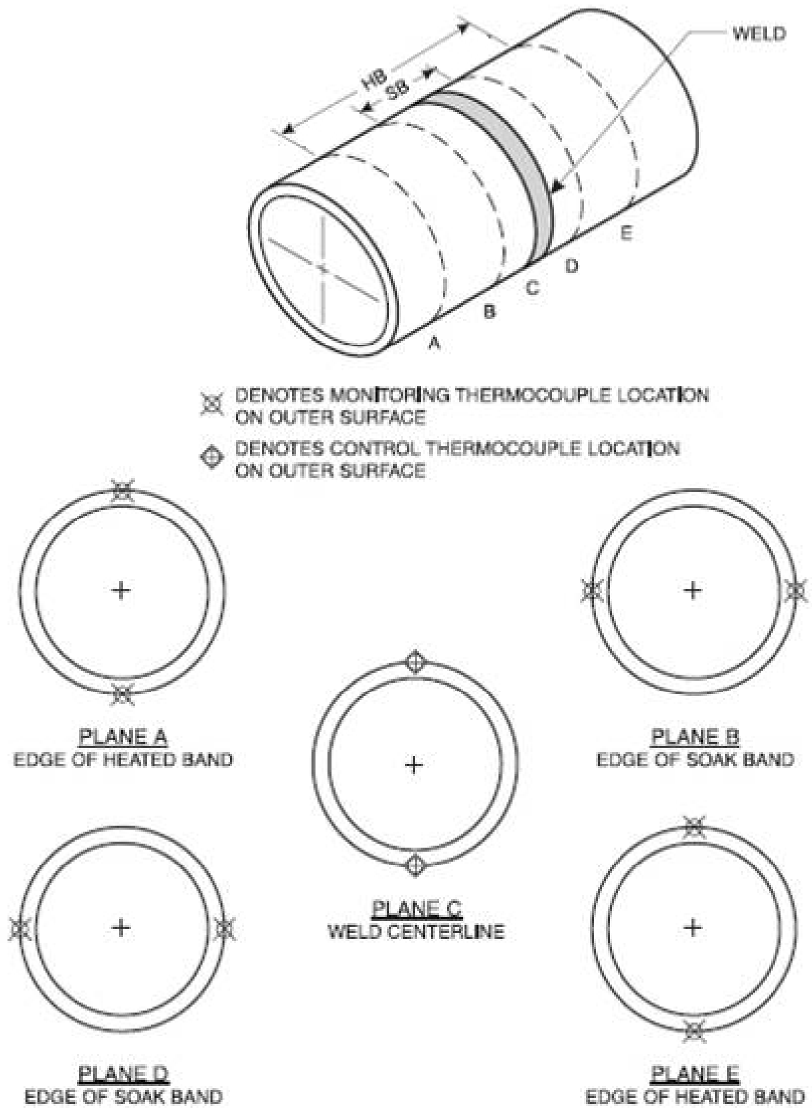


Figure 4 Location of Thermocouples (Monitoring and Control) for Pipe sizes >NPS 6 (DN 150) and up to NPS 12 (DN 300) and two Control Zones

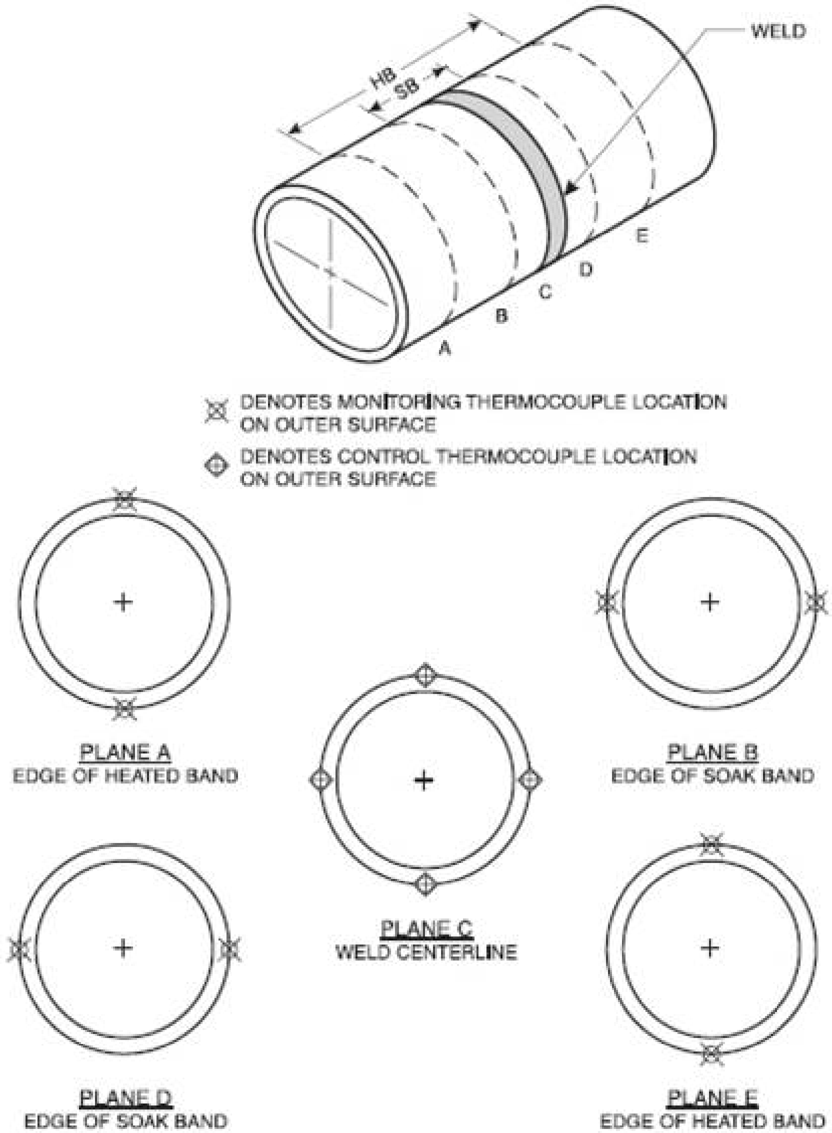


Figure 5 Location of Thermocouples (Monitoring and Control) for Pipe sizes >NPS 12 (DN 300) and up to NPS 30 (DN 750) and four Control Zones

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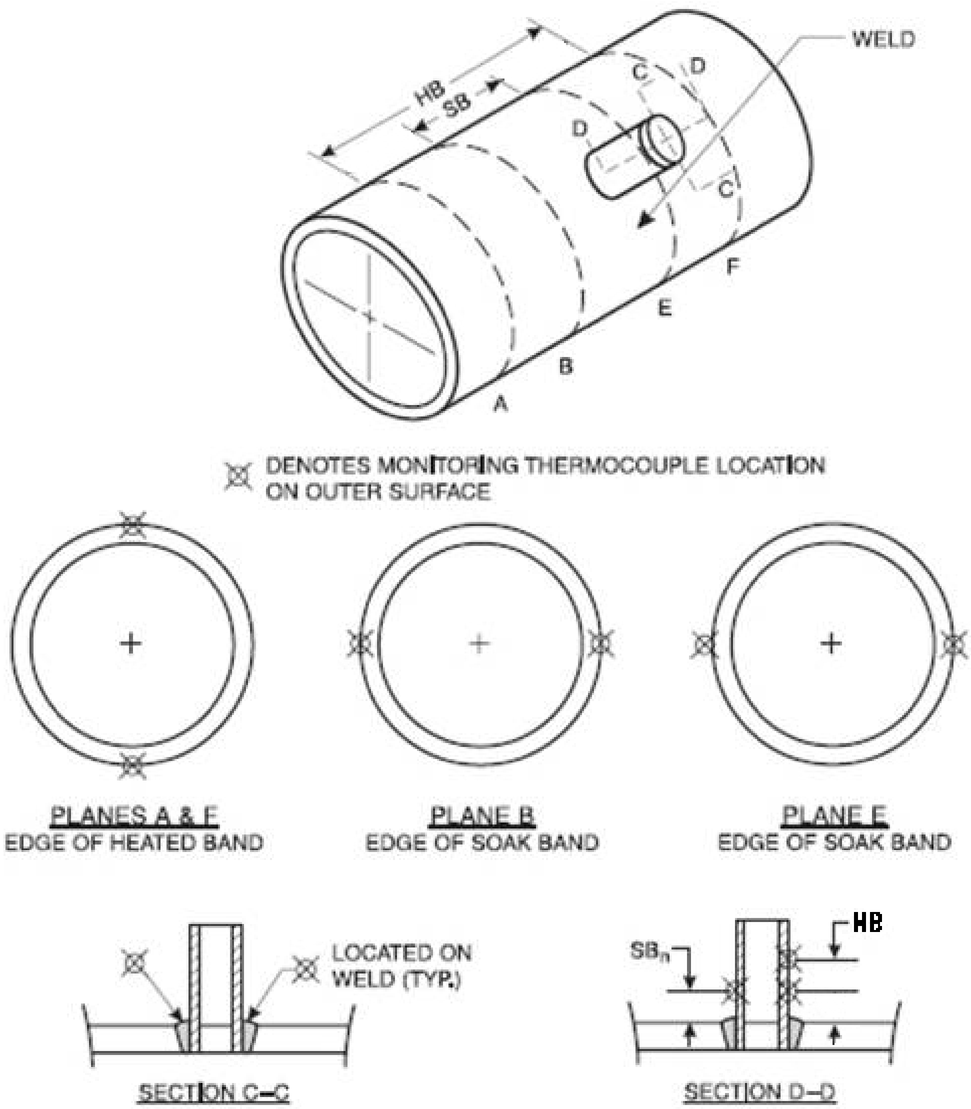


Figure 6 Location of Monitoring Thermocouples Branch Nozzle or attachment

(4) Special Considerations

(-a) Circumferential Welds Joining Piping in the Horizontal Position.

Due to natural internal convection heat flow, the 12:00 position on a circumferential weld in horizontally oriented piping cylindrical components will be considerably hotter than the 6:00 position. To help avoid exceeding the maximum allowed temperature, one control thermocouple shall always be installed at the 12:00 position. In addition, control zones and control thermocouples shall be installed as follows.

(-b) Butt Welds Joining Piping in the Vertical Position.
Due to natural internal convection heat flow, the upper side of the heated band in vertical piping will be hotter than the lower side.
Several approaches may be used to address this issue.

(-1) Air circulation dams may be placed inside the pipe preferably above the weld, to block the "chimney effect" within the pipe

(-2) The heated band may be biased such that approximately 60% of the heated band area is below the weld.

(-3) Separate control zones, above and below the weld may be used.

(-4) Gradient control or blocking heaters may also be installed below the weld, to balance the heat flow and in effect form a biasing of the heated band.

(-c) Butt Welds Joining Piping to Valves and Flanges.
During PWHT of butt welds between piping and components such as valve bodies or heavy flanges, consideration shall be given to the uneven conductive heat loss (or so-called "heat sink effect") on each side of the weld.
To counter this, the heat input may be biased to the thicker side of the joint. This may be accomplished by:

(-1) Use of separate control zones on the thicker and thinner components.

