Expansion loop for Thermal expansion of pipes

Pipes expands when it's heated, and contracted by cooling. Regarding Piping system design, the length fluctuation can lead to costly issues.
The bends and the expansion loop is one of approaches to absorb thermal expansion and contraction in pipes.
The expansion and cotraction of pipes can be calculated with the coefficient of Thermal expansion and the following equation.

$$\Delta L = \alpha \cdot \Delta T \cdot L_{pipe}$$

ΔL : Change of pipe length
α : Coefficient of Thermal expansion
ΔT : Change of temperature
L_{pipe} : Length of pipe

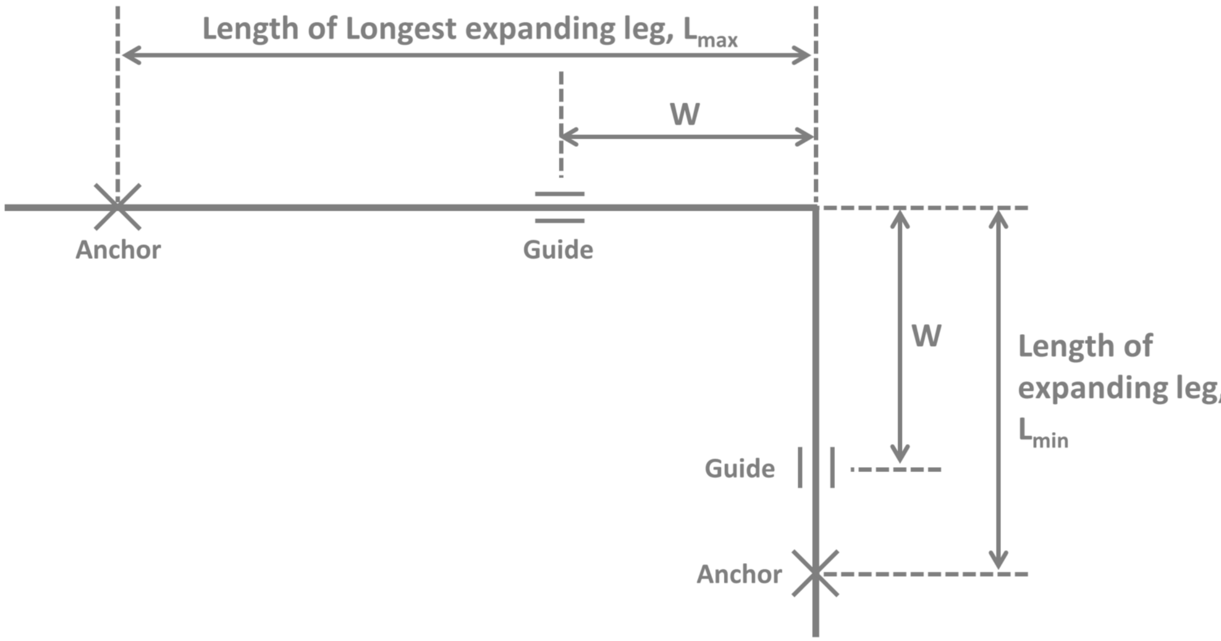
Reference : https://en.wikipedia.org/wiki/Thermal_expansion

Material	$10^{-6} \cdot \frac{m}{m \cdot K}$	$10^{-6} \cdot \frac{inch}{inch \cdot degF}$
Cast copper	17 - 18	9.2-9.8
Structural Steel	12	6.5
Wrought iron	11	6.4
Iron alloys	10 - 20	5.6 - 11
Iron carbon alloys	10 - 12	5.6 - 6.5
Cast austenitic stainless steel	10 - 17	5.6 - 9.6
Duplex stainless steel	10 - 15	5.6 - 8.3
Nonresulfurized carbon steel	8.8 - 15	4.9 - 8.4
Resulfurized carbon steel	11 - 14	6.2 - 7.5

Table 1 : Example, Coefficient of Linear thermal expansion
(Reference : Thermal Properties of Metals, ASM International)

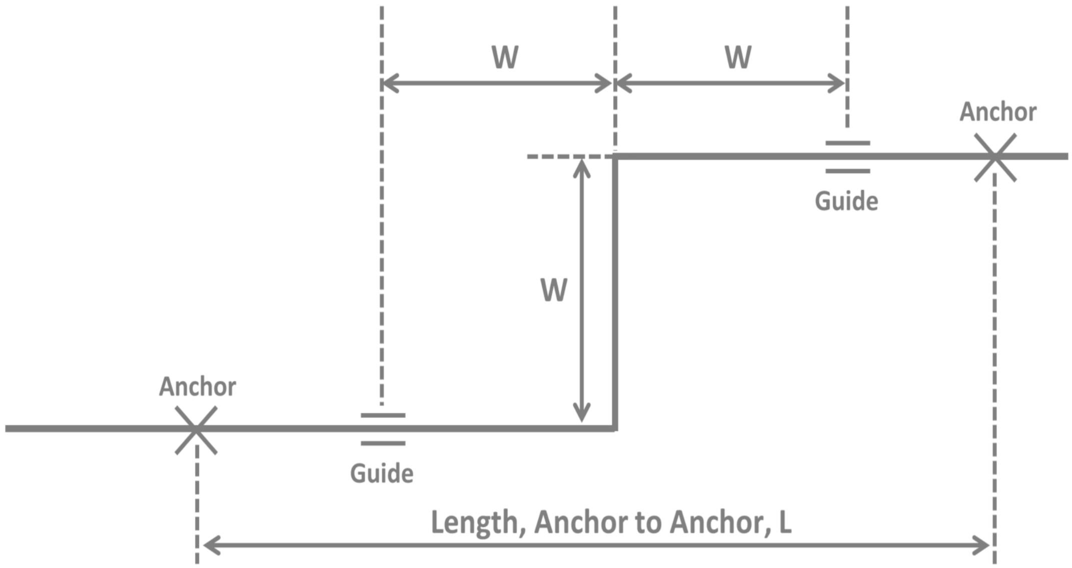
This application shows how to calculate length of loops for several types of the expansion loops.

