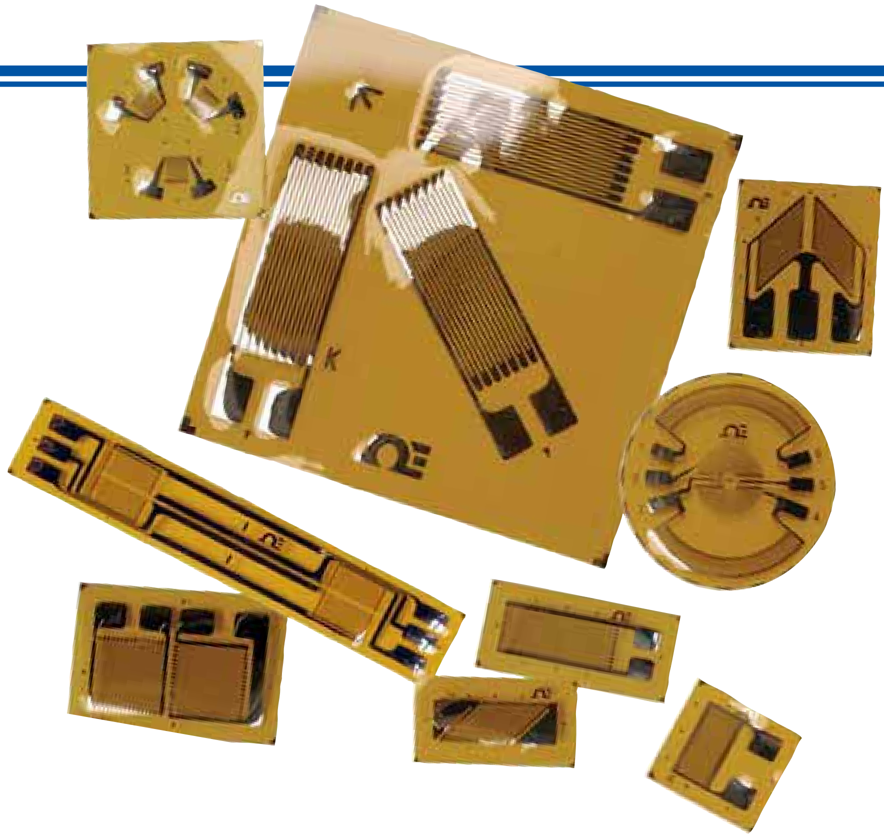
STRAIN GAUGE TECHNICAL DATA



STRAIN GAUGE MEASUREMENT

The most universal measuring device for the electrical measurement of mechanical quantities is the strain gauge. Several types of strain gauges depend for their operation on the proportional variance of electrical resistance to strain: the piezoresistive or semi-conductor gauge, the carbon resistive gauge, the bonded metallic wire, and foil resistance gauges. The bonded resistance strain gauge is by far the most widely used in experimental stress analysis. This gauge consists of a grid of very fine wire or foil bonded to a backing or carrier matrix. The electrical resistance of the grid varies linearly with strain. In use, the carrier matrix is bonded to the surface, force is applied, and the strain is found by measuring the change in resistance. The bonded resistance strain gauge is low in cost, can be made with a short gauge length, is only moderately affected by temperature changes, has small physical size and low mass, and has fairly high sensitivity to strain. In a strain gauge application, the carrier matrix and the adhesive must work together to transmit the strain from the specimen to the grid. In addition, they combine to function as an electrical insulator and heat dissipator. The three primary factors influencing gauge selection are: operating temperature, state of strain (gradient, magnitude, and time dependence), and the stability required.

Because of its outstanding sensitivity, the Wheatstone bridge circuit is the most frequently used circuit for static strain measurement. Ideally, the strain gauge is the only resistor in the circuit that varies, and then only due to a change in strain on the surface. There are two main methods used to indicate the change in resistance caused by strain on a gauge in a Wheatstone bridge. Often, an indicator will rebalance the bridge, displaying the change in resistance required in micro-strain. The second method calls for installation of an indicator, calibrated in micro-strain, that responds to the voltage output of the bridge. This method assumes a linear relationship between voltage out and strain, an initially balanced bridge, and a known VIN. In reality, the VOUT-strain relationship is nonlinear, but for strains up to a few thousand micro-strain, the error is not significant.