(-2) Biasing the heating elements towards the heavier component.

(-3) Reducing the volume of insulation used on the thinner section heated band in order to achieve the desired temperature profile across the soak band.

In such instances, additional monitoring thermocouples shall be used to insure that the required temperatures are achieved on both the thinner and heavier wall thickness components.

(-d) Butt Welds Joining Branch Connections or Attachments to Piping.

(-1) For welds joining branch connections or attachments to pipe, circumferential band PWHT practices, shall be used on both the piping cylindrical components, and the connection. The entire nozzle or attachment shall be included in the soak band.

(-2) For branch connections, where the heating pads fitted to the weld will not contour to the shape without leaving larger than normal gaps between the heaters, additional monitoring thermocouples shall be placed in the expected cold spots to ensure that the cold spots achieve the desired temperature.

(-3) Where small branch connections, 1/2 to 1-1/2 in. (13 to 38.1 mm) diameter, are welded to larger pipe-sections, circumferential bands around both the larger pipe and smaller branch connection, shall be heated using heaters with control thermocouples on the larger pipe and with monitoring thermocouples on the smaller branch connection. If separate control zones are used for the larger pipe and smaller branch connection, they shall each have separate control thermocouples.

(-e) Intersection with Branch Connections and Attachments not Requiring PWHT.

The soak band, heated band, and/or gradient control band of welds which require PWHT may intersect branch connections or attachments which do not require PWHT. In order to avoid distortion and/or induced residual stresses during PWHT, the temperature gradient across the components that are intersected shall be minimized. This may require the application of a supplementary heat source(s) to the branch connection or attachment.

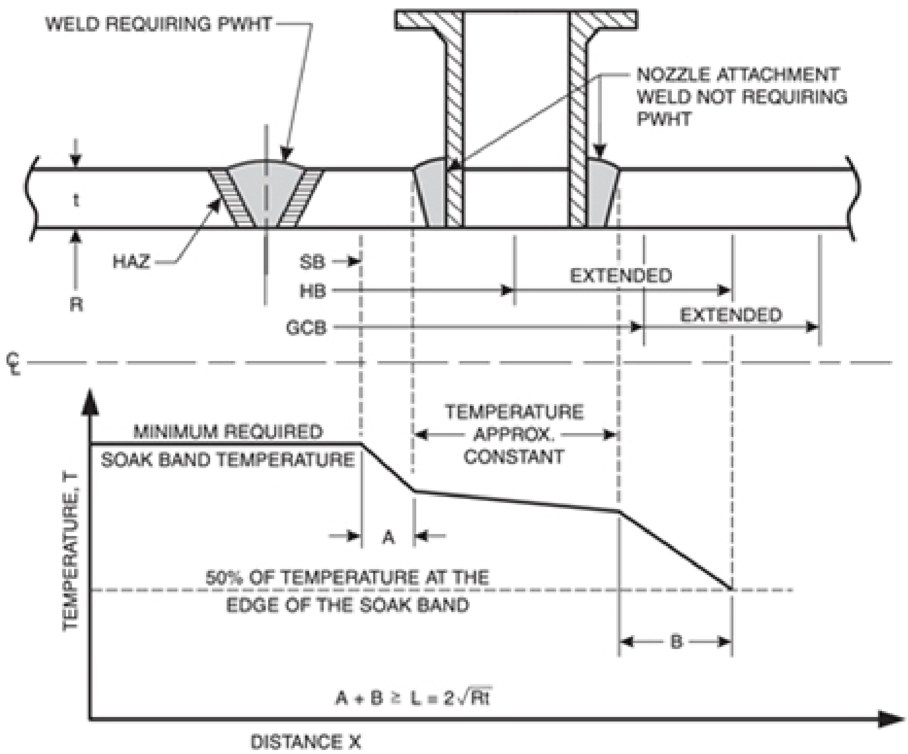
(-1) Alternatively, a reasonably uniform temperature shall be maintained across these components. The soak band, heated band or gradient control band, whichever intersects, shall be extended in the axial direction such that it ends beyond the weld on the opposite side connecting the attachment or associated pad to the component, for at least half of the soak band, heated band or gradient control band, whichever is appropriate.

(-2) Figure 7 provides an example of such an approach when the heated band from a weld requiring PWHT intersects a nozzle which does not require PWHT. Note that the total distance over which the temperature drops from that at the edge of the soak band to 50% (A plus B) is greater than or equal to $L = 2\sqrt{(Rt)}$.

(-3) It should be noted that although the non-specific term “reasonably uniform” is used to describe the temperature drop across the intersected component. The aim is to maintain a “reasonably constant” temperature drop across the intersected component. However, in order to provide a measurable limit, a maximum temperature drop is recommended as stated below.

(-4) The maximum temperature drop across an intersected component shall be 100°F (55°C) or that resulting from application of the maximum permissible axial temperature gradient.

(-5) It is also recognized that based upon experience or analysis, larger temperature gradients across nozzles or attachments may exhibit permissible levels of distortion or residual stress.



Notes:

1. The nozzle attachment weld shown as "not requiring PWHT" does not imply that such a weld would not require PWHT. It simply means that it does not require PWHT now. For example, it may have previously received PWHT.
2. The intent is to maintain an "approximately constant" temperature across the intersected component. However, a maximum temperature drop of 100°F (55°C) **or** that resulting from application of the maximum recommended axial temperature gradient, whichever is less, is permitted.

Nomenclature:

SB = Soak band (width of the volume of the material where the holding temperature equals or exceeds the minimum and equals or is below the maximum required. The minimum width is typically specified as a multiple of t on each side of the weld).
L = Minimum distance over which the temperature may drop to one half of that at the edge of the soak band.
HB = Heated band (width of heat source).
GCB = Gradient control band (minimum width of insulation and/or gradient heat source).
t = Nominal thickness of pipe.
R = Inside radius of pipe.

Figure 7 Example of One Approach When the Heated Band from a Weld Requiring PWHT Intersects a Weld Not Requiring PWHT

(-f) Proximity of Pipe-to-Nozzle Welds to Shell or Head.
Consideration shall be given to whether local circumferential band PWHT of pipe-to-nozzle welds may result in heating the nozzle and/or surrounding shell or head section to temperatures that may cause distortion and harmful induced stresses.

(-g) Lower Critical Temperature of P-No.15E Weld Metal (LCT).
Variations in P-No.15E weld metal chemistry are known to have a significant effect on its lower critical transformation temperature. Consideration shall therefore be given to ensuring that the upper limit of the heat treatment temperature does not exceed the LCT of the weld metal.

(g) The Thermal Cycle, PWHT

It is important to control four aspects of the thermal cycle associated with heating operations. These include temperature uniformity, the heating rate above a specified temperature, the specified hold temperature and time, and the cooling rate down to a specified temperature.

(1) Maximum Temperature Differences for PWHT
During heating and cooling, the maximum temperature difference within the heated band shall be 250°F (139°C) or, as limited by the maximum axial temperature gradient.

(2) The Maximum Heating Rate.
Above 800°F (425°C), the rate of heating shall be not more than 400°F/hr (222°C/hr) divided by the maximum material thickness in inches, but in no case more than 400°F/hr (222°C/hr).

(3) The Maximum Hold Temperature and Time.
During hold, the requirements for the maximum hold temperature and time shall be as defined in Table 132.

(4) The Maximum Cooling Rate.
Above 800°F (425°C), the rate of cooling shall be not more than 500°F/hr (278°C/hr) divided by the maximum material thickness in inches, but in no case more than 500°F/hr (278°C/hr).

(h) Insulation

(1) Classification of Insulation.
The requirements for the gradient control band width are based upon insulation R-values of 2°–4°F-ft^2-hr/Btu (0.35°– 0.70°C-m^2/W). Refractory ceramic fiber insulation with a density of 6–8 lbs/ft^3 (96.1– 128.1 kg/m^3) meets this requirement.
A minimum 1 in. (25 mm) layer shall be used for temperatures up to 1200°F (650°C), a minimum 2 in. (50 mm) layer shall be used for temperatures above 1200°F (650°C).

(2) Attachment of Insulation.
The pieces of insulation shall be sized such that when the piece(s) are wrapped around the pipe, the pipe surfaces shall be fully covered with either the ends of the insulation butted against themselves, or overlapped to preclude heat loss. No gaps shall be permitted in the insulation layer and any inadvertent gaps should be filled with insulation. The insulation may be held in place with banding or tie wire. The insulation shall not be compressed to less than 3/4 of its original thickness during banding or tying.

(3) During heating, the insulation has a tendency to shrink, and in doing so, create gaps. Inspection shall therefore be carried out at various times during the heating cycle to identify and rectify any gaps that may occur during the heating.

(4) When multiple layers of insulation are used, the seams shall be staggered to minimize the possibility of gaps.

(5) The insulation shall extend beyond the edge of the heated band out to the edge of the gradient control band to diminish heat losses and assure that the permissible maximum axial temperature gradient from heated to unheated sections is not exceeded.

(i) Quality Assurance System
In order to insure that local heating operations are in compliance with this code, all heating shall be performed in accordance with an established quality assurance system.

(1) Quality System.
All work shall be performed in accordance with a written quality assurance system. This system shall be described in a Quality Assurance Manual and shall define the organizational structure, responsibilities, procedures, processes and resources for implementing quality management. The written description of the quality assurance system shall be available for review.

(2) Process Control.
The use of written procedures and associated drawings shall be used. The Standard Procedure for Local Heating shown in Attachment 1, or an equivalent, shall be used in conjunction with a drawing/sketch which specifies placement of thermocouples, heat sources (including control zones) and insulation.

(3) Documentation.
A permanent record of the thermal cycle shall be produced. The temperature resolution of the record shall be to within 5°F (3°C), and the time resolution shall be to within 5 minutes.

(-a) The record of the thermal cycle shall be submitted to the customer upon the completion of local heating. The record of the thermal cycle should contain information such as the temperature and time scales and correspondence between thermocouple numbers on the record and the drawing/sketch. The records provided may be either electronic, or printed copy.

(-b) Copies of the procedures, drawings/sketches, Certificates of Conformance for thermocouple/ extension wire, and temperature recording device calibration records shall be submitted to the customer along with the record of the thermal cycle for each weld or group of welds.
(-c) The Standard Documentation Checklist for Local Heating in Attachment 2 shall be used as a basis for provision of documentation. While the format of the check list need not be identical, the information it includes shall be the same. This checklist, plus supporting documentation, shall be submitted to the customer at the completion of local heating.

(4) Control of Inspection, Measuring, and Test Equipment.
All thermocouples/extension wire shall be traceable to Certificates of Conformance. Calibration of temperature indicators/recorders shall be traceable to national standards, such as those maintained by the National Institute for Standards and Technology (NIST).

(5) Training.
All personnel performing local heating shall be trained in the proper use and application of the associated processes and equipment, including safety, calibration, maintenance, and inspection considerations.
Each organization shall be responsible for defining its own training program, and documentation of such training shall be maintained, and if requested shall be made available.

(6) Servicing.
All equipment should be serviced at appropriate intervals as recommended by the manufacturer to insure proper performance. Documentation of such servicing shall be maintained, and shall be made available on request.

