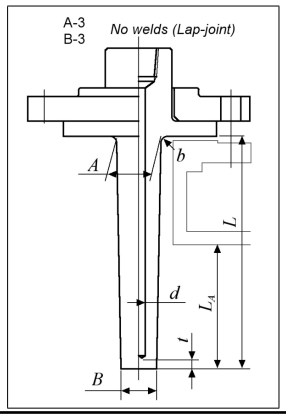
ASME PTC 19.3 TW-2010



[PROCESS CONDITION]

(1)				
(2)	Tag No.		SHELL	
(3)	Operating temperature	T	°C	20
(4)	Operating pressure	P	barG	1.00
(5)	Fluid density	γ	kg/m^3	820.000
(6)	Fluid viscosity	μ	cP	5.1000
(7)	Flow rate	Q		
(8)	Pipe.inner dia.	D_D	mm	
(9)	Fluid velocity	V	m/s	3.80

[THERMOWELL SPECIFICATION]

Type of Thermowell : B3

(10)	Material			316SS					
(11)	Root out.dia.	A	mm	30.0					
(12)	Tip out.dia.	B	mm	14.0					
(13)	Bore	d	mm	6.5					
(14)	Insertion length	L	mm	300.0	(16)	Fillet radius	b	mm	3.0
(15)	Actual insertion length	L_A	mm	150.0	(17)	Tip thickness	t	mm	5.0

Notes 1: Sign
Calculation report L
DWG & Specification sheet U
Notes 2: Since calculation of a 2 phase flow assumes that it is a single phase flow in mean density, please consider that the result is an object for reference.

[CALCULATION RESULT]

[1] Frequency Limit Calc. *Judgement* : ***Pass***

Strouhal frequency	f_s	Hz	54.7	Reynolds No. Re	8 554	≤ 10^5	
Natural frequency	f_n^c	Hz	281.7	Scruton No. N_{Sc}	0.038	≤ 2.5	
				Inline resonance velocity V_{IR}	10.2	m/s	
				Stress at V_{IR} S_{omax} =	1369.1	> $F_T F_E S_f$ =	94.0 N/mm^2

Frequency ratio f_s / f_n^c = 0.194 < 0.4 Upper frequency ratio limit

[2] Steady-State Stress Calc. *Judgement* : ***Pass***

Stress using the Von Mises criteria N/mm^2 1.86 < Allowable stress 1.5S N/mm^2 193.50

[3] Dynamic Stress Calc. *Judgement* : ***Pass***

Combind drag and lift stresses S_{omax} N/mm^2 1.98 < Allowable stress $F_T F_E S_f$ N/mm^2 93.96

[4] Pressure Stress Calc. *Judgement* : ***Pass***

Operating pressure P MPa 0.10 < External pressure rating for tip shank P_c MPa 65.17

Operating pressure P MPa 0.10 < External pressure rating for the tip P_t MPa 587.16

[REMARKS]

Fatigue endurance limit	S_f	N/mm^2	93.8	Strouhal No.	N_S	0.20
Allowable stress	S	N/mm^2	129.0	Damping factor	ζ	0.0005
Sensor average density	γ_s	kg/m^3	2 700	Stress concentration factor	K_t	1.4
Young's modulus	E	N/mm^2	195 168	Drag coefficient	C_D	1.40
Density of thermowell	γ_m	kg/m^3	7 980	Oscillating-drag coefficient	C_d	0.10
				Oscillating-lift coefficient	C_l	1.00
				Magnification factor (V_{IR})	F'_{Mmax}	1000.0

[Calculation Method : ASME PTC 19.3 TW-2010]

[1] Frequency Limit Calc.

Strouhal frequency $f_s = St \dfrac{V}{D_2} 10^3$

Natural Frequency $f_n^c = H_c f_n$ $\quad f_n = H_f H_{af} H_{as} f_a$ $\quad f_a = \dfrac{\lambda^2}{2\pi L^2}\sqrt{\dfrac{E I}{m}} 10^{12}$

Scruton No. $N_{Sc} = \pi^2 \zeta (\gamma_m / \gamma)[1-(d/B)^2]$ $\quad$ Reynolds No. $Re = \dfrac{VB\gamma}{\mu}$

Cyclic stress at the V_{IR} (S_L=0) $S_{omax} = K_t (S_d^2 + S_L^2)^{1/2}$ $\quad S_d = G_{SP} F'_{Mmax} P_d$ $\quad P_d = \dfrac{1}{2}\gamma C_d V_{IR}^2 \cdot 10^{-6}$ N/mm^2

Inline resonance velocity $V_{IR} = \dfrac{B f_n^c}{2 N_S}$ m/s $\quad G_{SP} = \dfrac{16L^2}{3\pi A^2[1-(d/A)^4]}\left\{3[1-(L_0/L)^2]+2(B/A-1)[1-(L_0/L)^3]\right\}$ $\quad L_0 = L - L_A$

[2] Steady-State Stress Calc. at the V

Von Mises criteria $\dfrac{\sqrt{(S_{max}-S_r)^2+(S_{max}-S_t)^2+(S_t-S_r)^2}}{2} \le 1.5S$ $\quad S_d = G_{SP} P_D$ $\quad P_D = \dfrac{1}{2}\gamma C_D V^2 \cdot 10^{-6}$

[3] Dynamic Stress Calc. at the V (Same equation of cyclic stress) $S_{omax} = K_t (S_d^2 + S_L^2)^{1/2}$ N/mm^2 $\quad S_L = G_{SP} F_M P_l$ $\quad P_l = \dfrac{1}{2}\gamma C_l V^2 \cdot 10^{-6}$ N/mm^2

F_M = 1.0 $\quad F'_M$ = 1.2

[4] Pressure Stress Calc. (Max. Pressure)

External pressure rating for tip shank $P_c = 0.66S\left[\dfrac{2.167}{2B/(B-d)} - 0.0833\right]$ MPa

External pressure rating for the tip $P_t = \dfrac{S}{0.13}\left(\dfrac{t}{d}\right)^2$ MPa

Notes 3: "*Pass *1*" means that We Recommend to Use. Freq. ratio "*fs/fn*" is higher than 0.4 and lower than 0.6. This ratio is not recommened to use in ASME.
Notes 4: "*Pass *2*." means that we do not recommend to use. Fluid density>300kg/m^3 and Freq. ratio fs/fn>0.2. This ratio is able to use in ASME.