L-Bends (Change of Direction)



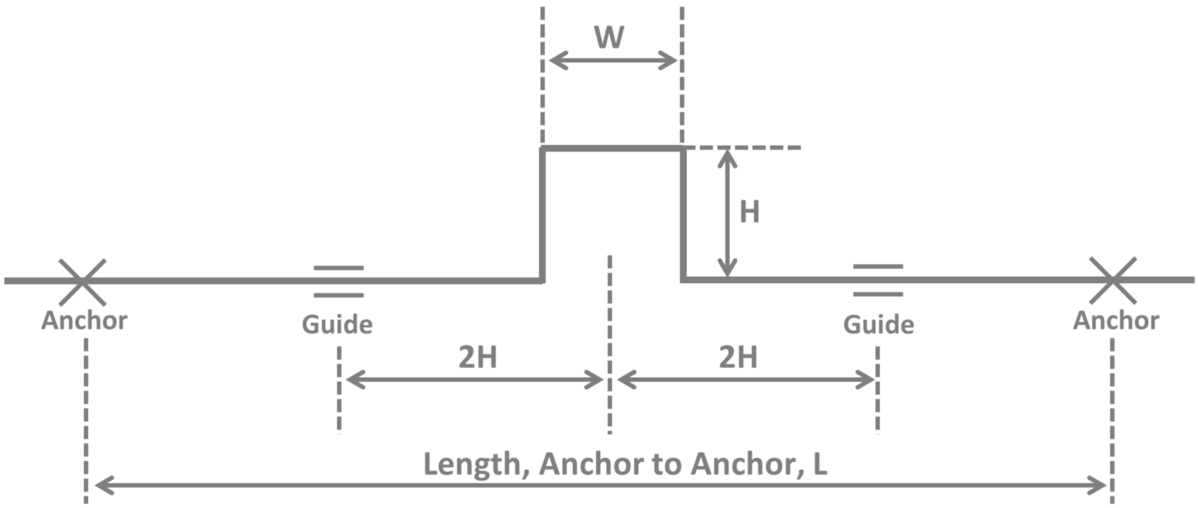
Coefficient of Linear Thermal expansion	$\alpha := 6.7 \cdot 10^{-6} \frac{\text{inch}}{\text{inch} \cdot \text{degF}}$
Length of longest expanding leg	$L_{max} := 100\ \text{ft}$
Initial temperature	$T_0 := 52\ \text{degF}$
Final temperature	$T_1 := 350\ \text{degF}$
Outside diameter of pipe	$D_{pipe} := 2.875\ \text{inch}$
Thermal expansion/contraction of long leg	$L_{ex} := \alpha \cdot (T_1 - T_0) \cdot L_{max} = 0.200\ \text{ft}$
Length, Guide to Corner (W in the diagram)	$W := 6.225 \cdot \sqrt{\frac{L_{ex}}{\text{inch}} \cdot \frac{D_{pipe}}{\text{inch}}} \cdot \text{ft}$
	$W = 196.054\ \text{in}$

Z-Bends (Expansion offset)



Coefficient of Linear Thermal expansion	$\alpha := 6.7 \cdot 10^{-6} \frac{\text{inch}}{\text{inch} \cdot \text{degF}}$
Length, Anchor to Anchor	$L := 100 \text{ ft}$
Initial temperature	$T_0 := 52 \text{ degF}$
Final temperature	$T_1 := 350 \text{ degF}$
Outside diameter of pipe	$D_{pipe} := 2.875 \text{ inch}$
Thermal expansion/contraction of long leg	$L_{ex} := \alpha \cdot (T_1 - T_0) \cdot L = 0.200 \text{ ft}$
Length, Guide to Corner (W in the diagram)	$W := 4 \cdot \sqrt{\frac{L_{ex}}{\text{inch}} \cdot \frac{D_{pipe}}{\text{inch}}} \cdot \text{ft}$
	$W = 125.978 \text{ in}$

U-Bends (Expansion loop)



Coefficient of Linear Thermal expansion	$\alpha := 6.7 \cdot 10^{-6} \frac{\text{inch}}{\text{inch} \cdot \text{degF}}$
Length, Anchor to Anchor	$L := 100 \text{ ft}$
Initial temperature	$T_0 := 52 \text{ degF}$
Final temperature	$T_1 := 350 \text{ degF}$
Outside diameter of pipe	$D_{pipe} := 2.875 \text{ inch}$
Thermal expansion/contraction of long leg	$L_{ex} := \alpha \cdot (T_1 - T_0) \cdot L = 2.396 \text{ in}$
Length of expansion loop (W and H in the diagram)	$L_{loop} := 6.225 \cdot \sqrt{\frac{L_{ex}}{\text{inch}} \cdot \frac{D_{pipe}}{\text{inch}}} \cdot \text{ft} = 196.054 \text{ in}$

$$W := \frac{L_{loop}}{5} = 39.211 \text{ in}$$

$$H := 2 \cdot W = 78.422 \text{ in}$$