C-1.3.2 (continued)

Example No. 6: Single Expansion Joint, attached to vessel nozzle, subjected to axial and lateral movement.

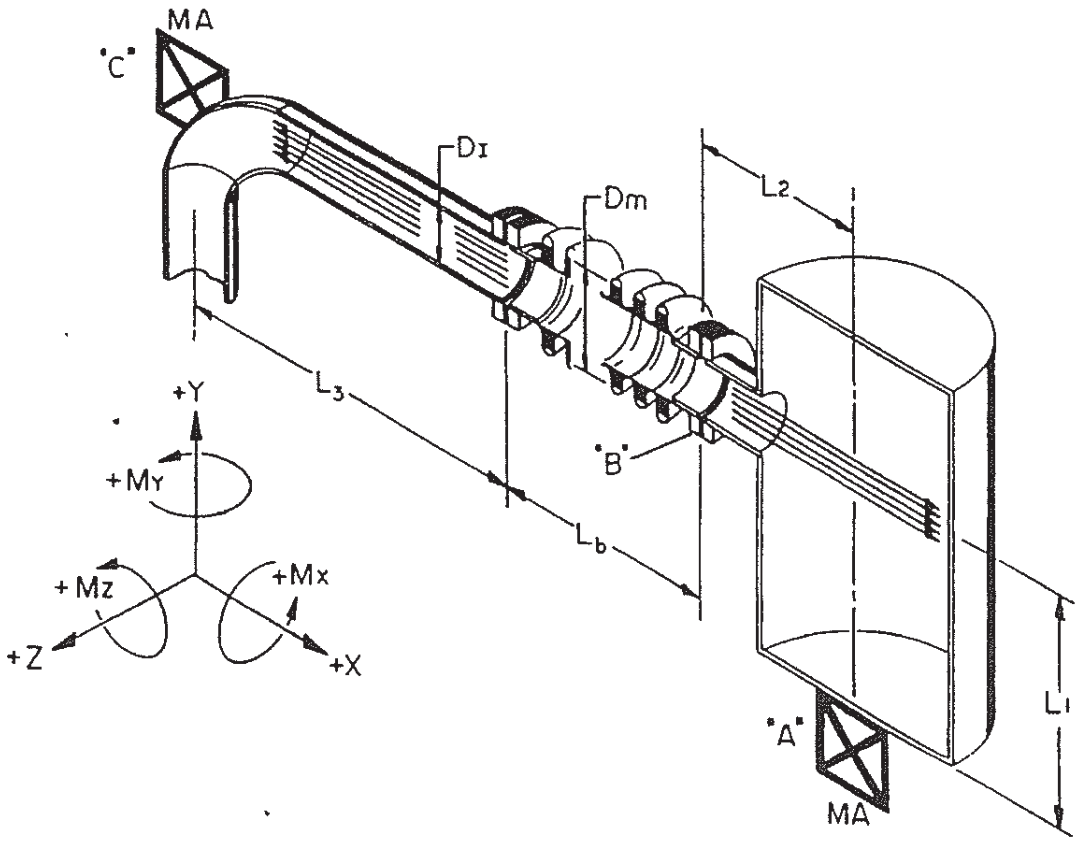

FIGURE C12

Problem: A large vertical vessel which operates at 150 psig at 500° F is equipped with a 24 in. diameter outlet line as shown in Figure C12. The outlet line contains a single bellows Expansion Joint which is designed to absorb the thermal growth of the vessel and pipe line. The lengths and calculated thermal growths for the all-carbon steel system are as follows:

$L_1 = 15$ ft.	$\Delta L_1 = .543$ in.
$L_2 = 6$ ft.	$\Delta L_2 = .217$ in.
$L_b = 1$ ft.	$\Delta L_b = .036$ in.
$L_3 = 14$ ft.	$\Delta L_3 = .507$ in.

C-1.3.2 (continued)

Determine the forces and moments acting on the nozzle flange "B"

Data provided by the Expansion Joint manufacturer:

$$D_m = 25.50 \text{ in.}$$
$$D_l = 23.25 \text{ in.}$$
$$f_w = 36840 \text{ lbs./in. per convolution}$$
$$N = 12$$

SOLUTION:

Calculate the equivalent movements per convolution:

$$e_x = \frac{x}{N} = \frac{.760}{12} = .063 \text{ in.}$$

where: $x = \Delta L_2 + \Delta L_b + L_3 = .217 + .036 + .507 = .760 \text{ in.}$

$$e_y = \frac{3D_m y}{N(L_b - x)} = \frac{(3)(25.50)(.543)}{(12)(12 - .76)} = .308 \text{ in.}$$

$y = \Delta L_1 = .543$

$L_b = 12 \text{ in.}$

C-1.3.2 (continued)

Calculate F_a, F_s, F_p and V.

$F_a = (f_w)(e_x)$
$= (36840)(.063)$
$= 2321$ lbs.

$F_s = (A_e)(P_d)$
$= (510.7)(150)$
$= 76605$ lbs.

$F_p = (A_p)(P_d)$
$= (424.6)(150)$
$= 63690$ lbs.

$V_l = \frac{f_w D_m e_y}{2L_b}$
$= \frac{(36840)(25.50)(.308)}{(2)(12)}$
$= 12056$ lbs.

where: $A_e = \frac{\pi}{4}\left(D_m^{\ 2}\right)$
$= \frac{\pi}{4}(25.5)^2$
$= 510.7$ in.^{2}

$P_d = 150$ psig

$A_p = \frac{\pi}{4}\left(D_i^{\ 2}\right)$
$\doteq \frac{\pi}{4}(23.25)^2$
$= 424.6$ in.^{2}

$L_b = 12$ in.

