THERMOWELL DESIGN GUIDELINES

Design Procedure***

The purpose of this design procedure is to enable the user to determine if a well selected for thermometry considerations is strong enough to withstand specific application conditions of temperature, pressure, velocity, and vibration. Well failures are caused by forces imposed by static pressure, steady state flow, and vibration. Separate evaluations of each of the above effects should be made in order to determine the limiting condition. This design procedure does not allow for effects due to corrosion or erosion.

The natural frequency of a well designed in accordance with Fig. 1.1 and of the dimensions given in Table 1.1 is given by the following equation:

$$f_n = \frac{K_f}{L^2}\sqrt{\frac{E}{\gamma}} \quad \ldots\ldots[1]$$

where

f_n = natural frequency of the well at use temperature, cycles per sec
L = length of well as given in Fig. 1.1, in.
E = modulus of elasticity of well material at use temerature, psi
γ = specific weight of well material at use temperature, lb per cu in.
K_f = a constant obtained from Table 1.2

The wake or Strouhal frequency is given by:

$$f_w = 2.64\frac{V}{B} \quad \ldots\ldots\ldots[2]$$

where

f_w = wake frequency, cycles per sec
V = fluid velocity, fps
B = diameter at tip (Fig. 1.1), in.

The ratio of wake to natural frequency (f_w/f_n) shall not exceed 0.8, and when this condition is met, the Magnification Factor, relationship of dynamic to static amplitude is given by:

$$F_M = \frac{(f_w/f_n)^2}{1-(f_w/f_n)^2} = \frac{r^2}{1-r^2} \quad \ldots\ldots.[3]$$

For $r \leqslant 0.8$

where

F_M = magnification factor, dimensionless
r = frequency ratio, (fw/fn), dimensionless

STRESS ANALYSIS

The maximum pressure that a thermometer, well can with stand for a given material at a given temperature shall be computed from the following:

$$P = K_1 S \quad \ldots\ldots\ldots\ldots.[4]$$

where

P = maximum allowable static gage pressure, psi
S = allowable stress for material at operating temperature as given in the ASME Boiler and Pressure Vessel or Piping Codes, psi
K_1 = a stress constant obtained from Table 1-3.

The maximum length that a thermometer well can be made for a given service is dependent upon both vibratory and steady state stress. The necessity for keeping the frequency ratio at 0.8 or less imposes one limitation on maximum length. The other limitation is one of steady state stress considerations, as given by the following equation:

$$L_{max} = \frac{K_2}{V}\sqrt{\frac{v(S - K_3P_0)}{1 + F_M}} \quad \ldots.[5]$$

where

L_{max} = maximum value of L (as shown in Fig. 1.1) for a given service, in.
V = fluid velocity, fps
v = specific volume of the fluid, cu ft per lb.
S = allowable stress for material at operating temperature as given in the ASME Boiler and Pressure vessel or Piping Codes, psi
P_0 = static operating gage pressure, psi
F_M = magnification factor as computed from Eq [3]
K_2, K_3 = stress constants obtained from Table 1-3.

TABLE 1.1 WELL DIMENSIONS. IN IN.

Dimension	Nominal Size of Sensing Element
	1/4
A (minimum)	13/16
B (minimum)	5/8
d (minimum)	0.254
d (maximum)	0.262

