

Thermowell Stress Calculations  
Timoshenko Beam Elements,  
ASME B31.3/PTC 19.3TW Stress Allowables

Fluid	Steam	
Pressure	150.0	psig ( 164.7 psia )
Temperature	400.0	Deg F
Steam Superheat	34.1	Deg F
Specific Volume	2.916	ft3/lbm / 0.343 lbm/ft3
Molecular Weight	18.016	
Cp/Cv Ratio	1.169	
Prandtl No.	1.267	
Specific Heat	0.599	Btu/lbm-Deg F
Thermal Cond.	0.019	Btu/h-ft-Deg F
Viscosity	0.017	cP
Flow Rate	400000	lbm/hr
Fluid Velocity	199.6	ft/s
Pipe i.d./Wall Thickness	17.250	/ 0.375" ( C.S. )
Line Loss	1.09	psi/100ft
Friction Factor(f)	0.011	
Pipe Rd / Tip Rd	8613846	/ 374515

Aerodynamic Coefficients: PTC 19.3TW

Mean Drag	1.000	
Osc. Lift/Drag (Sub)	1.000	/ 0.1000
Osc. Lift/Drag (Super)	1.000	/ 0.1000
Osc. Lift/Drag (Post)	1.000	/ 0.1000

Nominal Strouhal Numbers:

Critical Reynolds No.	500000	
Sub-Critical	0.20	
Super-Critical	0.20	
Post Critical	0.22	
Critical Transition	266.5	ft/s (Tip Rd: 500000)
Post Critical Transition	26649	ft/s (Tip Rd: 50000000)

Thermowell Design: Straight Shank

Flanged: NPS 1.5 150# RF, SCH 40 Stub, 6" Flg Proj.

U-Dim.	Root	Tip	Bore	Tip Thk
10.000"	0.750"	0.750"	0.260"	0.250"

Exposed Tip	3.625"
Root Fillet	0.125"
Exposed Tip	3.625"
Radially Aligned	

Well Material	316L S.S.
Well Modulus	26500 kPsi
Poisson Ratio	0.290

MAWS Static Well	15500 psi (B31.3)
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Fatigue Allow. Well	5093	psi (PTC 19.3TW)
Well Density	7.960	gm/cm3 at 70 Deg F
Intrinsic Damping	1.000%	
Sensor Density	2.700	gm/cm3 at 70 Deg F

Pipe Material	C.S.	
Pipe Modulus	27700	kPsi
Poisson Ratio	0.280	
MAWS Static Piping	20600	psi (B31.3)
Fatigue Allow. Piping	2836	psi (PTC 19.3TW)

Pressure Stresses:

Hoop	341	psi
Longitudinal	170	psi
Tip Disc(Radial)	30	psi

Modal Constants:

- Osc Drag Modes -

Mode No.	Critical (Hz)	Modal Excitation	Mass Damping	Shop Crits (Hz)
1	174.6	0.244	73.4	203.8
2	340.4	0.250	290.7	1248.0
3	1260.1	0.158	71.4	3372.5

- Osc Lift Modes -

Mode No.	Critical (Hz)	Modal Excitation	Mass Damping	Shop Crits (Hz)
1	171.5	0.241	75.5	203.8
2	326.5	0.255	260.8	1248.0
3	1262.1	0.159	71.4	3372.5

Service Criticals < 290 ft/s

Fluid Strouhal No.	Root Stresses Static (ksi)	Root Stresses Cyclic (ksi)	Tip Accel (g)	Bending Mode (D,L)	Noz/Hub Stress (ksi)	Noz/Wall Stress (ksi)	Mode Critical (Hz)
29.0	0.0	0.1	1	D1	0.0	0.0	174.6
0.188 Lo							
56.4	0.1	1.9	16 X	D2	0.2	0.4	340.4
0.189 Lo							
56.8	0.1	2.4	21 XX	L1	0.2	0.5	171.5
0.189 Lo							
105.4	0.3	2.1	31 XX	L2	0.0	0.8	326.5
0.194 Lo							
193.3	1.0	0.8	87 XXX	D3	0.1	0.2	1260.1
0.204 Lo							

Measurement Summary:

Well Conductivity	8.928	Btu/hr-ft-Deg F
Well Emissivity	0.154	
Insulation Thickness	2.5"	
Fluid Temperature	400.0	Deg F

Velocity (ft/s)	Tip Error (Deg F)	Wall Temp (Deg F)	2% Error (sec)
20.0	-0.06	396.2	367
39.9	-0.02	397.8	257
59.9	-0.01	398.4	209
79.8	-0.01	398.7	181
99.8	-0.01	398.9	163
119.8	-0.00	399.1	149
139.7	-0.00	399.2	139
159.7	-0.00	399.3	131
179.6	-0.00	399.3	124
199.6	-0.00	399.4	118