(j) Other Considerations
Additional issues shall be considered when performing local heating of pipe.
These include:
(1) The structural integrity of the pipe.
(2) Does the piping have sufficient strength at temperature to be self-supporting?
(3) Will the piping experience an unacceptable permanent distortion?
(4) Natural Convection within the pipe.
(5) Consideration shall be given to natural convection within otherwise sealed off sections of piping. Closing valves, blinding flanges and other techniques to seal off a section of piping may not prevent this form of natural convection. The resulting circulating air flow can cause undesirable heat transfer on the inside surface of the pipe. For pipe in the horizontal position, this can result in significant temperature differences between the 12:00 and 6:00 o'clock positions.
(6) Natural drafts can occur when a flow of air is possible through parts of a piping system that are not sealed off. This is often referred to as the "chimney effect". Such flow can result in considerable convection losses on the inside surface of the pipe.

(7) Thermal expansion of the pipe.
Large thermal stresses can be developed during PWHT if adequate provisions to permit thermal growth are not made.
(8) The presence of internal fluids within or adjacent to the heated area.

ATTACHMENT 1

Standard Procedure for Local Heating

Procedure No.: ________________ Revision No.:________ Date: _____________

Governing Code: _____________________________

Work piece Identification Number: _____________________

Material Specification: ________________________

Component Dimensions: ________________________

Thermocouple, Heater and Insulation Layout Drawing Number: _______________

Thermal Cycle

Heating Rate: _______________ °__/hour (specify max. or min.) above ______ °___

Hold Temperature Range: __________ to _________ °___

Minimum Hold Time: __________ hours Maximum Hold Time: __________ hours

Cooling Rate: _______________ °__/hour (specify max. or min.) above ______ °___

Steps

1.1. Match procedure/drawings to work piece, including verification of work piece identification number. Check the appropriateness of specified thermal cycle to the material and application.

Completed by: __________________ Date: ________

1.2. Install and test power/control equipment, including power supplies, temperature controllers, and temperature recorders.

Completed by: __________________ Date: ________

1.3. Check validity of calibration date on all temperature recorders. Enter serial number and date next calibration due for each recorder.

Serial number: _______________ Date Next Calibration Due: _________

Serial number: _______________ Date Next Calibration Due: _________

Serial number: _______________ Date Next Calibration Due: _________

Serial number: ________________ Date Next Calibration Due: _________

Completed by: ___________________ Date: ________

1.4. Install thermocouples (including spares) per drawing/sketch using approved methods. See direct attachment by capacitor discharge welding section (e)(4).

Completed by: ___________________ Date: ________

1.3. Verify specified (per drawing/sketch) placement of thermocouples.

Verified by: ___________________ (QC Inspector) Date: ________

1.6. Install heat sources and insulation per drawing/sketch using approved methods.

Completed by: ___________________ Date: ________

1.7. Verify specified (per drawing/sketch) placement of heat sources and insulation before the start of heating.

Verified by: ___________________ (QC Inspector) Date: ________

1.8. Install and connect thermocouple extension wire. Check operation of all thermocouples. Check for reversal of thermocouple polarity. Note that it may only be possible to detect a double polarity reversal visually. (When checking for polarity reversal, use the mnemonic device **BIG-RED-NEGATIVE** as a guide.)

Completed by: ___________________ Date: ________

1.9. Install and connect power cables. Check operation of all heat sources.

Completed by: ___________________ Date: ________

1.10. Obtain approval to begin the heating operation.

Approved by: ___________________ (QC Inspector) Date: ________

1.11. Perform and document periodic checks during heating, including equipment operation (recorder and power supplies) and adherence to specified heating rate. If a deviation occurs during heating, follow approved corrective action. If it appears that achieving the hold temperature will be difficult and requires excessive time, the QC Inspector should be notified and a decision made regarding whether to continue heating.

Completed by: ___________________ Date: ________ Time: _____

Completed by: ___________________ Date: ________ Time: _____

Completed by: ___________________ Date: ________ Time: _____

1.12. Verify the start of the hold period, i.e. all soak band thermocouples are within the required temperature range.

Verified by: ___________________ (QC Inspector) Date: ________

1.13. Perform and document periodic checks during the hold period, including equipment operation (recorder and power supplies) and adherence to required hold temperature range. If a deviation occurs during the hold period, follow approved corrective action. A maximum time in the hold temperature range may be specified for certain materials. If it appears that the maximum time limit will be exceeded, the QC Inspector should be notified and a decision made regarding whether to continue heating.

Completed by: ___________________ Date: ________ Time: _____

Completed by: ___________________ Date: ________ Time: _____

Completed by: ___________________ Date: ________ Time: _____

Completed by: ___________________ Date: ________ Time: _____

Completed by: ___________________ Date: ________ Time: _____

1.14. Verify completion of the hold period, i.e. all soak band thermocouples remained within the required temperature range for the minimum required time. Must be verified before the start of cooling.

Verified by: ___________________ (QC Inspector) Date: ________

1.15. Perform and document periodic checks during cooling period, including equipment operation (recorder and power supplies) and adherence to specified cooling rate. If a deviation occurs during cooling, follow approved corrective action.

Completed by: ___________________ Date: ________ Time: _____

Completed by: ___________________ Date: ________ Time: _____

Completed by: ___________________ Date: ________ Time: _____

1.16. Deactivate power/control equipment after the temperature is below that where cooling rate control is required.

Completed by: ___________________ Date: ________

1.17. Remove all equipment after the temperature is safe for personnel. Cut thermocouple wires and mark locations of attached thermocouples for light filing/grinding.

Completed by: ___________________ Date: ________

1.18. Note any deviations such as heating rate, hold time and temperature, or cooling rate which occurred during the thermal cycle. If no deviations occurred, enter “None”.

____

____

____

____

____

Completed by: ___________________ Date: ________

1.19. Complete and submit to the Customer appropriate documentation in accordance with Standard Documentation Checklist (Attachment 2).

Received by: __________________ (Customer’s Representative) Date: ________

ATTACHMENT 2

Standard Documentation Checklist for Local Heating

The following documentation shall be provided by the supplier of local heating services at the completion of work:

2.1. Procedure (Attachment 1) with **all** required information completed ____

2.2. Drawings/sketches for thermocouple, heater and insulation layout ____

2.3. Thermocouple and extension wire Certificates of Conformance ____

2.4. Certified Material Test Reports for any filler metals being used that match the P-No. 15E materials. The customer shall provide a copy of the CMTRs for filler metals matching the P-No. 15E materials being heat treated, which shall include the Lower Critical Transformation Temperature.

2.5. Temperature recorder calibration records ____

2.6. Hardness testing results (if applicable) ____

2.7. Strip chart record of the entire thermal cycle with the following information

a. Date(s), time period and location work performed ____

b. Identification of contractor/personnel performing the work ____

c. Identification number of the work piece ____

d. Temperature and time scales ____

e. Correspondence between thermocouple numbers on the chart(s) and drawing/sketch ____

f. Heating rate above specified temperature ____

g. Hold period temperature and time ____

h. Cooling rate above specified temperature ____

B31 Case 206

Approval Date: August 30, 2018
Fe-10.5Cr-0.5Mo-V-Nb Material

ASME B31.1 Power Piping

Inquiry: May Fe-10.5Cr-0.5Mo-V-Nb**,** UNS K91060, seamless tubes, seamless pipes, forgings and fittings, with the chemical analysis shown in Table 1, mechanical properties listed in Table 2, otherwise conforming to the specifications listed in Table 3 be used in B31.1 construction?

Reply: Yes, the material described in the inquiry may be used in B31.1 construction provided the following additional rules are met:

(a) The material shall be austenitized within the temperature range of 1050°C-1100°C (1920°F-2010°F) and tempered in the range of 750°C to 790°C (1380°F to 1455°F).
(b) The maximum tube or pipe wall thickness shall be 76.2 mm (3 in)
(c) The rate of cooling at mid-thickness from 900°C to 482°C (1,650°F to 900°F) shall be no slower than 5°C/min (9°F/min).
(d) The material shall have a hardness inclusively in the range of 190 to 250 HBW/196 to 265 HV [91 HRB to 25 HRC]
(e) The maximum allowable stress values for the material shall be those given in Tables 5M and 5.
(f) The maximum design temperature shall be 650°C (1202°F)
(g) Separate Welding Procedure Qualification in accordance with Section IX shall be required for this material. For purposes of Performance Qualification this material shall be considered P-No. 15F, Group 1. Welding shall be limited to the GTAW, SMAW and SAW processes.
(h) Post weld heat treatment is required, and it shall be performed between 730°C– 780°C (1345°F – 1435°F). The hold times for PWHT shall be as shown in ASME B31.1 Table 132 for P-No. 15E, Group 1 material
(i) Cold-forming rules of Table 129.3.3.1 shall apply, except austenitizing shall be as in (a) above. Specifically for cold formed flares, swages, and upsets in tubing or pipe, regardless of the dimension and the amount of cold work, the material shall be re-austenitized and tempered in accordance with (a) above.
(j) If during the manufacturing, any portion of the component is heated to a temperature greater than 790°C (1455°F) then the component must be re-austenitized and re-tempered in its entirety in accordance with (a), or that portion of the component heated above 790°C (1455°F), including any zone nearby similarly affected by the local heating, must be replaced, or must be removed, re-austenitized, and re-tempered, and then replaced in the component.
(k) Weld strength reduction factors for the CSEF steel group in Table 102.4.7 with note 11 shall apply when applicable.
(l) For external pressure design, Figure CS-3 of Section II Part D shall be used.
(m) This case number shall be shown in the documentation and marking of the material and on the Manufacturer's Data Report.

Table 1 Chemical Requirements	
Element	Composition Limits, %
Carbon	0.08-0.13
Manganese	0.20-0.50
Phosphorous, max.	0.020
Sulfur, max.	0.005
Silicon	0.15-0.45
Chromium	10.0-11.0
Molybdenum	0.40-0.60
Nickel, max.	0.25
Vanadium	0.18-0.25
Niobium	0.02-0.06
Nitrogen	0.030-0.070
Copper, max.	0.10
Aluminum, max.	0.02
Titanium, max.	0.01
Boron, max.	0.001
Zirconium, max.	0.01
Arsenic, max.	0.010
Tin, max.	0.010
Antimony, max.	0.003
Lead	Report
Tungsten, max.	0.05
N/Al ratio, min.	4.0
CNB (1), max.	10.5

Note (1) The Chromium-Nickel balance is defined as CNB = (Cr + 6Si + 4Mo + 1.5W + 11V + 5Cb + 9Ti + 12Al) - (40C + 30N + 4Ni + 2Mn + 1Cu)

Table 2 – Mechanical Property Requirements

Tensile strength, min., MPa (ksi)	620 (90)
Yield Strength, min., MPa (ksi)	450 (65)
Elongation, 50.8 mm (2 in.), min., % [Note (a)]	20

Note:
(a) For longitudinal strip tests on pipe and tube, a deduction from the basic values of 1.00% for each 0.8 mm (1/32 in.) decrease in wall thickness below 7.8 mm (5/16 in.) shall be made. The following table gives the computed values.

