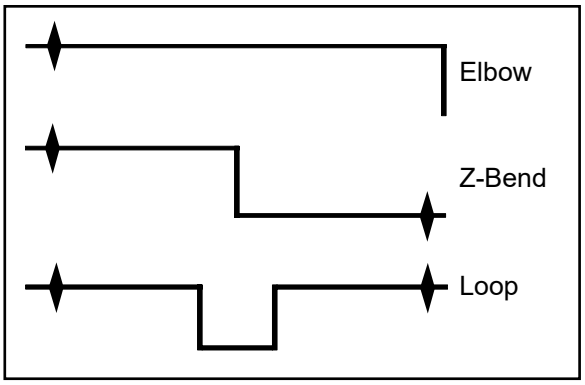
EXPANSION CALCULATIONS AND LOOP SIZING

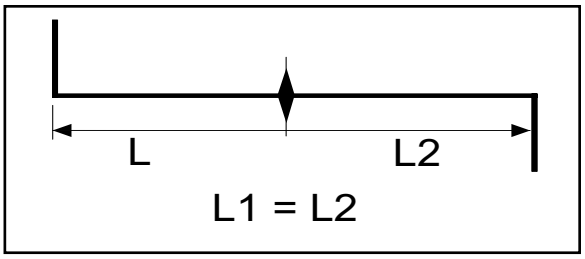
In a bonded system, the carrier pipe, foam insulation, and outer protective jacket are joined together forming one cohesive unit that expands and contracts together. Thermal expansion of the carrier pipe during operation is therefore transferred to the polyurethane foam and outer jacket. These movements are naturally restricted to a certain extent by the friction between the soil and jacket. In extreme cases, the force of friction can become so great that free expansion cannot occur and the unit becomes "fixed" into place. In such a case, the opposing force from thermal expansion can place impermissibly high stresses in the carrier pipe. Therefore, free expansion must be allowed to occur, but expansion must ultimately be compensated for through system design. The most common method is the inclusion of expansion elbows, loops, or z-bends.

Thermal expansion will occur between all fixed points in the piping system. If the system has the same covering height, natural fixed points will occur in the center of a line section between two expansion elbows. Unequal covering will cause the fixed point to be displaced due to varying frictional forces, and if there is any doubt, the fixed point should be set with an anchor. In all cases, this fixed point should be considered when calculating expansion.

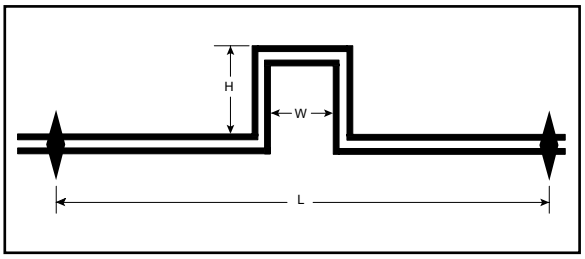
EXPANSION COMPENSATION



NATURAL FIXED POINT



EXPANSION LOOP



GUIDELINES FOR LOOP SIZING

1. The expansion loop is usually located on the side of the hottest line.
2. The expansion loop, as a rule, should be located in the center of the distance between two anchors.
3. The height of the expansion loop is normally twice the width. The exception to this rule occurs when more than one line runs parallel in a common trench. The dimensions of the loops for the additional line must be increased to allow nesting of the loops.

CALCULATIONS

1. The formula for calculating thermal expansion:
   $\Delta L = C \times L \times (T_f - T_g) \times 12in./ ft.$
   Coefficient of thermal expansion (C):
   Steel (C) = 6.5×10^{-6} in./ in.°F

   Distance between fixed points (L) in feet.
   Temperature of fluid (T_f)
   Temperature of ground (T_g)
2. After calculating the expansion, find the expansion loop size from the charts for the applicable pipe or tube. Loop sizes are taken to the nearest half foot on the height and width.

