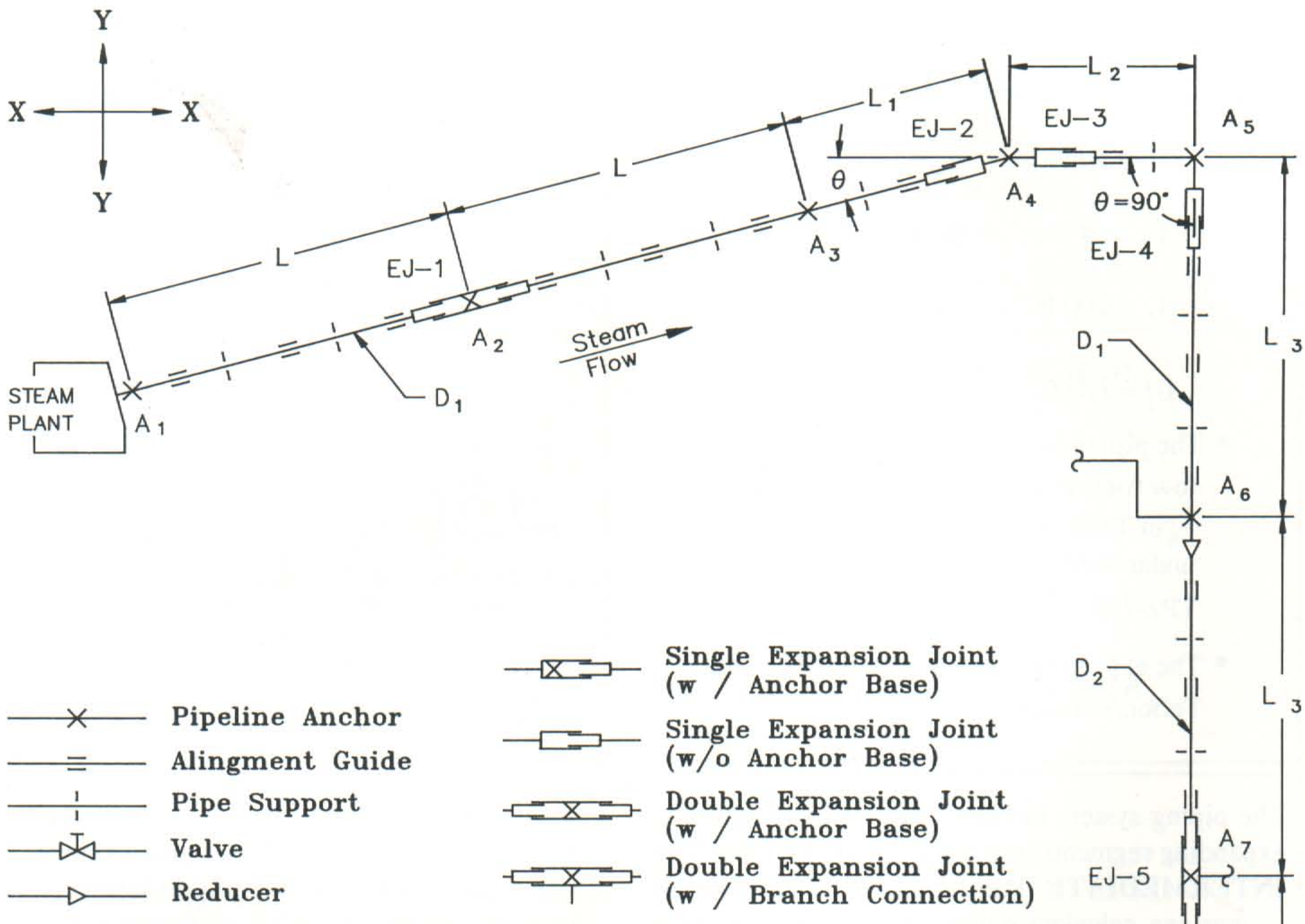
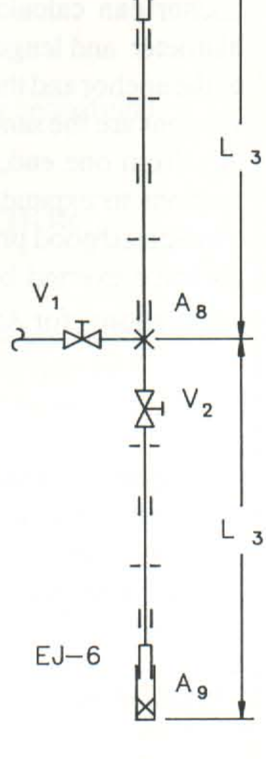
ENGINEERING BULLETIN EJ-1091
SAMPLE ANCHOR LOADING CALCULATIONS





ADVANCED THERMAL SYSTEMS, INC.

