Properties of Metals and Alloys for Use in Measurement Equipment

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Suggested revisions are invited and should be submitted to the Standards Department, API, 200 Massachusetts Avenue NW, Suite 1100, Washington, DC 20001; standards@api.org.

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1 Scope

This report consolidates the industry available data for the thermal expansion coefficients and the modulus of elasticity of the typical metals used in the API *MPMS* suite of documents. This document does not develop or calculate any of these properties.

2 Normative References

This document contains no normative references.

3 Terms, Definitions, and Symbols

3.1 Terms and Definitions

For the purposes of this document, the following definitions apply.

3.1.1
area thermal expansion (α_A)
The change in area per unit area resulting from a temperature change. Area thermal expansion is represented by ΔA / A_0, where ΔA is the area change of the specimen ($A_1 - A_0$) and A_0 and A_1 are the specimens' area at reference temperature T_0 and test temperature T_1, respectively. Area expansion is often expressed as a percentage or in parts per million (such as mm^2/m^2 or 10^{-6} m^2/m^2).

3.1.2
coefficient of thermal expansion (α)
The coefficient of thermal expansion is the relative amount by which the density of a material changes, per degree, due to a change in temperature. It describes how the size of an object changes with a change in temperature. Specifically, it measures the fractional change in size per degree change in temperature at a constant pressure, such that lower coefficients describe lower propensity for change in size. Several types of coefficients have been developed: volumetric, area, and linear. The choice of coefficient depends on which dimensions are considered important for the application.

The volumetric coefficient of thermal expansion coefficient is the most common thermal expansion coefficient, and the most relevant for fluids. In general, substances expand or contract when their temperature changes, with expansion or contraction occurring in all directions. Substances that expand at the same rate in every direction are called isotropic. For isotropic materials, the area and volumetric thermal expansion coefficient are, respectively, approximately two and three times larger than the linear thermal expansion coefficient.

3.1.3
cubical thermal expansion (α_V)
The change in volume per unit volume resulting from a temperature change. Volume thermal expansion is represented by ΔV / V_0, where ΔV is the volume change of the specimen ($V_1 - V_0$) and V_0 and V_1 are the specimens' volumes at reference temperature T_0 and test temperature T_1, respectively. Volume thermal expansion is often expressed as a percentage or in parts per million (such as cm^3/m^3 or 10^{-6} m^3/m^3).

3.1.4
density (ρ)
The density of a quantity of a homogeneous substance is the ratio of its mass to its volume. The density varies as the temperature changes and is therefore generally expressed as the mass per unit of volume at a specified temperature.