Table 2a – Computed Minimum Values

Wall Thickness	Minimum Elongation in 50.8 mm [2 in.], min., %
7.8 mm [5/16 (0.312) in.]	20.0
7.1 mm [9/32 (0.281) in.]	19.0
6.4 mm [1/4 (0.250) in.]	18.0
5.3 mm [7/32 (0.219) in.]	17.0
4.8 mm [3/16 (0.188) in.]	16.0
4.0 mm [5/32 (0.156) in.]	15.0
3.2 mm [1/8 (0.125) in.]	14.0
2.4 mm [3/32 (0.094) in.]	13.0
1.5 mm [1/16 (0.062) in.]	12.0
0.9 to 1.5 mm [0.062 to 0.035 in.], excl.	11.6
0.6 to 0.9 mm [0.035 to 0.022 in.], excl.	10.9
0.4 to 0.6 mm [0.022 to 0.015 in.], incl.	10.6

General Note:
(a) Where the wall thickness lies between two values shown above, the minimum elongation value shall be determined by the following equation.

E = 1.25t + 10.00 [E = 32t + 10.00]
Where
E=elongation in 50.8 mm (2 in.), %
t=actual thickness of specimen, mm (in.)

Table 3 Specifications	
Forgings	A182
Fittings	A234
Seamless Tube	A213
Seamless Pipe	A335

Table 4M - Metric
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding °C	Stress, MPa
21	177
40	177
65	177
100	177
125	175
150	172
175	170
200	168
225	166
250	165
275	164
300	163
325	161
350	159
375	156
400	152
425	148
450	142
475	135
500	127
525	118
550	108
575	*85.0 [1]*
600	*63.3 [1]*
625	*45.3 [1]*
650	*29.8 [1]*

Note (1) These values are obtained from time-dependent properties.

Table 4 – US Customary
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Stress, ksi
75	25.7
100	25.7
200	25.7
300	25.0
400	24.3
500	23.9
600	23.4
650	23.1
700	22.7
750	22.1
800	21.4
850	20.4
900	19.2
950	17.9
1000	16.3
1050	*13.7 (1)*
1100	*10.0 (1)*
1150	*6.9 (1)*
1200	*4.4 (1)*
1250[a]	*2.2 (1)*

Note (1) – These values are obtained from time-dependent properties.

[a] The value at 1250°F is for interpolation only; the maximum design temperature is 1202°F

B31 CASE 207
Use of ASTM A479 , Type 304L, Type 316, and Type 316L stainless steel bars, in ASME B31.12 Construction

Approval Date: May 22, 2018

Inquiry: Under what condition may ASTM A479, Type 304L, Type 316, and Type 316L stainless steels in bar form be used in B31.12 construction?

Reply: It is the opinion of the Committee that these materials may be used in B31.12 construction provided the following requirements are met:

(1) Basic allowable stresses for ASTM A479, Type 304L, Type 316, and Type 316L stainless steel shall be in accordance with ASME B31.3 Table A-1or A1-M.
(2) All applicable notes of Table A-1 or A1-M specified in ASME B31.3 shall be met.
(3) The material is exempted from impact testing requirements at design minimum temperature of -425°F (-255°C) or warmer. All other low temperature toughness test requirements of B31.12 shall be followed.

B31 Code Case 208-1
Approval Date: January 24, 2022
ASME B31.3 Process Piping

18Cr-11Ni-Cb-N, 347LN UNS S34751 Austenitic Stainless Steel Seamless Tubes, Seamless and Welded Pipe, Pipe Flanges, Forged Fittings, Valves and Parts, Wrought Piping Fittings, Forgings and Plate and Sheet
ASME B31.3

Inquiry: May UNS S34751 solution annealed austenitic stainless steel seamless tubes, seamless and welded pipe, pipe flanges, valves and parts, wrought piping fittings, forgings, plate and sheet meeting the requirements of ASTM A213/A213M-21a, A312/A312M-21, A376/A376M-19, A358/A358M-19, A182/A182M-21, A403/A403M-20, A965/A965M-21, and A240/A240M-20a be used in welded construction under the rules of ASME B31.3?

Reply: Yes, provided that the following additional requirements are met:

(a) The maximum allowable stress values shall be as given in Table 1.
(b) The maximum use temperature is 677°C (1250°F).
(c) The material shall be considered as P-No 8, Group 1.
(d) For temperatures above 538°C (1000°F), the stress values in Table 1 may be used only if the material has been heat treated at a temperature of 1040°C (1900°F) minimum.
(e) The minimum design temperature for this material shall be -200°C (-325°F), however, when a specification permits this material to be furnished without solution heat treatment or with other than a solution heat treatment, the minimum design temperature shall be -29°C (-20°F) unless the material is impact tested in accordance with para. 323.3.
(f) For post fabrication strain limits in the lower temperature range exceeding design temperature 540°C (1000°F) and forming strain of 15% and in the high temperature range exceeding 675°C (1250°F) and forming strains of 10%, the minimum heat treatment temperature shall be 1040°C (1900°F).

Table 1
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Allowable Stress [Note (1)], MPa		For Metal Temperature Not Exceeding, °F	Allowable Stress [Note (2)], ksi
40	138		100	20.0
65	138		200	20.0
100	138		300	20.0
125	138		400	**19.7**
150	138		500	**18.3**
175	138		600	**17.4**
200	137		650	**17.2**
225	132		700	**17.0**
250	128		750	**16.9**
275	124		800	**16.8**
300	122		850	**16.8**
325	120		900	**16.8**
350	118		950	**16.8**
375	117		1000	**16.7**
400	116		1050	**16.6**
425	116		1100	12.9
450	116		1150	9.56
475	116		1200	7.03
500	116		1250	5.11
525	115			
550	115			
575	**111**			
600	**83.0**			
625	**63.2**			
650	**47.8**			
675	**35.9**			
700	**26.9[Note (3)]**			

Note (2): The fonts used are in accordance with B31.3 Table A-1 Note 4a.

Note (1): The fonts used are in accordance with B31.3 Table A-1 Note 4b

Note (3): The maximum use temperature for this alloy is 677°C (1250°F). The value listed at 700°C is provided for interpolation purposes only.

B31 Case 209

Piping System Stress Analysis Examples

ANNULLED

Annulment Date: January 24, 2022

Reason: Code Case 209 no longer needed as Appendix S has been updated to align with the base code in the B31.3-2020 Edition.

B31 Case 210
47Ni-23Cr-23Fe-7W, UNS N06674, Alloy Seamless Pipe and Tube, and Forgings
ASME B31.1
Approval Date: November 15, 2018

Inquiry: May solution annealed 47Ni-23Cr-23Fe-7W, UNS N06674, alloy seamless pipe and tube, and forgings conforming to the specifications listed in Table 1, be used under the rules of ASME B31.1?

Reply: Yes, the material described in the inquiry may be used under the rules of ASME B31.1, provided the following additional requirements are met:

(a) The product forms and specifications are shown in Table 1.

(b) The *y* values shall be as follows:

(1) 1050°F (565°C) and below: 0.4

(2) 1100°F (595°C): 0.5

(3) 1150°F (620°C) and above: 0.7

(c) Post-forming heat treatment shall be required for temperatures up to the maximum use temperature, as follows:

(1) For temperatures exceeding 1050°F (565°C) but lower than 1200°F (650°C), with forming strains exceeding 15%

(2) For temperatures exceeding 1200°F (650°C) with forming strains exceeding 10%.

(3) Heat treatment of bends and formed components as noted in para. 129.3 shall be required.

(4) Heat treatment after cold-working as noted in 1, 2 and 3 above shall be solution annealing by heating to a minimum temperature of 2150°F (1175°C) followed by quenching in water or rapid cooling by other means.

(d) Mechanical properties shall be as shown in Table 2.

(e) Mean linear thermal expansion coefficients shall be as shown in Tables 3 and 3M.

(f) Modulus of elasticity values shall be as shown in Tables 4 and 4M.

(g) The maximum allowable stress values for the material shall be as given in Tables 5 and 5M. The maximum design temperature shall be 1472°F (800°C).

(h) Separate welding procedure and performance qualifications in accordance with Section IX shall be required for this material. The material shall be considered P-No. 45 for the purpose of performance qualifications.

(i) Heat treatment after welding is neither required nor prohibited, but if performed it shall be by solution annealing, by heating to a minimum temperature of 2150°F (1175°C) followed by quenching in water or rapid cooling by other means.

(j) This Case number shall be referenced in the documentation and marking of the material and shown on the Manufacturer's Data Report.

Table 1
Specifications

Product Form	ASTM Designation
Forgings	B564-17a
Seamless pipe and tube	B167-11(2016)

Table 2

Mechanical Properties Requirements

Tensile strength, min., ksi (MPa)	86(590
Yield strength, min., ksi (MPa)	34(235)
Elongation in 2 in., min., %	30

Table 3
Mean Linear Thermal Expansion Coefficients

Temperature Range, °F	Coefficient (in./in./°F)
70 – 100	7.3×10^{-6}
70 – 200	7.5×10^{-6}
70 – 300	7.7×10^{-6}
70 – 400	7.9×10^{-6}
70 – 500	8.0×10^{-6}
70 – 600	8.1×10^{-6}
70 – 700	8.2×10^{-6}
70 – 800	8.3×10^{-6}
70 – 900	8.4×10^{-6}
70 – 1,000	8.4×10^{-6}
70 – 1,100	8.4×10^{-6}
70 – 1,200	8.5×10^{-6}
70 – 1,300	8.8×10^{-6}
70 – 1,400	8.9×10^{-6}
70 – 1,500	9.0×10^{-6}
70 – 1,600	9.1×10^{-6}
70 – 1,700	9.2×10^{-6}
70 – 1,800	9.3×10^{-6}

Table 3M
Mean Linear Thermal Expansion Coefficients

Temperature Range, °C	Coefficient (mm/mm/°C)
20 – 100	13.6×10^{-6}
20 – 200	14.2×10^{-6}
20 – 300	14.5×10^{-6}
20 – 400	14.9×10^{-6}
20 – 500	15.1×10^{-6}
20 – 600	15.2×10^{-6}
20 – 700	15.8×10^{-6}
20 – 800	16.2×10^{-6}
20 – 900	16.4×10^{-6}
20 – 1,000	16.8×10^{-6}

Table 4
Modulus of Elasticity

Temperature, °F	ksi × 10^3
70	27.8
100	27.7
200	27.3
300	26.9
400	26.4
500	25.8
600	25.2
700	24.7
800	24.3
900	23.9
1,000	23.4
1,100	22.7
1,200	22.1
1,300	21.6
1,400	21.1
1,500	20.6
1,600	20.1
1,700	19.6
1,800	18.9

Table 4M Modulus of E lasticity

Temperature, °C	MPa × 10^3
20	192
100	188
200	182
300	175
400	169
500	164
600	156
700	149
800	143
900	137
1,000	129

Table 5
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Stress, ksi	Stress, ksi
100	22.7	22.7
150	…	22.7 (2)
200	20.3	22.7 (2)
250	…	22.7 (2)
300	19.3	22.7 (2)
350	…	22.7 (2)
400	18.6	22.7 (2)
450	…	22.7 (2)
500	18.0	22.7 (2)
550	…	22.7 (2)
600	17.4	22.7 (2)
650	17.0	22.7 (2)
700	16.7	22.6 (2)
750	16.4	22.1 (2)
800	16.1	21.7 (2)
850	15.8	21.3 (2)
900	15.5	21.0 (2)
950	15.3	20.7 (2)
1,000	15.1	20.4 (2)
1,050	15.0	20.3 (2)
1,100	14.9	17.2 (1), (2)
1,150	14.2 (1)	14.2 (1)
1,200	11.8 (1)	11.8 (1)
1,250	9.8 (1)	9.8 (1)
1,300	8.2 (1)	8.2 (1)
1,350	6.9 (1)	6.9 (1)
1,400	5.7 (1)	5.7 (1)
1,450	4.7 (1)	4.7 (1)
1,500	3.7 (1), (3)	3.7 (1), (3)

NOTES:
(1) These stress values are obtained from time-dependent properties.
(2) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of this alloy where slightly greater deformation is acceptable. These higher stress values exceed 66⅔% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for applications where slight amounts of distortion can cause leakage or malfunction.
(3) The maximum use temperature for this alloy is 1472°F (800°C); the value listed at 1500°F is provided for interpolation purposes only.