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SUPPLEMENT TO
PAGES 18 & 19 OF
BULLETIN TP2-790

The following examples have been prepared to assist those engineers responsible for the design of anchors located in pipelines which utilize slip type expansion joints manufactured by Advanced Thermal Systems Inc. (ATS). These sample calculations supplement the information provided on pages 18 & 19 of ATS Bulletin TP2-790. The following design conditions have been selected for the calculations:

Flowing Media: Saturated Steam @ 388°F

$p = P_{design} = 200$ psig

$D_1 = 10$ in. $L_2 = 100$ ft.

$D_2 = 8$ in $L_3 = 215$ ft.

$L = 200$ ft. $K = 600$ lb/in. of Dia.

$L_1 = 120$ ft. $\theta = 30°$

- The piping is to be supported on ATS low friction slide supports. Multiply F_S in Table 5 by 0.45. Refer to Note 3 under Table 5 on Page 18 of Bulletin TP2-790
- The expansion joint is packed with Teflon/Asbestos packing.

TABLE 5

ANCHOR CALCULATION VALUES

Nominal Pipe Size D	Expansion Joint			Pipe Supports	
	Thrust Area $a = in^2$	Packing Friction F_c = lbs. (K x D) -*Note 1		Support Friction F_s = lbs./100 ft.	
		Teflon/Asbestos	Graphite	Water	Steam
1-1/2"	2.8	900	1500	215	185
2"	4.4	1200	2000	270	220
2-1/2"	6.5	1500	2500	390	320
3"	9.6	1800	3000	485	370
4"	15.9	2400	4000	735	545
5"	24.3	3000	5000	1005	700
6"	34.5	3600	6000	1315	880
8"	58.4	4800	8000	2030	1275
10"	90.8	6000	10000	3000	1805
12"	127.7	7200	12000	3900	2180
14"	153.9	8400	14000	4500	2385
16"	201.0	9600	16000	5500	2720
18"	254.5	10800	18000	6710	3160
20"	314.0	12000	20000	7920	3506
24"	452.0	14400	24000	10770	4330

***See Page 18 of TP2-790 for notes under Table 5**

The piping system has been divided into individual expanding segments by means of anchors - **MAIN** or **INTERMEDIATE**. The forces on an intermediate anchor can calculate out to be zero when the pipe diameter and length of pipe is the same on both sides of the anchor and the number and type of guides in both sections are the same. The pipeline will heat up gradually from one end, thereby causing one of the pipe sections to expand before the other. It is, therefore, considered good practice to design the anchor to resist the force exerted by one of the two pipe sections. See calculations for Anchors A_2, A_3, and $A_{7(Y-Y)}$.

NOTES

1. It is recommended that a transient load factor of 15% be added to all calculated anchor loads to allow for system pressure surges and or other unknown conditions which may occur during the operating life of the system.
2. The centrifugal force at Anchors A_4 and A_5 has not been considered in the calculations shown. For steam applications this force is quite low and can be accounted for by adding 5% minimum load factor. Refer to page 18 of Bulletin TP2-790 for formula if actual calculation is desired.
3. The anchors A_6, A_7, and A_8 must be designed to resist the forces and moments due to the branch connections. The net loading on the anchor is determined by a summation of the moments about the anchor and the vector sum of the forces acting upon it. Installations at a branch connection require that the calculated force and moment be provided to ATS so that the anchor can be adequately designed
4. The calculated stress levels of the anchors must be within the allowable code limits to satisfactorily accommodate the higher loads which will be encountered during a hydrotest.

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MAIN ANCHORS

$$F_{A1} = F_P + F_C + F_S\,(L)$$

$$F_P = p \times a_1$$
$$= 200 \text{ psig} \times 90.8 \text{ in}^2$$
$$= 18{,}160 \text{ lbs.}$$

F_{A1} = 18,160 lbs + 6000 lbs + (812 lbs/100 ft) x 200 ft

= **25,784 lbs**

WHERE:

F_{A1} = FORCE AT ANCHOR $_{A1}$

F_p = Pressure Force
a_1 = 90.8 in² (From Table 5)

F_C = Force to compress
= 6,000 lbs (10" Dia. - Table 5)

F_S = Support Friction
= 1805 lbs/100 ft x .45
= 812 lbs/100 ft

See Note 3 under Table 5 on Page 18 of Bulletin TP2-790

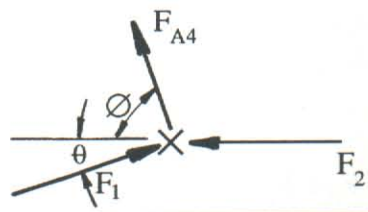
$$F_{A4} = (F_1 + F_2) \times \sin\frac{\theta}{2}$$

$$F_1 = F_2 = F_P + F_C$$

$$F_{A4} = 2(F_P + F_C) \times \sin(\theta/2)$$
$$= 2(18{,}160 \text{ lbs} + 6{,}000 \text{ lbs}) \times \sin(30°/2)$$
$$= \mathbf{12{,}506 \text{ lbs}}$$