EXAMPLE

Find the loop size for a 6" diameter steel pipe carrying 200°F heating water with 200 ft. between anchors and an average annual ground temperature of 50°F.

Given:

Steel (C)	=	6.5×10^{-6} in./ in.°F
Distance (L)	=	200 ft.
Temp. Diff. (ΔT)	=	(200°F - 50°F) = 150°F
Pipe Diam. (D)	=	6"

Calculations:

$\Delta L = C \times L \times (T_f - T_g) \times 12in./ ft.$
$\Delta L = 6.5 \times 10^{-6} \times 200 \times (200 - 50) \times 12$
$\Delta L = 2.34$ in. (expansion)

From the expansion loop chart for steel:
Requires 5'x10' expansion loop.

EXPANSION LOOP SIZES FOR STEEL PIPE

Expansion loops are sized for A53 Grade B ERW steel pipe allowable stresses.

PIPE SIZE (IN)	ΔL (IN)	LOOP SIZE (FT)		PIPE SIZE (IN)	ΔL (IN)	LOOP SIZE (FT)	
		H	W			H	W
3/4	0.00 - 1.50	4	2	10	0.00 - 0.42	4	2
	1.50 - 6.00	6	3		0.42 - 0.91	6	3
1	0.00 - 1.00	4	2		0.91 - 1.44	8	4
	1.00 - 4.14	6	3		1.44 - 2.00	10	5
1-1/4	0.00 - 0.93	4	2		2.00 - 2.57	12	6
	0.93 - 3.33	6	3		2.57 - 3.16	14	7
	3.33 - 5.56	8	4		3.16 - 3.80	16	8
1-1/2	0.00 - 0.88	4	2		3.80 - 4.14	18	9
	0.88 - 2.75	6	3	12 & 14	0.00 - 0.39	4	2
	2.75 - 4.75	8	4		0.39 - 0.87	6	3
2	0.00 - 0.85	4	2		0.87 - 1.34	8	4
	0.85 - 2.38	6	3		1.34 - 1.88	10	5
	2.38 - 4.00	8	4		1.88 - 2.43	12	6
2-1/2	0.00 - 0.78	4	2		2.43 - 3.00	14	7
	0.78 - 2.14	6	3		3.00 - 3.57	16	8
	2.14 - 3.71	8	4		3.57 - 4.14	18	9
	3.71 - 5.31	10	5	16	0.00 - 0.41	4	2
3	0.00 - 0.72	4	2		0.41 - 0.85	6	3
	0.72 - 1.78	6	3		0.85 - 1.32	8	4
	1.78 - 3.00	8	4		1.32 - 1.83	10	5
	3.00 - 4.35	10	5		1.83 - 2.34	12	6
3-1/2	0.00 - 0.68	4	2		2.34 - 2.86	14	7
	0.68 - 1.35	6	3		2.86 - 3.43	16	8
	1.35 - 2.70	8	4		3.43 - 4.00	18	9
	2.70 - 3.84	10	5				
	3.84 - 5.00	12	6				
4	0.00 - 0.63	4	2				
	0.63 - 1.45	6	3				
	1.45 -2.41	8	4				
	2.41 - 3.45	10	5				
	3.45 - 4.52	12	6				
5	0.00 - 0.42	4	2				
	0.42 - 1.27	6	3				
	1.27 - 2.12	8	4				
	2.12 - 3.00	10	5				
	3.00 - 3.96	12	6				
	3.96 - 4.13	14	7				
6	0.00 - 0.46	4	2				
	0.46 - 1.16	6	3				
	1.16 - 1.87	8	4				
	1.87 - 2.35	10	5				
	2.35 - 3.51	12	6				
	3.51 - 4.26	14	7				
8	0.00 - 0.54	4	2				
	0.54 - 1.00	6	3				
	1.00 - 1.64	8	4				
	1.64 - 2.30	10	5				
	2.30 - 2.95	12	6				
	2.95 - 3.64	14	7				
	3.64 - 4.35	16	8				