POTENTIAL ERROR SOURCES

In a stress analysis application, the entire gauge installation cannot be calibrated as can some pressure transducers. Therefore, it is important to examine potential error sources prior to taking data. Some gauges may be damaged during installation. It is important therefore to check the resistance of the strain gauge prior to applying stress. Electrical noise and interference may alter your readings. Shielded leads and adequately insulating coatings may prevent these problems. A value of less than 500 MΩ (using an ohmmeter) usually indicates surface contamination. Thermally induced voltages are caused by thermocouple effects at the junction of dissimilar metals within the measurement circuit. Magnetically induced voltages can occur when wiring is located in a time-varying magnetic field.

Magnetic induction can be controlled by using twisted lead wires and forming minimum but equal loop areas in each side of the bridge.

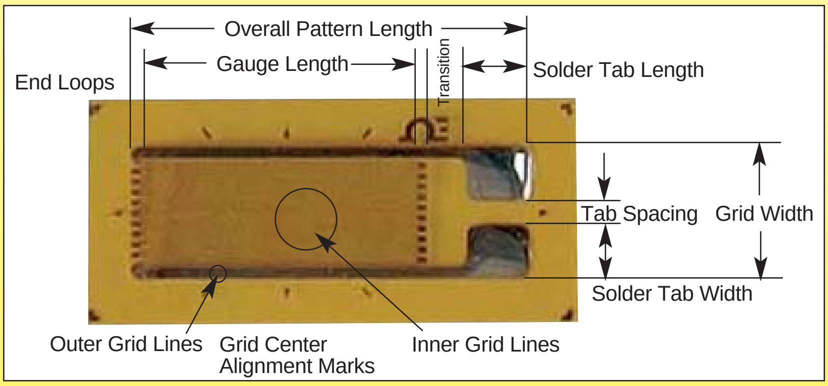
Temperature effects on gauge resistance and gauge factor should be compensated for as well. This may require measurement of temperature at the gauge itself, using thermocouples, thermistors, or RTD's. Most metallic gauge alloys, however, exhibit a nearly linear gauge factor variation with temperature over a broad range, which is less than ±1% within ±100°C/180°F.

PRIME STRAIN GAUGE SELECTION CONSIDERATIONS

- Gauge Length
- Number of Gauges in Gauge Pattern
- Arrangement of Gauges in Gauge Pattern
- Grid Resistance
- Strain-Sensitive Alloy
- Carrier Material
- Gauge Width

THE STRAIN GAUGE IS ONE OF THE MOST IMPORTANT TOOLS used to apply electrical measurement techniques to the measurement of mechanical quantities. As their name indicates, they are used for the measurement of strain. As a technical term, "strain" is comprised of tensile and compressive strain, distinguished by a positive or negative sign. Thus, strain gauges can be used to detect expansion as well as contraction.

The strain of a body is always caused by an external influence or an internal effect. Strain can be caused by forces, pressures, moments, heat, structural changes of the material and the like. If certain conditions are fulfilled, the amount or the value of the influencing quantity can be derived from the measured strain value. In experimental stress analysis, this feature is widely exploited. Experimental stress analysis uses the strain values measured on the surface of a specimen or structural part to determine the stress in the material and also to predict its safety and endurance. Special transducers can be designed for the measurement of forces or other derived quantities, *e.g.*, moments, pressures, accelerations, displacements, vibrations and others. The transducer generally contains a pressure-sensitive diaphragm with strain gauges bonded to it.



• Solder Tab Type
• Configuration of Solder Tab
• Availability

STRAIN GAUGE DIMENSIONS

The active grid length, in the case of foil gauges, is the net grid length without the tabs, and includes the return loops of the wire gauges.

Carrier dimensions are designed by OMEGA® for optimum function of the strain gauge.

STRAIN GAUGE RESISTANCE

The resistance of a strain gauge is defined as the electrical resistance measured between the two metal ribbons or contact areas intended for the connection of measurement cables. The range covers strain gauges with nominal resistances of 120, 350, 600 and 700 ohms.

GAUGE FACTOR (STRAIN SENSITIVITY)

The strain sensitivity k of a strain gauge is the proportionality factor between the relative change of the resistance.

Strain sensitivity is a figure without dimension and is generally called gauge factor.

The gauge factor of each production lot is determined by sample measurement and is given on each package as the nominal value with its tolerance.

REFERENCE TEMPERATURE

The reference temperature is the ambient temperature for which the technical data concerning a strain gauge are valid, unless temperature ranges are given.

