

## THERMAL MOVEMENT ANALYSIS OF METAL FABRICATIONS

Expansion Coefficients and Expected Expansion of Various Metals at Normal Range  
Temperatures of 38°C

Metal	Coefficient of Thermal Expansion $\mu$ in./in. °C	Expected Expansion of a 120 inch sheet* (in)	Expected Expansion of a 3 meter sheet* (mm)
3003 Aluminum	23.2	0.11	2.79
5005 Aluminum	23.8	0.11	2.79
6063 Aluminum	23.4	0.11	2.79
Copper	16.8	0.08	2.03
Gilding Metal	18.1	0.08	2.03
Commercial Bronze	18.4	0.08	2.03
Jewelry Bronze	18.6	0.08	2.03
Red Brass	18.7	0.09	2.29
Cartridge Brass	19.9	0.09	2.29
Yellow Brass	20.3	0.09	2.29
Muntz Metal	20.8	0.09	2.29
Architectural Bronze	20.9	0.10	2.54
Phosphor Bronze	18.2	0.08	2.03
Silicon Bronze	18.0	0.08	2.03
Aluminum Bronze	16.8	0.08	2.03
Nickel Silver	16.2	0.07	1.78
Iron	11.7	0.05	1.27
Steel	11.7	0.05	1.27
Cast Iron	10.5	0.05	1.27
304 Stainless Steel	16.5	0.08	2.03
Lead	29.3	0.13	3.30
Monel	14.0	0.06	1.52
Tin	23.0	0.10	2.54
Zinc – rolled	32.5	0.15	3.81
Zinc-Cu, Tn Alloy	24.9 with grain	0.11	2.79
Zinc-Cu, Tn Alloy	19.4 across grain	0.09	2.29
Titanium	8.4	0.04	1.02
Gold	14.2	0.05	1.27

\*A length of metal, 120 inches (roughly 3 meters), when installed outdoors can experience a temperature differential of as much as 100°F (38°C). When this occurs, the metal will increase in length the amount indicated for that metal. If the metal is to be subjected to a higher temperature range, then you must allow for the additional expansion.

(Reference: Zahner, L. Architectural Metals: A Guide to the Selection, Specification and Performance. New York: John Wiley, 1995, Page 17)

Most metals will undergo dimensional changes when subjected to variations in temperature. For materials, there is a Coefficient of Thermal Expansion (also referred to as the coefficient of linear expansion), that is defined as the unit length change of a solid when its temperature is changed by 1 degree.

To determine the expected amount of expansion or contraction of a particular metal you need to know the maximum expected high temperature and the minimum expected low temperature the service life of the metal will experience.

You also need to know temperature the metal is at or expected to be at when it is installed.

For example;

Stainless steel alloy 304

Coefficient of Thermal Expansion (CTE) equals 0.0000165 in/in °C (refer to chart)

Determine the difference between the installed temperature and the maximum and minimum temperatures expected.

$$\Delta T_{\text{hot}} = T_{\text{hot}} - T_{\text{install}}$$

$$\Delta T_{\text{cold}} = T_{\text{install}} - T_{\text{cold}}$$

Assuming the metal is being installed at 6°C (40°F)

The hottest expected service life temperature is 70°C (160°F)

The coldest expected service life temperature is -34°C (-30°F)

$$\Delta T_{\text{hot}} = 70 - 6 = 66$$

$$\Delta T_{\text{cold}} = 6 - (-34) = 40$$

Maximum expansion and contraction from the installed condition of 304 stainless under these conditions is expected to be:

Maximum expansion per unit foot =  $0.0000165 \times 66 \times 12 = 0.013$  inches / ft

Maximum contraction per unit foot +  $0.0000165 \times 40 \times 12 = 0.008$  inches / ft