Table 5M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Stress, MPa	Stress, MPa
40	157	157
65	145	157 (2)
100	139	157 (2)
125	136	157 (2)
150	133	157 (2)
175	131	157 (2)
200	129	157 (2)
225	127	157 (2)
250	125	157 (2)
275	123	157 (2)
300	121	157 (2)
325	119	157 (2)
350	117	157 (2)
375	115	155 (2)
400	113	152 (2)
425	111	150 (2)
450	109	147 (2)
475	108	145 (2)
500	106	143 (2)
525	105	142 (2)
550	104	140 (2)
575	103	136 (1), (2)
600	103	113 (1), (2)
625	95.2 (1)	95.2 (1)
650	80.6 (1)	80.6 (1)
675	68.6 (1)	68.6 (1)
700	58.4 (1)	58.4 (1)
725	49.6 (1)	49.6 (1)
750	42.0 (1)	42.0 (1)
775	35.2 (1)	35.2 (1)
800	29.2 (1)	29.2 (1)

NOTES:
(1) These stress values are obtained from time-dependent properties.
(2) Due to the relatively low yield strength of this material, these higher stress values were established at temperatures where the short time tensile properties govern to permit the use of this alloy where slightly greater deformation is acceptable. These higher stress values exceed 66⅔% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for applications where slight amounts of distortion can cause leakage or malfunction.

B31 Case 211

Alternative Heat Treatments for Fabrication Processes
Approval Date: March 13, 2019

ASME B31.1 Power Piping

Inquiry: May the heat treatment requirements specified in ASME B31P be used as an alternative to the required heat treatments specified in paras. 129.3, 131, and 132 of ASME B31.1?

Reply: It is the opinion of the Committee that the heat treatments specified in ASME B31P may be used as an alternative to the respective heat treatments specified in ASME B31.1 for the materials referenced in ASME B31P.

B31 CASE 212
Use of 9Cr-3W–3Co–Nd–B Material, in ASME B31.1 Construction
ASME B31.1 Power Piping
Approval Date: March 13, 2019

Inquiry: May normalized and tempered 9Cr-3W-3Co-Nd-B seamless tubes, pipes, and forgings conforming to the chemical analysis shown in Table 1, the minimum mechanical properties listed in Table 2, and otherwise conforming to the specifications listed in Table 3 be used for ASME B31.1 construction?

Reply: Yes, provided the following additional requirements are met:

(a) The material shall be normalized at 1,960°F to 2140°F (1,070°C to 1,170°C) and tempered at 1,380°F to 1455°F (750°C to 790°C) as final heat treatment.

(b) The material shall not exceed a Brinell Hardness Number of 250 HBW (25 HRC).

(c) The maximum design temperature shall be 1,200°F (649°C).

(d) The maximum allowable stress values for the material shall be those given in Tables 4 and 4M.

(e) Separate welding procedure qualifications conducted in accordance with Section IX shall be required for this material. For the purpose of performance qualification, the material shall be considered P-No. 15E, Group 1.

(f) Postweld heat treatment for this material is mandatory, and the following rules shall apply:

(1) The time requirement shall be as given for P-No. 15E, Group 1 materials in Table 132.

(2) The PWHT temperature range shall be 1350°F to 1455°F (730°C to 790°C).

(g) All cold-formed material shall be heat treated as follows:

(1) Cold-forming is defined as any forming that is performed at a temperature below 1,300°F (705°C) and produces permanent strain in the material.

(2) The forming strains shall be calculated using the equations of para. 129.3.4.1. When the forming strains cannot be calculated as shown in para. 129.3.4.1, the Manufacturer shall have the responsibility to determine the maximum forming strain, except as limited by (3) and (8).

(3) For cold-formed flares, swages, or upsets in tubing or pipe, the material shall be normalized and tempered in accordance with (8).

(4) For design temperatures exceeding 1000°F (540°C) but less than or equal to 1115°F (600°C), and cold-forming strains greater than 25%, the material shall be normalized and tempered in accordance with (8).

(5) For design temperatures exceeding 1115°F (600°C) and cold-forming strains greater than 20%, the material shall be normalized and tempered in accordance with (8).

(6) For design temperatures exceeding 1000°F (540°C) but less than or equal to 1115°F (600°C), and cold-forming strains greater than 5% but less than or equal to 25%, the material shall be heat treated the same as noted in (9).

(7) For design temperatures exceeding 1115°F (600°C) and cold-forming strains greater than 5% but less than or equal to 20%, the material shall be heat treated the same as noted in (a).

(8) Normalization and tempering shall be performed in accordance with the requirements of (a) and shall not be performed locally. The material shall either be heat treated in its entirety, or the cold-strained area (including the transition to the undeformed portion) shall be cut away from the balance of the component and heat treated separately, or replaced.

(9) Post-cold-forming heat treatment shall be performed at 1350°F to 1425°F (730°C to 775°C) for 1 h/in. (1 h/25 mm) or 30 min minimum. Alternatively, the material may be normalized and tempered in accordance with (8).

(10) For design temperatures less than or equal to 1115°F (600°C) and cold-forming strains greater than 5% but less than or equal to 25%, if a portion of the component is heated above the post-forming heat treatment temperature, then the component shall be normalized and tempered according to (8).

(11) If a longitudinal weld is made to a portion of the material that is cold-strained, that portion shall be normalized and tempered in accordance with (8).

(12) In all other cases, heat treatment is neither required nor prohibited.

(h) All material formed at or above 1300°F (705°C) shall be renormalized and tempered in accordance with (a). This heat treatment shall not be performed locally. The material shall be either heat treated in its entirety, or the hot-formed area (including the transition) shall be cut away from the balance of the tube or component and heat treated separately or replaced.

(i) Except as provided in (j), if during manufacturing any portion of the component is heated to a temperature greater than 1455°F (790°C), then the component heated above 1455°F (790°C) including the heat-affected zone created by the local heating shall be removed, renormalized, and tempered, and then replaced in the component.

(j) If the allowable stresses to be used are less than or equal to those provided in Table A-2 for Grade 9 material (i.e., A213 T9, A335 P9) at the design temperature, then the requirements of *(i)* may be waived, provided that the portion of the component heated to a temperature greater than 1455°F (790°C) is reheat treated within the temperature range 1350°F to 1425°F (730°C to 775°C).

(k) The Y value shall be the same as ferritic steels in Table 104.1.2(A).

(l) This Case number shall be referenced in the documentation and marking of the material and shall be shown on the Manufacturer's Data Report.

Table 1
Chemical Requirements

Element	Composition Limits, %
Carbon	0.05 - 0.10
Manganese	0.20 - 0.70
Phosphorus, max.	0.020
Sulfur, max.	0.008
Silicon	0.05 - 0.50
Chromium	8.50 - 9.50
Tungsten	2.5 - 3.5
Cobalt	2.5 - 3.5
Nickel, max.	0.20
Vanadium	0.15 - 0.30
Columbium + Tantalum	0.05 - 0.12
Neodymium	0.010 - 0.060
Boron	0.007 - 0.015
Aluminum, max.	0.030
Nitrogen	0.005 - 0.015
Oxygen, max.	0.0050
Iron	Balance

Table 2
Mechanical Property Requirements

Tensile strength, min., ksi (MPa)	90 (620)
Yield strength, min., ksi (MPa)	64 (440)
Elongation in 2 in. (50 mm), min., % [Note (1)]	19

NOTE:

(1) For longitudinal strip tests, a deduction from the basic values of 1.00% for each 1/32 in. (0.8 mm) decrease in wall thickness below 5/16 in. (8.0 mm) shall be made. The following table gives the computed values

Wall Thickness, in.	Elongation in 2 in. (50 mm), Min. %
5/16 (0.312) (8.0 mm)	19.0
9/32 (0.281) (7.2 mm)	18.0
1/4 (0.250) (6.4 mm)	17.0
7/32 (0.219) (5.6 mm)	16.0
3/16 (0.188) (4.8 mm)	15.0
5/32(0.156) (4.0 mm)	14.0
1/8 (0.125) (3.2 mm)	13.0
3/32 (0.094) (2.4 mm)	12.0
1/16 (0.062) (1.6 mm)	11.0
0.062 to 0.035, excl. (1.6 mm to 0.9 mm, excl.)	10.6
0.035 to 0.022, excl. (0.9 mm to 0.6 mm, excl.)	9.9
0.022 to 0.015, incl. (0.6 mm to 0.4 mm, incl.)	9.6

GENERAL NOTE: The above table gives the computed minimum elongation values for each 1/32 in. (0.8 mm) decrease in wall thickness. Where the wall thickness lies between two values shown above, the minimum elongation value shall be determined by the following equation:

$$E = 32t + 9.0 \; [E=1.25t+9.0]$$

where

E = elongation in 2 in. [50 mm], %

t = actual thickness of specimen, in. [mm]

Table 3
Specifications

Material	Specification
Forgings	ASTM A182/A182M-18
Pipe	ASTM A335/A335M-18a
Tube	ASTM A213/A213M-18a

Table 4
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °F	Stress, ksi
−20 to 100	25.7
200	25.7
300	25.1
400	24.3
500	23.8
600	23.3
650	23.0
700	22.7
750	22.2
800	21.7
850	21.0
900	20.2
950	19.2
1,000	18.1
1,050	16.9
1,100	15.5
1,150	*12.0* [Note (1)]
1,200	*6.5* [Note (1)]

NOTE:

(1) These values are obtained from time-dependent properties.

Table 4M
Maximum Allowable Stress Values

For Metal Temperature Not Exceeding, °C	Stress, MPa
−30 to 40	177
100	177
200	168
300	162
400	153
425	150
450	146
475	141
500	135
525	129
550	121
575	113
600	103 [Note (1)]
625	79 [Note (1)]
650	44 [Note (1)], [Note (2)]

NOTES:

(1) These values are obtained from time-dependent properties.