The technical data quoted for strain gauges are based on a reference temperature of 23°C (73°F).

TEMPERATURE CHARACTERISTICS

Temperature-dependent changes in specific strain gauge grid resistance occur in the applied gauge owing to the linear thermal expansion coefficients of the grid and specimen materials. These resistance changes appear to be mechanical strain in the specimen. The representation of apparent strain as a function of temperature is called the temperature characteristic of the strain gauge application.

In order to keep apparent strain through temperature changes as small as possible, each strain gauge is matched during production to a certain linear thermal expansion coefficient. OMEGA offers strain gauges with temperature characteristics matched to ferritic steel and aluminum.

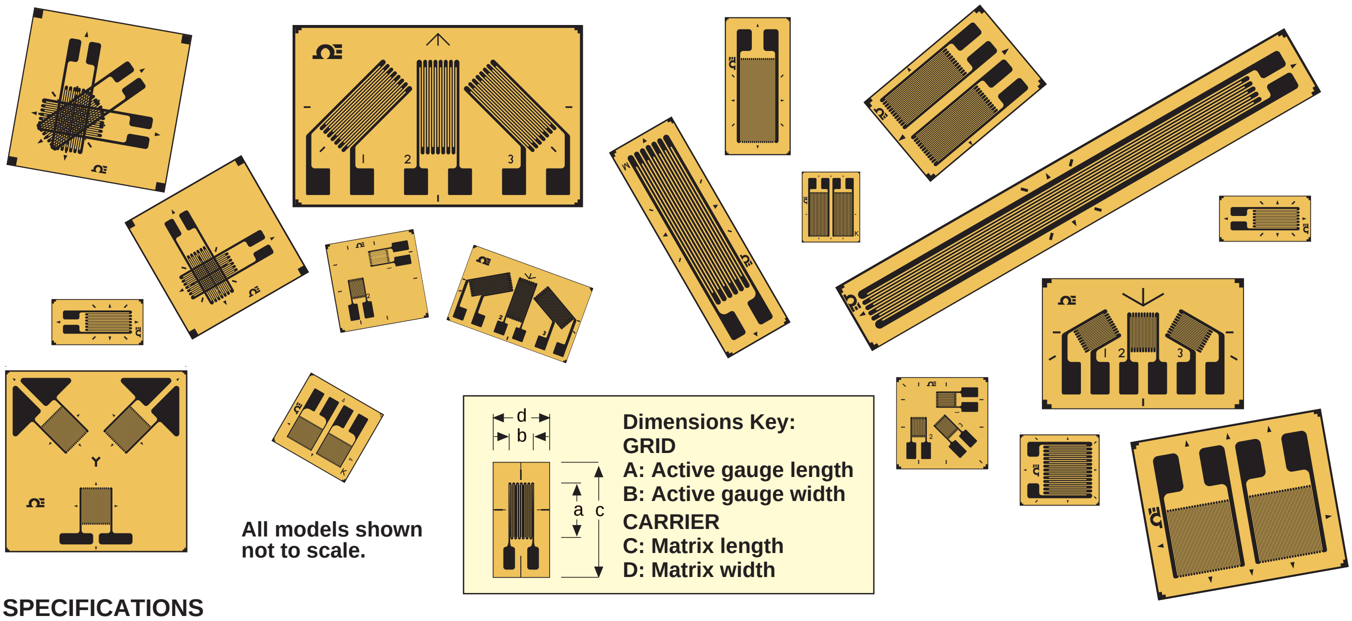
SERVICE TEMPERATURE RANGE

The service temperature range is the range of ambient temperature wherein the use of a strain gauge is possible without permanent change in the measurement properties. Service temperature ranges are different, whether static or dynamic values are to be sensed.

MAXIMUM PERMITTED RMS BRIDGE ENERGIZING VOLTAGE

The maximum values quoted are permitted only for appropriate application on materials with good conduction (*e.g.*, steel of sufficient thickness) if room temperature is not exceeded. In other cases, temperature rise in the measuring grid area may lead to measurement error. Measurement on plastics and other materials with bad heat conduction requires reduction of the energizing voltage or of the duty cycle (pulsed operation).

OMEGA® STRAIN GAUGES
SPECIFICATIONS CHART



All models shown not to scale.