F_{A4} = FORCE AT ANCHOR $_{A4}$

$$\varnothing = 90 - \frac{\theta}{2}$$



$$F_{A5} = \sqrt{F_3^2 + F_4^2}$$

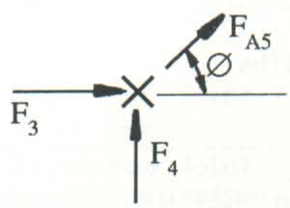
$$F_3 = F_P + F_C + F_S(L_2)$$
= 18,160 lbs + 6000 lbs + (812 lbs/100 ft) x100 ft

F_3 = 24,972 lbs

$$F_4 = F_P + F_C$$
= 18,160 lbs + 6,000 lbs
= 24,160 lbs

$$F_{A5} = \sqrt{24{,}972^2 \text{ lbs} + 24{,}160^2 \text{ lbs}}$$
= **34,746 lbs**

F_{A5} = FORCE AT ANCHOR $_{A5}$



$$\tan \varnothing = \frac{F_4}{F_3}$$

See Note 2 on Page 2 for centrifugal force at A_5

$$F_{A6} = F_5 - F_6$$

$$F_5 = F_P + F_C + F_S\,(L_3)$$
= 18,160 lbs + 6,000 lbs + (812 lbs/100 ft) x 215 ft
= 25,906 lbs

$$F_6 = F_P + F_C + F_S\,(L_3)$$

$$F_P = p \times a_2$$
$$= 200 \text{ psig} \times 58.4 \text{ in}^2$$
$$= 11{,}680 \text{ lbs}$$

Cont'd. on Page 4

F_{A6} = FORCE AT ANCHOR $_{A6}$
(Y-Y) Direction

Note:
Total loading on A_6 must consider moment in (x-x) direction due to branch line. See Note 3 on Page 2

D_2 = 8 in.
a_2 = 58.4 in² (From Table 5 - Page 2)

F_S = 1275 lb/100 ft x 0.45
= 574 lb/100 ft

See Note 3 under Table 5, Page 18 of Bulletin TP2-790

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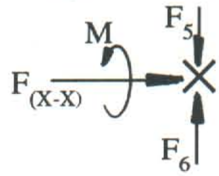
$F_6 = 11{,}680 \text{ lbs} + 4800 \text{ lbs} + (574 \text{ lbs}/100 \text{ ft}) \times 215 \text{ ft}$
$= 17{,}714 \text{ lbs}$

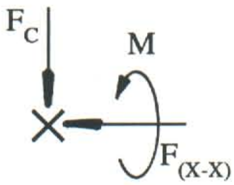
$F_{A6} = 25{,}906 \text{ lbs} - 17{,}714 \text{ lbs}$
$= \mathbf{8{,}192 \text{ lbs}}$

$F_C = 4{,}800$ lbs (8" Dia - Table 5)



$F_{A7} = F_C$

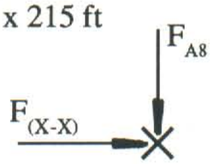
$F_{A7} = 4{,}800$ lbs



F_{A7} = FORCE AT ANCHOR$_{A7}$
(Y-Y) Direction

Anchor$_{A7}$ is considered a MAIN anchor due to the moment in the (x-x) direction from the branch line.
See Note 3 on Page 2

$F_{A8} = F_C + F_S (L_3)$
$= 4{,}800 \text{ lbs} + (574 \text{ lbs}/100 \text{ ft}) \times 215 \text{ ft}$
$= 6{,}034 \text{ lbs}$



$F_{A8} = F_P + F_C + F_S (L_3)$
$= 11{,}680 \text{ lbs} + 4{,}800 \text{ lbs} + (574 \text{ lb}/100 \text{ ft}) \times 215 \text{ ft}$

$= \mathbf{17{,}714 \text{ lbs}}$

WITH VALVE V_2 OPENED

F_{A8} = FORCE AT ANCHOR$_{A8}$
(Y-Y) Direction

WITH VALVE V_2 CLOSED

F_{A8} = FORCE AT ANCHOR$_{A8}$
(Y-Y) Direction

Total loading on Anchor $_{A8}$ must consider the moment in the (X-X) direction due to the branch line. See Note 3 on Page 2.

$F_{A9} = F_P + F_C$
$= 11{,}680 \text{ lbs} + 4{,}800 \text{ lbs}$
$= \mathbf{16{,}480 \text{ lbs}}$

F_{A9} = FORCE AT ANCHOR$_{A9}$

WITH VALVE V_2 OPENED

$F_{A9} = 0$ lbs

WITH VALVE V_2 CLOSED

INTERMEDIATE ANCHORS

$F_{A2} = F_C$
$= \mathbf{6{,}000 \text{ lbs}}$

F_{A2} = FORCE AT ANCHOR$_{A2}$

$F_{A3} = F_C + F_S (L)$

$= 6{,}000 \text{ LBS} + (812 \text{ lbs}/100 \text{ ft}) \times 200 \text{ ft}$

$= \mathbf{7{,}624 \text{ lbs}}$

F_{A3} = FORCE AT ANCHOR$_{A3}$

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