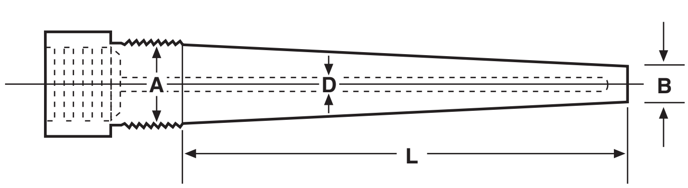
TABLE 1.2 VALUES OF K_f

Well Length L, in.	K_f
2½	2.06
4½	2.07
7½	2.08
10½	2.09
16	2.09
24	2.09

TABLE 1.3 VALUES OF STRESS CONSTANTS

Stress Constant	
K_1	0.412
K_2	37.5
K_3	0.116

*** Power Test Code Thermometer Wells, J.W. Murdock, Journal of Engineering for Power, Trans. ASME, vole. 81, 1959.



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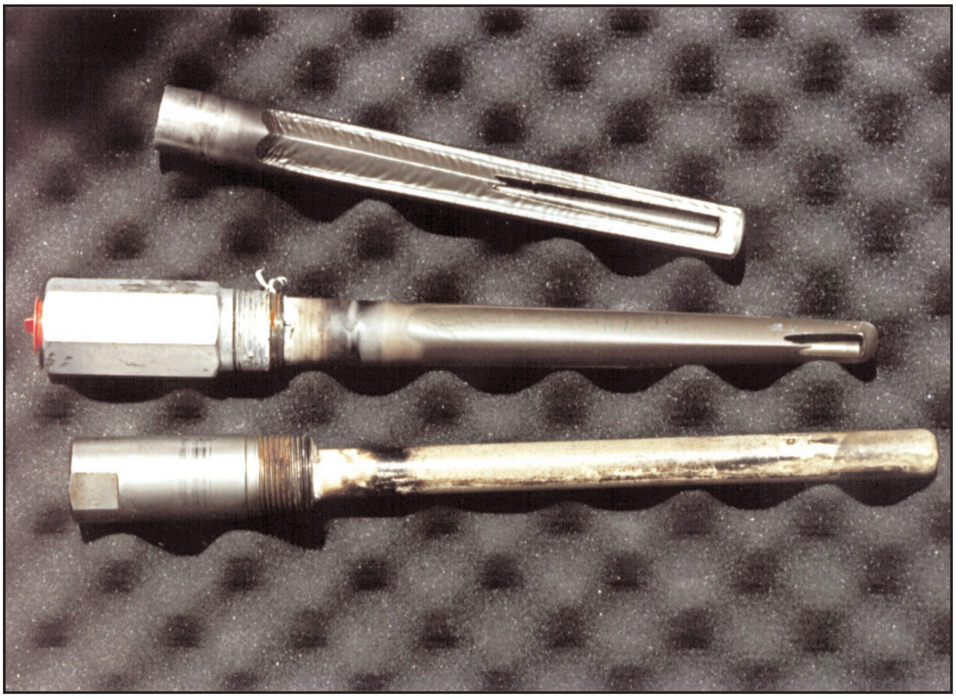

Note: For high erosion and low pressure applications, ask for JMS drawing #8135. For high erosion and high pressure applications, ask for JMS drawing #11468. These are JMS-SE proprietary designs.

Table 4: Allowable Stress Values (PSI)[1]

MATERIAL	TEMPERATURE °F						
	0	300	500	700	900	1100	1300
Aluminum (1100)	2,350	1,850	--	--	--	--	--
Aluminum (6061-T6)	6,000	5,000	--	--	--	--	--
Nickel	10,000	10,000	9,500	--	--	--	--
Steel[2]	11,250	11,000	10,250	9,000	7,750	6,500	--
304SS	18,750	13,750	11,400	10,500	10,000	8,250	--
316SS	18,750	16,400	15,500	15,100	11,650	8,500	3,400
310SS	18,750	14,600	12,600	11,300	10,300	9,450	3,500
321 - 347SS	18,750	15,300	13,500	12,200	11,300	9,100	4,000
410SS	15,000	13,800	12,850	12,050	9,650	2,900	2,200
446SS	17,500	16,100	15,000	--	--	--	--
A182-F11	16,150	16,150	16,150	16,150	13,100	4,000	--
A182-F22	17,500	17,500	17,500	17,500	14,000	4,200	--
Copper	6,000	5,000	--	--	--	--	--
Admiralty Brass	10,000	10,000	--	--	--	--	--
Monel 400	16,600	13,600	13,100	13,100	8,000	--	--
Inconel 600	20,000	18,800	18,500	18,500	16,000	3,000	4,150
Incoloy 800[3]	15,600	12,100	10,400	9,600	9,100	8,800	--
Hastelloy B[4]	25,000	24,750	21,450	--	--	--	--
Hastelloy X[5]	23,350	18,850	16,000	15,500	15,500	15,500	9,500

1. Values from ASME Boiler and Pressure Vessel Code Section VIII - Unfired Pressure Vessels, 1965.
2. ASME Spec. Min, Tensile = 45,000 PSI
3. ASME Code (See Note 1), Case 1325 (special ruling)
4. ASME Code (See Note 1), Case 1323 (special ruling)
5. ASME Code (See Note 1), Case 1321 (special ruling)

Note:
JMS has a complete design guide on disc for your use. Call and ask for the Thermowell Design Guide.