TECHNICAL TERMS

Gauge Length

This dimension represents the actual grid length in the sensitive direction.

Gauge Resistance

The gauge resistance is the electrical resistance of an unbonded gauge at room temperature and subject to no external pressure. The gauge resistance generally used is 120Ω but gauges are also produced with gauge resistance of 60Ω, 350Ω and 1000Ω. High-resistance gauges yield a high bridge output when high voltages are applied but they are also susceptible to noise. The majority of the strain gauges used in the production of transducers have a gauge resistance of 350Ω.

Gauge Factor

The amount shown in the following equation is called the gauge factor. In this equation, ε indicates the strain generated due to uniaxial stress in the direction of the strain gauge axis. ΔR/R shows the ratio of resistance change due to strain ε.

$$K = \frac{\Delta R / R}{\varepsilon}$$

where K : Gauge Factor
ε : Mechanical strain
R : Gauge Resistance
ΔR : Resistance change

Longitudinal Sensitivity

Longitudinal sensitivity is very similar to the gauge factor and refers to the sensitivity of the gauge when no strain is applied in the direction perpendicular to the gauge axis.

Transverse Sensitivity

The gauge also exhibits sensitivity in the direction perpendicular to the axial direction. The amount shown in the following equation due to the uniaxial strain (εt) in the direction perpendicular to the gauge axis, and the resistance variation generated thereby, is called transverse sensitivity (Kt).

$$Kt = \frac{\Delta R / R}{\varepsilon t} \times 100$$

where
Kt : Transverse Sensitivity
εt : Uniaxial strain perpendicular to the gauge axis

Transverse Sensitivity Ratio

This refers to the ratio of transverse sensitivity to longitudinal sensitivity. This is usually 1% or less and does not usually pose a problem except in high-precision measurement or in locations with biaxial strain.

Gauge Hysteresis

When a strain gauge is bonded to a test specimen and strain is applied, resistance change for identical strain in increase and decrease processes may differ. This difference is referred to as hysteresis. Gauge hysteresis varies depending on factors such as grid configuration, base material, adhesive and temperature.

Thermal Hysteresis

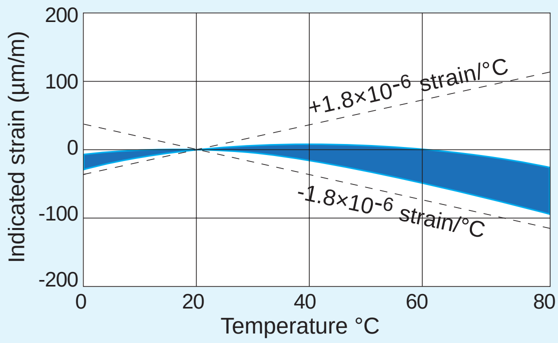
Thermal hysteresis refers to hysteresis that occurs in the heating or cooling cycle such that the respective cycles do not pass through the same point. Thermal hysteresis poses an ongoing problem in strain measurement where temperature change occurs. This hysteresis must be removed by applying heat experience to stabilize the characteristic of the strain gauge and the adhesive.

Gauge Zero Drift with Temperature

At high temperature, effects such as thermal oxidation of the sensing elements in a strain gauge cause the zero point of the gauge in a no-load state to gradually drift. This is one of the characteristics that determine a strain gauge's resistance to heat. Above 200°C, Ni-Cr alloy performs far better than Cu-Ni alloy, and alloys such as Pt-W are used in 500°C to 800°C environments.

Self-Temperature-Compensated Gauges

The ambient temperature change may cause a variation of strain gauge resistance. The variation is ascribable to the thermal expansion of both strain gauge material and specimen, together with the thermal coefficient of resistance of the gauge material. Self-temperature compensated gauges are commonly used to minimize the gauge thermal output when bonded to test specimens having a specific liner thermal expansion coefficient in the specified temperature range. The following graph shows an example of thermal output.

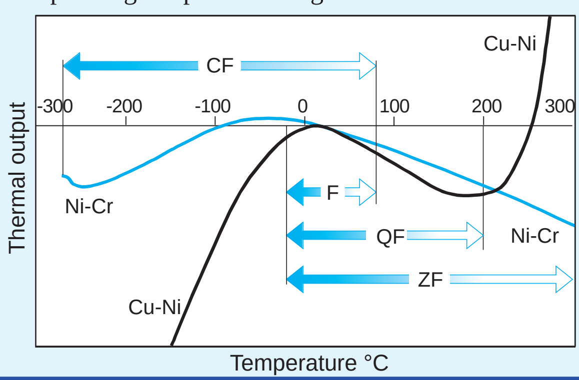


Temperature Compensation Range

This refers to a temperature range in which the thermal output of a self-temperature compensated gauge should be within the given range. Compensation is accurate within approximately $\pm 1.8 \times 10^{-6}$ strain/°C. For greater accuracy, corrections can be made using the curves for apparent strain vs. temperature which is suplied with each package of gauge.