(2) The maximum use temperature shall be 649°C. Datum for 650°C temperature is provided for interpolation purposes.

B31 Case 213
Approval Date: April 22, 2019
Leaded Semi-Red Brass Castings (C84400)
ASME B31.1

Inquiry: May leaded semi-red brass castings (C84400) be used for construction of ball valves?

Reply: It is the opinion of the Committee that leaded semi-red brass castings (C84400) conforming to the requirements of ASTM B584-14 may be used for nonwelded construction of ball valves under the rules of ASME B31.1, provided the following additional requirements are met:

(a) The maximum allowable stress values in tension for the material shall be those given in Table 1.
(b) The maximum design temperature shall be 450ºF (232ºC).
(c) The thermal expansion coefficient for Brass Alloys in B31.1 Table B-1 shall be used. The Modulus of Elasticity values for C83600 in B31.1 Table C-2 shall be used. The density is 0.314 lb/in^3 (8.69 g/cm^3) and the Poisson's ratio is 0.33.
(d) Due to the lead content of this alloy, this material shall not be used in potable water systems.
(e) This Case number shall be referenced in the documentation and marking of the material and shown on the Manufacturer's Data Report.

Table 1
Maximum Allowable Stress Values in Tension

For Metal Temperature, °F, Not Exceeding	Stress, ksi		For Metal Temperature, °C, Not Exceeding	Stress, MPa
100	5.5		40	38.0
150	5.5		65	38.0
200	5.5		100	38.0
250	5.5		125	37.8
300	5.3		150	36.6
350	5.2		175	35.8
400	4.4		200	31.0
450	4.4		225	30.1
			250	29.8

Note: The maximum temperature for this alloy is 450°F (232°C); the value listed at 250°C is provided for interpolation purposes only.

B31 Code Case 214
Approval Date: May 30, 2019
ASME B31.3 Process Piping

Alternative Heat Treatments for Fabrication Processes

Proposal: Code Case to allow the use of ASME B31P, Standard Heat treatments for Fabrication Processes as an alternative to the preheat, PWHT, and PFHT required by B31.3.

Explanation: ASME B31P, Standard Heat treatments for Fabrication Processes, was published in May 2018. In order to allow the use of this Standard by the ASME Codes prior to changes being adopted in the next edition of the respective Codes this Code Case is being proposed to allow B31P to be used as an alternative to the rules currently in the published ASME B31 Codes. A similar Code Case is currently being balloted in ASME B31.1 (18-2339).

Summary of Changes: To allow the use of ASME B31P, Standard Heat Treatments for Fabrication Processes, as an alternative to the heat treatment rules specified in ASME B31. 3.

Referenced Code: ASME B31.3 – 2016 & 2018

Inquiry: May the heat treatment requirements specified in ASME B31P be used as an alternative to the required heat treatments specified in paras. 330, 331, and 332 of ASME B31.3?

Reply: It is the opinion of the Committee that the heat treatments specified in ASME B31P may be used as an alternative to the respective heat treatments specified in ASME B31.3 for the materials referenced in ASME B31P.

B31 Case 215-1
9Cr–1Mo–V Material Compositions
ASME B31.1
Approval Date: February 7, 2022

Inquiry: May seamless tubes, seamless pipes, electric-fusion-welded pipes, fittings, forgings, and plates, consisting of either Type 1 or Type 2 chemical compositions of 9Cr-1Mo-V as listed under for the specifications and grades shown in Table 1, be used in B31.1 construction?

Reply: In the opinion of the committee, yes, provided the following additional requirements are met:

(a) The maximum allowable stress values shall be those shown in Tables 2 and 2M for the temperatures shown. Maximum allowable stress values for temperatures lower than those listed in Tables 2 and 2M shall be taken from Mandatory Appendix A.
(b) Maximum service temperature is limited to 1,200 °F (649 °C), where the allowable stress value at 650 °C listed in Table 2M is provided for interpolation purposes only.
(c) For welding procedure, performance qualification, and PWHT, the material shall be considered P-No. 15E, Group 1.
(d) Cold-forming rules for P-No. 15E materials in 129.3.3.1 shall apply.
(e) Weld strength reduction factors for the creep strength-enhanced ferritic steels in Table 102.4.7-1 shall apply.
(f) Lead (Pb) content shall be measured and reported.
(g) The requirements listed in para. 123.1.7 are met for material specification editions not listed in Mandatory Appendix F or Table 1 below.
(h) For boiler external piping applications, this Case number shall be referenced in the documentation and marking of the material and recorded on the Manufacturer's Data Report.

Table 1
Material Specifications and Grades

Material	Specification	Grade
Fittings	A234/A234M – 18, 18a, 19	WP91
Forgings	A182/A182M – 18, 18a, 19, 19a, 20,,21; A336/A336M – 18, 18a, 19, 21	F91
Plate	A387/A387M – 17a	Grade 91
Seamless Pipe	A335/A335M – 18, 18a, 18b, 19, 19a, 21	P91
Seamless Tube	A213/A213M – 18, 18a, 18b, 19, 19a, 21, 21a	T91
Electric-Fusion-Welded Pipe	A691/A691M – 18, 18a, 19	91
Forged and Bored Pipe	A369/A369M - 18, 18a	FP91

Table 2
Maximum Allowable Stresses, ksi

For Metal Temperature Not Exceeding, °F	Type 1 Allowable Stress, ksi	Type 2 Allowable Stress, ksi
950	17.8	17.8
1,000	16.1	16.3
1,050	12.2	12.6
1,100	8.7	9.1
1,150	5.7	6.1
1,200	3.5	3.7

Table 2M
Maximum Allowable Stresses, MPa

For Metal Temperature Not Exceeding, °C	Type 1 Allowable Stress, MPa	Type 2 Allowable Stress, MPa
525	117	117
550	98.5	102
575	75.5	78.2
600	54.3	57.6
625	36.8	39.2
650	24.0	25.1

B31 Code Case 216
Approval Date: March 29, 2021
ASME B31.3 Process Piping

Use of Enhanced Pressure Ratings for Brazed Copper Tubes and Fittings by Cold Stretch Process

Inquiry: Under what condition may higher pressure ratings be used for ASTM B88 Type L tubes and ASME B16.22 fittings in ASME B31.3 construction?

Reply: It is the opinion of the Committee that enhanced pressure ratings may be used for ASTM B88 Type L tubes and ASME B16.22 fittings in ASME B31.3 construction provided the following conditions are met:

(a) The tubes shall conform to ASTM B88 Type L in the H58 temper.
(b) The fittings shall conform to ASME B16.22.
(c) The maximum design temperature is 38°C (100°F).
(d) The piping shall be limited to Category D and Normal Fluid Services.
(e) External pressure is not permitted.
(f) The maximum tube and fitting nominal or standard size is 3 in.
(g) The joints shall be brazed. The qualification of brazing procedures, brazers, and brazing operators shall be in accordance with para. 328.2. Silver brazing filler metals (BAg-XX) with appropriate flux shall be used in the brazing process.
(h) In brazing qualification, the specimen in the tension test shall break in the base metal outside of the joint with tensile strength equal to or greater than (207 MPa) 30 ksi.
(i) The piping system shall receive a cold stretch operation by hydrostatic or pneumatic pressure test in accordance with para. 345, except the minimum test pressure shall be 1.7 times the design pressure and the maximum test pressure shall be 1.8 times the design pressure. The test pressure shall be maintained for at least 20 min.
(j) The internal design gage pressure, P, shall not exceed the pressure calculated as follows:

$$P = \frac{2St}{D - 0.8t}$$

Where S = 68.9 MPa (10.0 ksi)
t = minimum wall thickness, for ASTM B88 Type L
D = maximum outside diameter, for annealed temper ASTM B88 Type L

(k) Piping flexibility analysis shall be performed in accordance with para. 319 using the basic allowable stresses (S_c and S_h) equal to 41.4 MPa (6.0 ksi).
(l) Analysis of sustained loads shall be performed in accordance with para. 320 using the basic allowable stresses (S_h) equal to 41.4 MPa (6.0 ksi).
(m) Before cold stretch operation, the brazed joints shall be 100% visually examined. The following conditions are not permitted:
    1) The presence of flux residue and unmelted filler metal
    2) Excessive oxidation of the joint
    3) Cracks in braze metal or base material

(n) Additional brazing is not permitted after the cold stretch operation. If a braze repair is required, the following conditions shall be satisfied:
   1) The braze joint to be repaired shall be removed and replaced along with 150 mm (6 in.) of tube on each side of the joint.
   2) The piping shall receive the cold stretch operation as required in (i).

(o) The design, cold stretch and repair records shall be retained by the owner for the life of the piping.

B31 Code Case 217
Approval Date: September 3, 2021
ASME B31.3 Process Piping

Alternative NDE Personnel Qualification and Certification Requirements

Referenced Code: ASME B31.3 – 2018 & 2020

Inquiry: May alternative personnel qualification and certification requirements be used as options to those specified in ASME B31.3, para. 342.1?

Reply: It is the opinion of the Committee that the personnel qualification and certification requirements below may be used as alternatives to those specified in ASME B31.3, para. 342.1:

Personnel performing nondestructive examination to the requirements of this Code shall be qualified and certified for the method to be utilized in accordance with their employer's written practice. The written practice shall be based on the training, examination, and experience requirements of one of the following:

(a) ASME BPVC, Section V, Article 1

(b) ASNT CP-189,

(c) ASNT SNT-TC-1A,

(d) Other national or international central certification program or standard

B31 Code Case 218
Approval Date: January 3, 2023
ASME B31.12 Hydrogen Piping and Pipelines

Use of Enhanced Materials Performance Factors (H_f and M_f) of 1.0 in B31.12 construction

Referenced Code: ASME B31.3 – 2019

Inquiry: Under what conditions may an enhanced value of 1.0 be used for Materials Performance Factors H_f and M_f where the current values of H_f and M_f are less than 1.0 in Tables IX-5A, IX-5B and IX-5C in B31.12 construction?

Reply: It is the opinion of the Committee that an enhanced value of 1.0 can be used in Materials Performance Factors H_f and M_f in Tables IX-5A, IX-5B and IX-5C where the current values of H_f and M_f are less than 1.0 in B31.12 construction provided the following conditions are met:

a) For welded piping components, the following requirements apply:

   1) Welded piping or pipeline materials shall be heat treated in accordance with material specification. As welded piping components are not permitted.

