

Defining Strain, Strain Gauge, and Strain Gauge Measurement

What is Strain?

Strain is the amount of deformation of a body due to an applied force. More specifically, strain (ϵ) is defined as the fractional change in length, as shown in Figure 1 below.

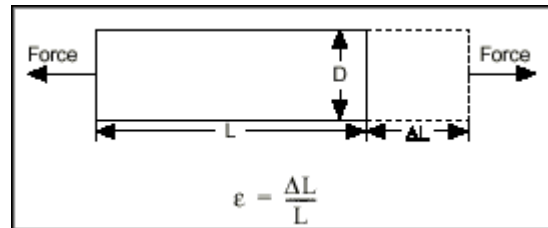


Figure 1. Definition of Strain

Strain can be positive (tensile) or negative (compressive). Although dimensionless, strain is sometimes expressed in units such as in./in. or mm/mm. In practice, the magnitude of measured strain is very small. Therefore, strain is often expressed as microstrain ($\mu\epsilon$), which is $\epsilon \times 10^{-6}$.

When a bar is strained with a uniaxial force, as in Figure 1, a phenomenon known as Poisson Strain causes the girth of the bar, D , to contract in the transverse, or perpendicular, direction. The magnitude of this transverse contraction is a material property indicated by its Poisson's Ratio. The Poisson's Ratio ν of a material is defined as the negative ratio of the strain in the transverse direction (perpendicular to the force) to the strain in the axial direction (parallel to the force), or $\nu = \epsilon_T/\epsilon$. Poisson's Ratio for steel, for example, ranges from 0.25 to 0.3.

The Strain Gauge

While there are several methods of measuring strain, the most common is with a strain gauge, a device whose electrical resistance varies in proportion to the amount of strain in the device. The most widely used gauge is the bonded metallic strain gauge.

The metallic strain gauge consists of a very fine wire or, more commonly, metallic foil arranged in a grid pattern. The grid pattern maximizes the amount of metallic wire or foil subject to strain in the parallel direction (Figure 2). The cross sectional area of the grid is minimized to reduce the effect of shear strain and Poisson Strain. The grid is bonded to a thin backing, called the carrier, which is attached directly to the test specimen. Therefore, the strain experienced by the test specimen is transferred directly to the strain gauge, which responds with a linear change in electrical resistance. Strain gauges are available commercially with nominal resistance values from 30 to 3000 Ω , with 120, 350, and 1000 Ω being the most common values.

Strain Gauge Measurement

In practice, the strain measurements rarely involve quantities larger than a few millistrain ($\epsilon \times 10^{-3}$). Therefore, to measure the strain requires accurate measurement of very small changes in resistance. For example, suppose a test specimen undergoes a strain of 500 $\mu\epsilon$. A strain gauge with a gauge factor of 2 will exhibit a change in electrical resistance of only 2 (500×10^{-6}) = 0.1%. For a 120 Ω gauge, this is a change of only 0.12 Ω .