Operating Temperature Range

This range is the temperature range within which a strain gauge can be used continuously in the appropriate conditions. The figure below shows thermal output characteristics for Cu-Ni and Ni-Cr alloys used for the sensing elements in TML strain gauges. Most strain gauges use Cu-Ni alloy, with Ni-Cr alloy is used in strain gauge series that have a wider operating temperature range.



Gauge Length Selection

Different gauge lengths should be selected depending on specimens. Gauges with short gauge lengths are used to measure local strain, while gauges with long lengths can be used to measure averaged strain over a larger area. For a heterogenous material, a gauge length is required that can average out irregular strain in the material. For example, as concrete is composed of cement and aggregate (gravel or sand, etc.) the length of a gauge used is more than three times the diameter of the aggregate so as to give an averaged evaluation of the concrete.

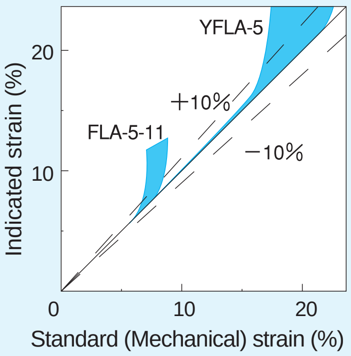
Gauge length (mm)	Gauge Applications
0.2 ~ 1	For stress concentration measurement
2 ~ 6	For metal and general use
10 ~ 20	For mortar, wood, FRP, etc.
30 ~ 120	For concrete

Strain Limit

The strain limit is the maximum amount of strain under which a strain gauge can operate under a given condition without suffering damage. At TML, the strain limit is the smallest value of mechanical strain at which the indicated strain exceeds the mechanical strain by 10%.

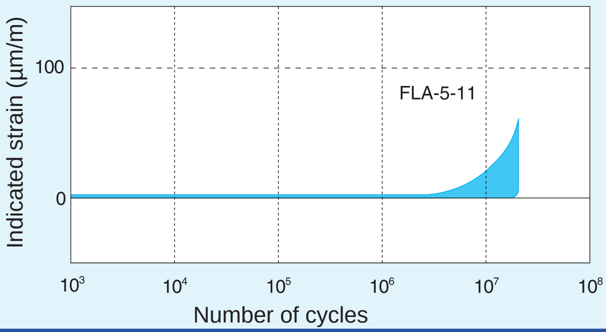
General use strain gauge
F series : FLA-5-11

Post-Yield strain gauge
YF series : YFLA-5



Fatigue Life

When strain is applied repeatedly to a strain gauge, as the amount of strain becomes large, the gauge resistance increases and disconnection or peeling-off of the gauge occurs to make the gauge useless. In general, the fatigue life is determined by the amount of applied strain and speed of cyclic loading and expressed by the number of repetitions. At TML, a constant mechanical strain is applied repeatedly to the bonded strain gauge and the fatigue life is indicated by the number of repetitions at which the indicated strain value without loading exceeds 100×10^{-6} strain. The calibraiton result is exampled below. Even if the number of repetitions is over rthe specified life, the gauges do not always become out of service. Usually, the fatigue life is an extend of 10^6 ~ 10^7 times. At less than 500×10^{-6} strain, the fatigue life extends and can be regarded infinite. Post-yield strain gauges of which sensing element is heat-treated are inadequate for cyclic loading.



Permissible Current (Permissible Volgate)

The current flowing a strain gauge is related to the output voltage of the gauge bridge, and the larger the current, the larger the voltage is obtained. To the contrary, depending upon the material of a specimen and the area of the gauge, Joule's heat is generated by the current to raise the temperature of gauge and as a result apparent strains are produced. In general, a current less than 30mA is recommended for metallic specimens and less than 10mA for wooden and plastic specimens.

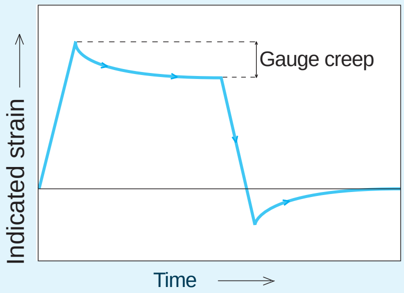
Strain Gauge Frequency Response

The frequency response of a strain gauge is determined by the gauge length and the longitudinal elastic wave speed of the test specimen.

Gauge length (mm)	0.2	1	3	5	10	30	60
Steel [kHz]	660	530	360	270	170	-	-
Concrete [kHz]	-	-	-	-	120	50	20

Gauge Creep

A bonded strain gauge subjected to a constant strain will give a decreasing indicated value as time progresses. This phenomenon is referred to as creep. In general, the shorter the gauge length, the greater the gauge creep becomes. Also, this tendency exhibits well if the strain gauge or adhesive absorbs moisture.



Gauge creep