   2) The weld seam shall have a quality factor or longitudinal joint factor of 1.00 in accordance with para. IP-3.2 or para. PL-3.7.1.

b) Post weld heat treatment (PWHT) shall be performed in accordance with Table GR-3.6.1-1. For materials with specified minimum yield strength (SMYS) exceeding 386 MPa (56 ksi), PWHT shall be performed regardless of the thickness and the time and temperature in PWHT shall be in accordance with Table GR-3.6.1-1. Alternative PWHT rules in B31P are not permitted.

c) For industrial piping, nondestructive examination shall be performed in accordance with IP-10. Production hardness acceptance shall be in accordance with Table IP-10.4.3-2. For piping materials with specified minimum yield strength (SMYS) exceeding 386 MPa (56 ksi), the extent of required examination shall be in accordance with para. IP-10.4.2 and modified by Table 1. Fillet welds are not permitted.

d) For pipeline, para. PL-3.7.1(1) Option A (Prescriptive Design Method) shall be used and the material performance factor H_f shall be 1.0.

e) For pipeline, nondestructive examination shall be performed in accordance with para. PL-3.19. The extent of production hardness test shall be 100% when the pipeline material has a SMYS exceeding 386 MPa (56 ksi).

f) Fatigue analysis is required when the piping or pipeline is specified by owner as cyclic service.

g) The application of this Code Case shall be approved by owner.

Table 1. Required Nondestructive Examinations for Piping with SMYS>386 MPa (56 ksi)	
Girth and miter groove welds	100% VT 50% random RT or UT 50% random hardness testing
Longitudinal groove welds	100% VT 100% RT or UT 100% hardness testing

B31 Case 219
Ni-Cr-Co-Mo-Ti Precipitation Hardened Alloy UNS N07208
ASME B31.1
Approval Date: February 1, 2023

Inquiry: May Ni-Cr-Co-Mo-Ti precipitation hardened alloy (UNS N07208) wrought bar, fittings, forgings, forgings stock, plate, sheet, strip, seamless pipe and tube, and welded pipe and tube be used in welded and nonwelded construction under ASME B31.1 rules?

Reply: Yes, in the opinion of the Committee Ni-Cr-Co-Mo-Ti precipitation hardened alloy UNS N07208 material, as described in the inquiry, may be used, provided the following additional requirements are met:

(a) The various product forms for this alloy conforms to the specifications listed in Table 1.
(b) The chemical composition of this alloy conforms to Table 2.
(c) The maximum design temperature is 1600°F (870°C).
(d) The material shall be:
   1) Solution annealed within the temperature range of 2000°F – 2125°F (1095°C – 1160°C) for 30 minutes per 1 inch (25 mm) of thickness followed by water quenching or rapid air cooling; and then
   2) Aged within the temperature range of 1450°F – 1550°F (790°C – 840 °C) for 4 hours minimum followed by air cooling.
(e) As an alternative to (d), the material may be supplied in the solution annealed condition provided the following requirements are met:
   1) The material supplied in the solution annealed conditions shall have a maximum tensile strength of 150.0 ksi (1035 MPa) and a maximum yield strength of 100.0 ksi (690 MPa). It shall also have minimum elongation of 30% in 2 in. (50 mm) or 4*D* (refers to diameter of the tensile specimen) gage length.
   2) The material supplier marks the material as solution annealed.
   3) The heat treatment requirements of (d)(2) shall be performed on a sample from the material to demonstrate compliance with this Code Case. The material shall be aged and air cooled in accordance with (d)(2) by the Manufacturer to obtain the mechanical properties of this Code Case. Local heat treatment is not permitted. The extent of testing shall be as defined in the specifications listed in Table 1.
(f) The density is 0.30 lb/in^3 (8300 kg/m^3).
(g) Poisson's ratio is 0.31.
(h) The room temperature tensile properties of this alloy shall be those listed in Tables 3 and 3M.
(i) The maximum allowable stress values for the material shall be those listed in Tables 4 and 4M.

(j) The elevated temperature tensile strength values for the material shall be those listed in Tables 5 and 5M.
(k) The elevated temperature yield strength values for the material shall be those listed in Tables 6 and 6M.
(l) Tables 8 and 8M list mean coefficient of thermal expansion.
(m) Postweld heat treatment (PWHT) for this material is mandatory. The postweld heat treatment shall be performed for 4 hours minimum between 1450°F – 1550°F (790°C - 840°C). Solution annealing prior to PWHT is not required.
(n) Welding procedure and performance qualification shall be conducted in accordance with ASME Boiler and Pressure Vessel Section IX. Separate welding procedure qualification is required for this material. For performance qualifications, this material shall be considered P-No. 43 and used for the purpose of performance qualification. Welding procedure qualifications shall be performed with material in the heat treated condition planned for production welding, which may be either solution annealed-aged-welded-postweld heat treated or solution annealed-welded-postweld heat treated. If welding of both heat treat conditions is planned, qualifications for both conditions shall be required. The heat-treated condition shall be noted on the PQR and WPS used for construction. Procedure and performance qualifications qualified under previous versions of this case do not require requalification. When welding this alloy to itself, the filler metal shall be SFA-5.14/SFA-5.14M ERNiCrCoMo-2 (UNS N07208). Welding shall be limited to bare solid wire filler metals using either the GTAW or GMAW welding processes. The guided bend test required by QW-160 shall be performed using a 4t minimum bend radius.
(o) Calculations of forming strains shall be made for the component. The component shall be heat treated in accordance with the requirements specified in (d) following any:
    1) Cold forming that produces forming strains in excess of 10%. Forming strains shall be calculated as listed in ASME B31.1 2020 edition paragraph 129.3.4.1. When forming strains cannot be calculated as noted above, the manufacturer shall have the responsibility to determine the maximum forming strain.
    2) Swages, upsets, or flares
    3) Hot forming of this material

No localized heat treatments to relax forming strains may be performed. The entire affected component or the part shall be included in both heat treatments.

(p) The rules of ASME B31.1 2020 edition paragraph 102.4.7 and Table 102.4.7-1 shall apply for temperatures at and above 1100°F (593°C). Weld strength reduction factors listed in Table 7 shall apply.
(q) In accordance with Table 104.1.2, the temperature-dependent design value *y* shall be as follows:
    1) 1,150°F (620°C) and below: 0.4
    2) 1,200°F (650°C): 0.5
    3) Above 1,200°F (650°C): 0.7
(r) External pressure design is prohibited.
(s) This case number shall appear in the marking and certification for the material and on the Manufacturer's Data Report.

Table 1	
ASTM Specifications	
ASTM B366-19	Fittings
ASTM B619-19	Welded Pipe
ASTM B637-18	Bar/Forging/Forging Stock
ASTM B670-07(2018)	Plate/Sheet/Strip
ASTM B983-16e1	Seamless Pipe/Tube
ASTM B1007-17	Welded Tube

Table 2	
Chemical Requirements	
Element	**Nominal Composition, %**
Ni	Remainder
Cr	18.5-20.5
Fe	1.5 max
Mn	0.3 max
Co	9.0 – 11.0
C	0.04 – 0.08
Si	0.15 max
S	0.015 max
P	0.015 max
Al	1.38-1.65
B	0.003-0.010
Cu	0.1 max
Mo	8.0-9.0
Ta	0.1 max
Ti	1.9-2.3
Nb	0.2 max
W	0.5 max
Zr	0.02 max

Table 3 Tensile Properties (Room Temperature, Customary)	
Tensile Strength, min., ksi	155.0
Yield Strength, min., ksi	90.0
Elongation, min., %	20

Table 3M Tensile Properties (Room Temperature, Metric)	
Tensile Strength, min., MPa	1070
Yield Strength, min., MPa	620
Elongation, min., %	20

Table 4 – Maximum Allowable Stress Values (Customary)	
For Metal Temperature Not Exceeding, °F	**Stress Value, ksi**
100	44.3
200	44.3
300	44.3
400	44.3
500	44.1
600	43.3
650	43.1
700	42.9
750	42.7
800	42.6
850	42.5
900	42.5
950	42.4
1000	42.3
1050	42.0
1100	41.7
1150	39.9 [Note (1)]
1200	32.6 [Note (1)]
1250	26.0 [Note (1)]
1300	20.3 [Note (1)]
1350	15.4 [Note (1)]
1400	11.3 [Note (1)]
1450	7.8 [Note (1)]
1500	5.2 [Note (1)]
1550	2.4 [Note (1)]
1600	1.6 [Note (1)]

Notes:
(1) These stress values are obtained from time-dependent properties.

Table 4M – Maximum Allowable Stress Values (Metric)	
For Metal Temperature Not Exceeding, °C	**Stress Value, MPa**
40	305
65	305
100	305
125	305
150	305
175	305
200	305
225	305
250	305
275	302
300	300
325	298
350	297
375	295
400	294
425	294
450	293
475	293
500	293
525	292
550	291
575	289
600	287
625	268 [Note (1)]
650	223 [Note (1)]
675	182 [Note (1)]
700	146 [Note (1)]
725	115 [Note (1)]
750	87 [Note (1)]
775	65 [Note (1)]
800	45 [Note (1)]
825	22 [Note (1)]
850	15 [Note (1)]
875	10 [Note (1)] [Note (2)]

Notes:
(1) These stress values are obtained from time-dependent properties.
(2) The maximum use temperature shall be 1600°F (870°C). Datum for 875°C temperature is provided for interpolation purposes.

Table 5 – Tensile Strength Values S_u (Customary)	
For Metal Temperature Not Exceeding, °F	S_u Values, ksi
100	155.0
200	155.0
300	155.0
400	155.0
500	154.4
600	151.7
650	150.7
700	150.0
750	149.5
800	149.2
850	148.9
900	148.7
950	148.4
1000	147.9
1050	147.2
1100	146.0
1150	144.4
1200	142.1
1250	139.0
1300	135.0
1350	130.0
1400	123.8
1450	116.3
1500	107.3
1550	96.8
1600	84.6

Table 5M – Tensile Strength Values S_u (Metric)	
For Metal Temperature Not Exceeding, °C	S_u Values, MPa
40	1069
65	1069
100	1069
125	1069
150	1069
175	1069
200	1069
225	1069
250	1069
275	1059
300	1050
325	1043
350	1038
375	1034
400	1031
425	1029
450	1027
475	1026
500	1024
525	1022
550	1018
575	1012
600	1004
625	993
650	979
675	960
700	936
725	906
750	870
775	827
800	776
825	717
850	649
875	571 [Note (1)]

Notes:
(1) The maximum use temperature shall be 1600°F (870°C). Datum for 875°C temperature is provided for interpolation purposes.

Table 6 – Yield Strength Values S_y (Customary)	
For Metal Temperature Not Exceeding, °F	**S_y Values, ksi**
100	90.0
200	83.1
300	81.1
400	80.3
500	79.8
600	79.2
650	78.8
700	78.3
750	77.9
800	77.5
850	77.1
900	76.8
950	76.5
1000	76.4
1050	76.4
1100	76.4
1150	76.4
1200	76.4
1250	76.4
1300	76.4
1350	76.1
1400	75.0
1450	73.2
1500	70.2
1550	65.8
1600	59.7

Table 6M – Yield Strength Values S_y (Metric)	
For Metal Temperature Not Exceeding, °C	**S_y Values, MPa**
40	621
65	587
100	571
125	564
150	559
175	556
200	554
225	552
250	551
275	549
300	547
325	545
350	542
375	540
400	537
425	534
450	532
475	530
500	528
525	527
550	527
575	527
600	527
625	527
650	527
675	527
700	527
725	526
750	521
775	511
800	497
825	475
850	445
875	404 [Note (1)]

Notes:

(1) The maximum use temperature shall be 1600°F (870°C). Datum for 875°C temperature is provided for interpolation purposes.

