

**Pipe Branch Reinforcement
per ASME B31.1b -2009 Power Piping Code
Branch (1) Calculations**

Client:	Description:	Prepared By	Approval	Date	Rev.
Customer No.:	Item No.:				0
Owner No.:	Dwg. No.:				1
					2
					3
					4

The user is responsible to verify method and results.

Refer to para. 104.3.1 and Fig. 104.3.1(D) of the Code

Design Temperature **-320 deg. F (to -196 deg. C)** **Dimensional Units** **Inch**

Design Pressure Class:300 ASME B16.5 -2009 Flanges, ASTM A182 Gr. F304L SS 18Cr-8Ni Forging , Group: 2.3
Design pressure: 600 psig = 42.2 kg/cm² = 41.4 bar-G = 4137 kPa

Materials - Refer to ASME B31.1b - 2009, Tables A-1 thru A-9

Run Pipe: ASTM A312 TP304L S30403 Welded Pipe SS 18Cr-8Ni (see Note (9)) Weld joint factor, E_h = 0.85
Weld: P-8 Notes: Table A-3: (1)(9) St = 70 ksi Sy = 25 ksi Weld strength reduction factor, W_h = 1.00
Branch Pipe: ASTM A312 TP304L S30403 Welded Pipe SS 18Cr-8Ni (see Note (9)) Weld joint factor, E_{b1} = 0.85
Weld: P-8 Notes: Table A-3: (1)(9) St = 70 ksi Sy = 25 ksi Weld strength reduction factor, W_{b1} = 1.00
Reinforcement: ASTM A312 TP304L S30403 SMLS Pipe SS 18Cr-8Ni (see Note (9))
Weld: P-8 Notes: Table A-3: (1)(9) St = 70 ksi Sy = 25 ksi

Allowable Stresses at Design Temperature

Run: SE_h = 14.2 ksi = 97.9 MPa
Branch: SE_b = 14.2 ksi = 97.9 MPa
Reinforcement: SE_r = 16.7 ksi = 115.1 MPa

Material Coefficient, Y

"Y" from Table 104.1.2(A) of Code: Header, Y_h = 0.4
Branch (1), Y_{b1} = 0.4

Longitudinal Weld Intersection?

Does Branch-1 intersect a longitudinal weld on the run? **Yes**

Angle Between Run and Branch

Angle, alpha α = 90 degrees

Integral Reinforcement Dimensions

Height of largest 60-degree right triangle supported by the branch and run O.D. projected surfaces and lying completely within the area of reinforcement in Example B: t_{ri} = n/a

Maximum height = 0.82 in.

Width integral reinf. area = (t_{ri}) tan 30 w_{ri} = n/a

Special Reinforcement Type:

Full encirclement type reinforcing is NOT part of ASME B31.1. Other design may be required by Engineering. Suggested usage:

Review when D_{oh} / T_h > 100 and / or D_{ob} > D_{oh} / 2.

Suggested reinf. thk. = run thk, t_{nh} = 0.375 in.

Max useful length for w_r = 2 d2 - (Dob/SIN Alpha) = 7.5 in.

Note:

Allowances

Thickness allowance (corrosion, etc.) A = 0.0000 in.

Run Dimensions

Pipe size: NPS 12 (DN 300)
Wall thk: Sch 40S per ASME B36.19M
Pipe outside diameter D_{oh} = 12.750 in.
Pipe nominal thickness t_{nh} = 0.375 in.
Thk. tolerance: Mill_h = 12.5% or h₁ = 0.000 in.

Branch Dimensions

Pipe size: NPS 8 (DN 200)
Wall thk: Sch 40S per ASME B36.19M
Pipe outside diameter D_{ob} = 8.625 in.
Pipe nominal thickness: t_{nb} = 0.322 in.
Thk. tolerance: Mill_b = 12.5% or h₂ = 0.000 in.

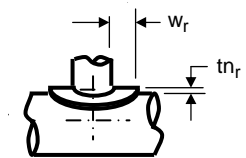
Ring or Saddle Reinforcement Dimensions

Thk. (nom.) ring, full encir. pad, or saddle: t_{nr} = 0.375 in.
Width of ring or pad (= 0 if saddle is used): w_r = 3.500 in.
Width of saddle (= 0 if ring is used): w_s = 0.00 in.
Optional special weld leg height leg = 0.000 in.
Thk. tolerance: Mill_r = 0.0% or h₃ = 0.000 in.

Branch Type:

Ring reinforced (re-pad), 90 deg.

Weld will not fit on outer edge of reinf. zone. Its area not applied to A5.2.



Check if diameter and thickness ratios are reasonable using criteria from ASME B31.3, para. 304.3.1(b)(1) & (2).

(D_{ob} / D_{oh}) must not exceed 1.0 **OK ... Branch OD is not greater than Run OD.** D_{ob} / D_{oh} = 0.68

(D_{oh}/T_h) must not exceed 100, unless D_{ob} <(D_{oh}/ 2) **OK... Run OD/ Run Thk. < 100. See below.** D_{oh} / T_h = 38.9

Is branch size less than 1/2 of run size? **OK... Branch OD may be any size not exceeding Run OD.** D_{oh} / 2 = 6.4 in.