Forces and moments acting on vessel anchor "A"

$F_x = F_a + F_s = 2321 + 76605$
$= 78926$ lbs.

$F_y = -V_l = -12056$ lbs.

$F_z = 0$ (no forces exist in Z direction)

C-1.3.2 (continued)

$M_x = F_z Y - F_y Z = 0$ where: $X = -(L_2 + L_b/2) = -6.5$ ft.

$M_y = F_x Z - F_z X = 0$ $Y = L_1 = 15$ ft.

$M_z = F_y X - F_x Y$ $Z = 0$

$= (-12056)(-6.5) - (78926)(15)$

$= 1{,}105{,}526$ ft. lbs.

Forces and moments acting on nozzle flange face "B"

$F_x = F_a + F_s - F_p = 2321 + 76605 - 63690$

$= 15236$ lbs.

$F_y = -12056$ lbs.

$F_z = 0$

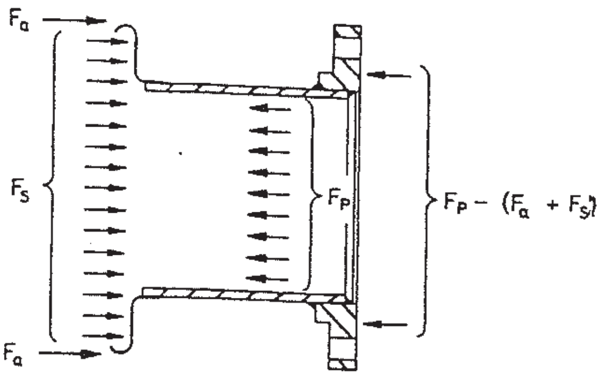

FIGURE C13

$M_x = F_z Y - F_y Z = 0$ where: $X = L_b/2 = -0.5$ ft.

$M_y = F_x Z - F_z X = 0$ $Y = Z = 0$

$M_z = F_y X - F_x Y$

$= (-12056)(-0.5) - 0$

$= 6028$ ft. lbs.

Forces and moments acting on main anchor "C"

$F_x = -F_a - F_s = -2321 - 76605$

$= -78926$ lbs.

$F_y = 12056$ lbs.

$F_z = 0$

$M_x = F_z Y - F_y Z = 0$ where: $X = L_3 + L_b/2 = 14.5$ ft.

$M_y = F_x Z - F_z X = 0$ $Y = Z = 0$

$M_z = F_y X - F_x Y = (12056)(14.5) - 0$

$= 174812$ ft. lbs.

C-1.3.2 (continued)

EXPANSION JOINT FLANGE LOADING CONSIDERATIONS

Typically a flange connection is required to withstand the axial thrust that is produced during operation of a piping system as shown in Figure C13.1. The axial force that results from the pressure being applied against the elbow is restrained by the flange bolts, thus creating a force and moment on the flange at the flange connection attempting to unseat the gasket.

However, when an unrestrained expansion joint is employed as shown in Figure C13.2, the flange loading conditions change dramatically. In order to keep the expansion joint from freely extending, a main anchor is normally utilized to restrain the elbow. This main anchor will also carry the pressure thrust that results from the pressurization of the system and release this load from the flange bolts. In this instance, the loading on the flange due to pressure is a compressive load that is equal to the (F_s-F_p) as shown in Figure C13.2. This compressive load is in addition to that normally applied due to gasket seating.

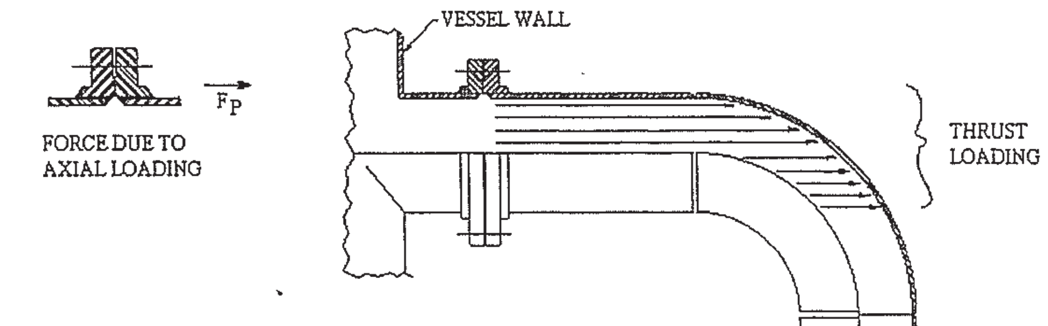

FIGURE C13.1

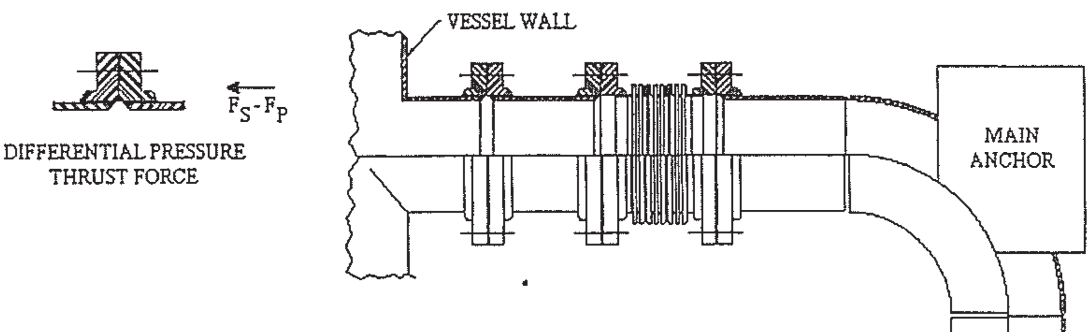

FIGURE C13.2