SPECIFICATIONS

	SGD SERIES	KFG SERIES—PRE-WIRED
Foil Measuring Grid	Constantan foil 5 microns thick	Constantan foil 6 microns thick
Carrier	Polyimide	Kapton®
Substrate Thickness	20 microns	15 microns
Cover Thickness	25 microns	9 microns
Connection Dimensions: mm (in)	Solder pads or ribbon leads, tinned copper flat wire 30 L x 0.1 D x 0.3 mm W (1.2 L x 0.004 D x 0.012" W); other wire types available upon request	Pre-wired, 2 or 3 leads 27 AWG strand polyvinyl insulation 1 x 2 mm (0.04 x 0.08")
Nominal Resistance	Stated in “To Order” box	120 ±0.4 Ω
Resistance Tolerance Per Package	±0.15% to ±0.5% depending on gauge spec	0.3%
Gage Factor (Actual Value Printed on Each Package)	2.0 ±5%	2.10 ±10%
Gage Factor Tolerance Per Package	1.00%	1.00%
THERMAL PROPERTIES		
Reference Temperature	23°C (73°F)	23°C (73°F)
SERVICE TEMPERATURE		
Static Measurements	-75 to 200°C (-100 to 392°F)	-20 to 100°C (-4 to 212°F)
Dynamic Measurements	-75 to 200°C (-100 to 392°F)	-20 to 100°C (-4 to 212°F)
TEMPERATURE CHARACTERISTICS		
Steel (and Certain Stainless Steels)	11 ppm/°C (6.1 ppm/°F)	10.8 ppm/°C (6 ppm/°F)
Aluminum	23 ppm/°C (12.8 ppm/°F)	——
Uncompensated	±20 ppm/°C (11.1 ppm/°F)	——
Temperature Compensated Range	-5 to 120°C (5 to 248°F)	10 to 80°C (50 to 176°F)
Tolerance of Temp Compensation	2 ppm/°C (1.0 ppm/°F)	1 ppm/°C (0.5 ppm/°F)
MECHANICAL PROPERTIES		
Maximum Strain	3% or 30,000 microstrain	5% or 50,000 microstrain
Hysteresis	Negligible	Negligible
Fatigue (at ±1500 microstrain)	>10,000,000 cycles	>10,000,000 cycles
Smallest Bending Radius	3 mm (⅛")	3 mm (⅛")
Transverse Sensitivity	——	Stated on each package

OMEGA® TRANSDUCER-QUALITY STRAIN GAUGES

SPECIFICATION CHART

OMEGA's transducer-quality strain gauges are high-quality encapsulated foil strain gauges that are available in many configurations. They are commonly used in transducer technology as well as in experimental analysis. The gauges come in a variety of lengths, patterns, thermal expansion coefficients (matched to stainless steel, carbon steel, and aluminum), alloy materials, and solder configurations. Resistors and resistor wire, used for zero temperature compensation, span temperature compensation, and zero balance, are also available for use with these gauges.

SPECIFICATIONS

	SGT SERIES
Foil Measuring Grid	Constantan foil 5 microns thick
Carrier	Polyimide
Substrate Thickness	20 microns
Cover Thickness	25 microns
Connection Dimensions: mm (in)	Solder pads or ribbon leads, tinned copper flat wire 30 L x 0.1 D x 0.3 W (1.2 L x 0.004 Dia. x 0.012 W); other wire types available upon request
Nominal Resistance	Stated in "To Order" box
Resistance Tolerance Per Package	±0.15% to ±0.5% depending on gauge spec
Gage Factor (Actual Value Printed on Each Package)	2.0 ±5%
Gauge Factor Tolerance Per Package	1.00%
THERMAL PROPERTIES	
Reference Temperature	23°C (73°F)
SERVICE TEMPERATURE	
Static Measurements	-75 to 95°C (-100 to 200°F)
Dynamic Measurements	-75 to 95°C (-100 to 200°F)
TEMPERATURE CHARACTERISTICS	
Steel (and Certain Stainless Steels)	11 ppm/°C (6.1 ppm/°F)
Aluminum	23 ppm/°C (12.8 ppm/°F)
Uncompensated	±20 ppm/°C (11.1 ppm/°F)
Temperature Compensated Range	-5 to 120°C (5 to 248°F)
Tolerance of Temp Compensation	2 ppm/°C (1.0 ppm/°F)
MECHANICAL PROPERTIES	
Maximum Strain	3% or 30,000 microstrain
Hysteresis	Negligible
Fatigue (at ±1500 microstrain)	>10,000,000 cycles
Smallest Bending Radius	3 mm (⅛")

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