Required minimum wall thickness. Refer to para. 104.1.2 Eq. (3) and Table 104.1.2(A) of B31.1 Code,

t_m = [P D_o / (2 (SE + P Y))] + A

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Minimum required run thickness, $t_{mh} = (P D_{oh} / (2 (SE_h + P Y))) + A$	$t_{mh} =$	0.2649	in.
Run actual measured or minimum thickness, $T_h = t_{nh}(1 - Mill_h) - h_1$	$T_h =$	0.328	in.
Run actual corroded thickness (measured or minimum thickness, less corrosion allowance), $t_{ha} = T_h - A$	$t_{ha} =$	0.328	in.
OK... Run thickness IS sufficient at design pressure.			
Minimum required branch thickness, $t_{mb} = (P D_{ob} / (2 (SE_b + P Y_{b1}))) + A$	$t_{mb} =$	0.1792	in.
Branch actual measured or minimum thickness, $T_b = t_{nb} (1 - Mill_b) - h_2$	$T_b =$	0.282	in.
Branch actual corroded thickness (measured or minimum thickness, less corrosion allowance), $t_{ba} = T_b - A$	$t_{ba} =$	0.282	in.
OK... Branch thickness IS sufficient at design pressure			
Allowable Stress if Branch Intersects a Weld			
Allowable stress of run for reinforcement design, $SE_{hr} = SE_h$ when branch intersects a weld on the run, or $SE_{hr} = SE_h / E_h$ when the branch does not intersect a weld on the run.	$SE_{hr} =$	14.2	ksi
Minimum required run thickness for reinforcement design, $t_{mhr} = (P D_{oh} / (2 (SE_{hr} + P Y))) + A$	$t_{mhr} =$	0.2649	in.
Other Dimensions			
Ring or saddle minimum thickness = $t_{nr} (1 - Mill_r) - h_3$	$t_r =$	0.375	in.
Inside center-line long dimension of finished branch opening = $[D_{ob} - 2 (T_b - A)] / \sin \alpha$	$d_1 =$	8.062	in.
Half width of reinforcement zone = d_1 or $(T_b - A) + (T_h - A) + d_1 / 2$, whichever is greater, but not more than D_{oh}	$d_2 =$	8.062	in.
Reinf. zone height outside of run pipe, for ring or saddle = $2.5 (T_h - A)$ or $2.5 (T_b - A) + t_r$, whichever is less	$L_r =$	0.820	in.
Reinf. zone height outside of run pipe, for integral reinf. = $2.5 (T_h - A)$	$L_i =$	0.000	in.
Reinf. zone height outside of run pipe = $L_r + L_i$	$L_4 =$	0.820	in.
Reference long axis outside dimension of reinforcing ring or saddle = $2 w_r + [(D_{ob}) (2 - \sin \alpha)]$	$D_r =$	15.625	in.
Reference find the smaller of t_{nb} or t_{nr} (weld reference para. 127.4.8(B))	$t_{min} =$	0.322	in.
Min. throat of weld at branch periphery = smaller of 6.0 mm (1/4") or $0.7 t_{nb}$, but not less than $0.7 t_{min}$	$t_c =$	0.225	in.
Minimum leg of weld at branch periphery = $t_c / 0.707$	$Weld_b =$	0.319	in.
Minimum leg of weld at outer edge of ring or saddle = $0.5 t_r / 0.707$	$Weld_r =$	0.265	in.
Leg height of weld at branch periphery = greater of $(t_c / 0.707)$ or $(L_4 - leg)$	$Weld_{bp} =$	0.319	in.
Maximum ring width which would apply = $d_2 - (D_{ob} / 2) / \sin \alpha$	$WR_{max} =$	3.749	in.
Reinforcement height = lesser of $(t_r$ or $L_4)$, or lesser of $(t_{ri}$ or $L_4)$ as applicable	$R_h =$	0.375	in.
Reinforcement width = lesser of $(w_r$ or $WR_{max})$, or lesser of $(w_{ri}$ or $WR_{max})$	$R_w =$	3.500	in.
Count of Welds Within Reinforcement Zone			
Number of complete welds, other than on pad edge, which will fit within the reinforcement zone height	$N_{wh} =$	2	
Number of complete welds on pad edge which will fit within reinforcement zone width	$N_{ww} =$	0	
Strength Correction Factors			
Factor for strength correction of branch area = 1 if $SE_b > SE_h$, or = (SE_b / SE_h) if $SE_b \leq SE_h$	$F_b =$	1.000	
Strength correction factor for reinforcing material = 1 if $SE_r > SE_h$, or = (SE_r / SE_h) if $SE_r \leq SE_h$	$F_r =$	1.000	
Strength correction factor for welds, $F_w =$ lesser of F_b or F_r	$F_w =$	1.000	
Areas			
Pressure design area expected at end of service life = $(t_{mhr} - A)d_1$	$A_6 =$	2.135	in.^2
Required reinforcement area = $A_6 (2 - \sin \alpha)$	$A_7 =$	2.135	in.^2
Area of excess thickness in run pipe wall = $(2 d_2 - d_1) (T_h - t_{mhr})$	$A_1 =$	0.510	in.^2
Area of excess thickness in branch pipe wall = $2 L_4 (T_b - t_{mb}) / \sin \alpha$	$A_2 =$	0.168	in.^2
Total area of welds within zone = $(N_{wh} / 2)(Weld_{bp}^2) + (N_{ww} / 2)(Weld_r^2)$	$A_3 =$	0.102	in.^2
Area of added reinforcement metal within the reinforcement zone = $2 \times R_h \times R_w$	$A_4 =$	2.625	in.^2
Area provided by integral reinforcement, = $R_h \times R_w$	$A_{4i} =$	0.000	in.^2
Area provided by saddle = (least of w_s or $WR_{max}) \times t_r \times 2$	$A_5 =$	0.000	in.^2
Total contributing area (with strength correction for added metal within the reinf. zone) $A_c = A_1 + (A_2)(F_b) + (A_3)(F_w) + (A_4 + A_{4i} + A_5)(F_r)$	$A_c =$	3.405	in.^2
Percent of area replaced = A_c / A_7 %	% Area	159%	
This branch has sufficient reinforcement.			