Table 7 - Weld Strength Reduction Factors (WSRF) to Be Applied When Calculating Maximum Allowable Working Pressure or Minimum Required Thickness of Components Fabricated With a Longitudinal Seam Weld											
Temp (°F)	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600
Temp (°C)	593	621	649	677	704	732	760	788	816	843	871
WSRF	**0.99**	**0.93**	**0.93**	**0.93**	**0.93**	**0.93**	**0.93**	**0.93**	**0.86**	**0.86**	**0.84**

Table 8 - Mean Coefficient of Thermal Expansion (Customary)	
	Mean Coefficient of Thermal Expansion, $\times 10^{-6}$ in./in./°F
Temperature, °F	
70	---
100	6.5
125	6.6
150	6.7
200	6.8
250	6.9
300	6.9
350	6.9
400	7.0
450	7.0
500	7.1
550	7.1
600	7.2
650	7.2
700	7.3
750	7.3
800	7.4
850	7.4
900	7.4
950	7.5
1000	7.5
1050	7.5
1100	7.6
1150	7.7
1200	7.8
1250	7.9
1300	7.9
1350	8.0
1400	8.1
1450	8.2
1500	8.4
1550	8.5
1600	8.7
1650	8.8
1700	9.0
1750	9.2
1800	9.3
1850	9.5
1900	9.5
1950	9.6
2000	9.6

Table 8M - Mean Coefficient of Thermal Expansion (Metric)	
	Mean Coefficient of Thermal Expansion, $\times 10^{-6}$ mm/mm/°C
Temperature, °C	
20	11.6
50	11.9
75	12.1
100	12.3
125	12.4
150	12.5
175	12.6
200	12.6
225	12.7
250	12.8
275	12.8
300	12.9
325	13
350	13
375	13.1
400	13.2
425	13.3
450	13.3
475	13.4
500	13.5
525	13.6
550	13.6
575	13.7
600	13.8
625	13.9
650	14
675	14.1
700	14.3
725	14.4
750	14.6
775	14.8
800	15
825	15.2
850	15.4
875	15.7
900	16
925	16.2
950	16.5
975	16.8
1000	17
1025	17.2
1050	17.3
1075	17.3
1100	17.3

Code Case 220
Approval Date: July 10, 2023
ASME B31.12 Hydrogen Piping and Pipelines

Fatigue Crack Growth Rate Properties in Hydrogen for B31.12 Pipeline Materials

Inquiry: What are the alternative rules in lieu of the fatigue crack growth rate properties specified in paragraph PL-3.7.1(b)(2)(-4) for B31.12 pipeline steel construction?

Reply: It is the opinion of the Committee that the rules of this Case may be used in lieu of the fatigue crack growth rate properties specified in paragraph PL-3.7.1(b)(2)(-4) for B31.12 pipeline steel construction.

(a) The fatigue crack growth rate at the deepest point on the crack periphery da/dN, m/cycle (inch/cycle), shall be a function of the range of stress intensity factor ΔK, MPa $m^{1/2}$ (ksi $in^{1/2}$), and the stress intensity factor ratio R_K.

$$\frac{da}{dN} = C[f(R_K)][\Delta K]^m[f(P)] \qquad (1)$$

$$\Delta K = K_{Imax} - K_{Imin} \qquad (2)$$

$$R_K = \frac{K_{Imin}+K_{res}}{K_{Imax}+K_{res}} \qquad (3)$$

where:
P is the partial pressure of hydrogen, MPa (psi)

K_{Imin} is the stress intensity factor at minimum load without considering weld residual stress, MPa $m^{1/2}$ (ksi $in^{1/2}$);

K_{Imax} is the stress intensity factor at maximum load without considering weld residual stress, MPa $m^{1/2}$ (ksi $in^{1/2}$);

K_{res} is the stress intensity factor due to weld residual stress, MPa $m^{1/2}$ (ksi $in^{1/2}$), and

Factors $f(R_K)$, f(P), C and m shall be taken from Table 1 or 1M.

(b) The fatigue crack growth rate at the surface on the crack periphery dl/dN, m/cycle (inch/cycle), shall be calculated in accordance with the following equation:

$$\frac{dl}{dN} = 2C[f(R_K)][\Delta K]^m[f(P)] \qquad (4)$$

where the factors are the same as in Paragraph (a).

(c) If $K_{Imin} + K_{res} \leq 0$, the value of $K_{Imin} + K_{res}$ shall be set to 0 in all equations.
(d) If $K_{Imax} + K_{res} \leq 0$, the fatigue crack grow rate da/dN or dl/dN is 0.

(e) If the calculated fatigue crack growth rate in hydrogen is lower than the fatigue crack growth rate in air, the fatigue crack growth rate in air shall be used. The fatigue crack growth rate in air shall be calculated using Equations 1 and 4 with the factors in Table 2 or 2M:

(f) The design pressure shall not exceed 20.7 MPa (3000 psi).

Table 1. Fatigue Crack Growth Rate Factors in hydrogen (U.S. Customary Units)

	da/dN_{low}	da/dN_{high}
C (inch/cycle)	2.54E-12	8.34E-10
m	6.5	3.66
C_H	0.43	2.0
f(P)	$0.0056P^{0.51}$	1.0
$f(R_K)$	$\frac{1 + C_H R_k}{1 - R_k}$	

Note:
(1) P is partial pressure of hydrogen, psi
(2) if $\Delta K < \Delta K_c$, the fatigue crack growth rate factors for da/dN_{low} shall be used.
(3) If $\Delta K \geq \Delta K_c$, the fatigue crack growth rate factors for da/dN_{high} shall be used.
(4) The following equation shall be used in calculating ΔK_c.

$$\Delta K_c = 2.23\left(21.66 + 10R_k - 3.7{R_k}^2\right)P^{-0.18} \text{ ksi in}^{1/2} \quad (5)$$

Table 2M. Fatigue Crack Growth Rate Factors in hydrogen (SI Units)

	da/dN_{low}	da/dN_{high}
C (m/cycle)	3.5E-14	1.5E-11
m	6.5	3.66
C_H	0.43	2.0
f(P)	$0.071P^{0.51}$	1.0
$f(R_K)$	$\frac{1 + C_H R_k}{1 - R_k}$	

Note:
(1) P is partial pressure of hydrogen, MPa
(2) if $\Delta K < \Delta K_c$, the fatigue crack growth rate factors for da/dN_{low} shall be used.
(3) If $\Delta K \geq \Delta K_c$, the fatigue crack growth rate factors for da/dN_{high} shall be used.
(4) The following equation shall be used in calculating ΔK_c.

$$\Delta K_c = \left(21.66 + 10R_k - 3.7{R_k}^2\right)P^{-0.18}, \text{ MPa m}^{1/2} \quad (6)$$

Table 2. Fatigue Crack Growth Rate Factors in Air (U.S. Customary Units)

	da/dN_{air}
C (inch/cycle)	2.0E-10
m	3.07
f(P)	1.0
$f(R_K)$	$\left[\frac{2.88}{2.88 - R_K}\right]^{3.07}$

Note:

(1) If $\Delta K < \Delta K_a$, the fatigue crack growth rate factors in air (da/dN_{air}) in Table 2 shall be used.

(2) If $\Delta K \geq \Delta K_a$, the fatigue crack growth rate factors in hydrogen in Table 1 shall be used.

(3) The following equation shall be used in calculating ΔK_a.

$$\Delta K_a = 1.92\left(8.6 - 3R_k + 7.9{R_k}^2 - 9.4{R_k}^3\right)P^{-0.15}, \text{ ksi in}^{1/2} \qquad (7)$$

Table 2M. **Fatigue Crack Growth Rate Factors in Air**, **(SI Units)**

	da/dN_{air}
C (m/cycle)	3.8E-12
m	3.07
f(P)	1.0
$f(R_K)$	$\left[\frac{2.88}{2.88 - R_K}\right]^{3.07}$

Note:

(1) If $\Delta K < \Delta K_a$, the fatigue crack growth rate factors in air (da/dN_{air}) in Table 2M shall be used

(2) If $\Delta K \geq \Delta K_a$, the fatigue crack growth rate factors in hydrogen in Table 1M shall be used.

(3) The following equation shall be used in calculating ΔK_a.

$$\Delta K_a = \left(8.6 - 3R_k + 7.9{R_k}^2 - 9.4{R_k}^3\right)P^{-0.15}, \text{ MPa m}^{1/2} \qquad (8)$$

B31 Case 221
Use of Carbon Steel Materials Above 800°F in ASME B31.1 Construction
Approval Date: October 18, 2023
B31.1

Inquiry: May carbon steel materials be used in applications above 800°F (427°C) for short-term operating periods for ASME B31.1 construction?

Reply: It is the opinion of the Committee that selected carbon steel materials may be used in applications above 800°F (427°C) for short-term operating periods for ASME B31.1 construction provided the following requirements are met:

(1) The duration of the short-term operating periods shall not exceed the requirements of para. 102.2.4(a) or (b).
(2) Materials shall be those listed in the ASME Boiler and Pressure Vessel Code, Section II or their ASTM equivalent as allowed by para. 123.1.1(d).
(3) The maximum operating temperature shall not exceed the maximum temperature limit for the material selected as defined in Section II, Part D, Table 1A for materials applicable to Section I or Section VIII, Division 1.
(4) Material allowable stress values at temperatures above 800°F (427°C) shall be obtained from Section II, Part D, Table 1A for materials applicable to Section I or Section VIII, Division 1.
(5) The piping system shall be analyzed for compliance with para. 103, at the coincidental pressure and temperature for all various short-term operating periods.
(6) The maximum permissible design temperature based on sustained operating conditions shall not exceed 800°F (427°C).
(7) Other piping components including fittings, flanges, valves and those referred to in paras. 102.2.1 and 102.2.2 shall be reviewed for compliance to these short-term operating conditions.
(8) Mandatory minimum nondestructive examinations shall be in accordance with Table 136.4.1-1 for the maximum coincidental short-term operating temperature and pressure in addition to the piping design conditions, except for open-ended discharge piping from pressure-relieving valves [see para. 122.6.2(g)] which may have visual examination only.
(9) All other requirements of ASME B31.1 shall apply.
(10) For boiler external piping applications, this Case number shall be recorded on the Manufacturer's Data Report.

B31 Case 222
Weld reinforcement requirements for aluminum alloys
Approval Date: December 23, 2024
B31.12 Hydrogen Piping

Inquiry: In lieu of Table GR-3.4.6-1, what are the alternative requirements for weld reinforcement of aluminum alloys?

Reply: It is the opinion of the Committee that in lieu of Table GR-3.4.6-1, the weld reinforcement of aluminum alloys shall meet the following requirements:

(a) The maximum internal protrusion shall not exceed 1.5 mm (1⁄16 in.) for thickness not exceeding 2 mm (5⁄64 in.)
(b) The maximum internal protrusion shall not exceed 2.5 mm (3⁄32 in.) for thickness greater than 2 mm but not exceeding 6 mm (1⁄4 in.)
(c) External reinforcement and for greater thicknesses shall follow Table GR-3.4.6-1.