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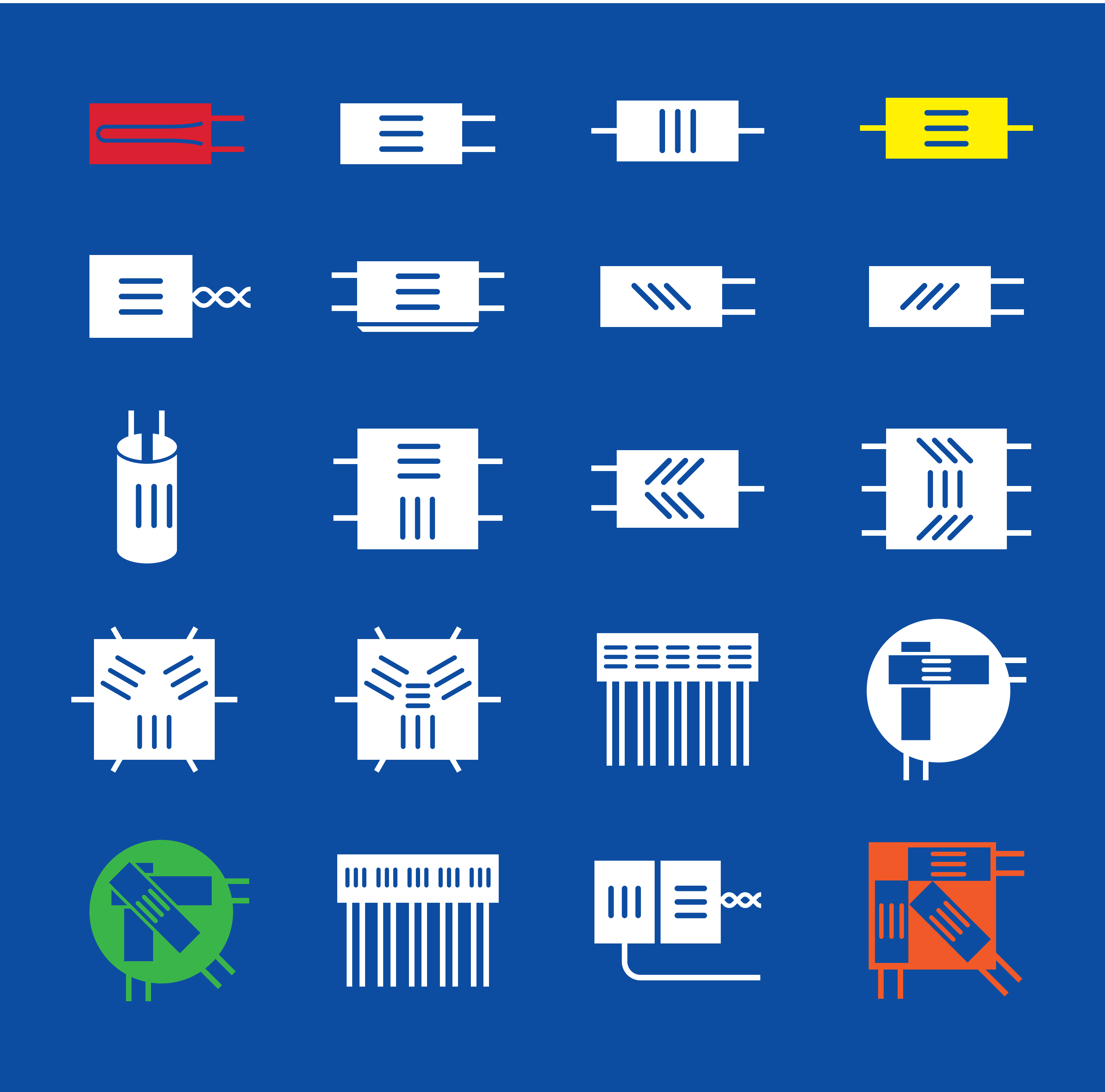
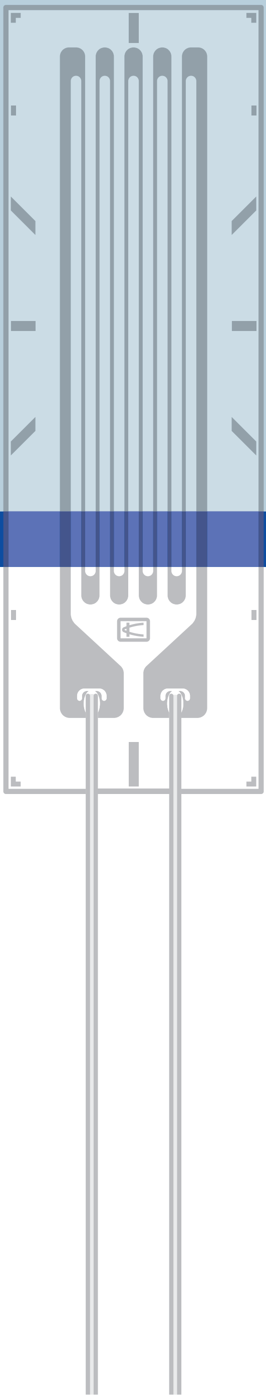
STRAIN GAGES



Wide range of applications and easy handling— essential factors for choosing Kyowa strain gages



Strain gages are designed to electrically detect "strain," minute mechanical changes occurring in response to applied force. They are used not only for machines and moving objects but also in various fields including electrical equipment, civil engineering, building construction, chemicals and medicine. Strain gages enable detection of imperceptible elongations or shrinkages occurring in structures. Measurement of such elongations or shrinkages reveals the stress applied to the structure. Stress is an important factor to confirm the strength and safety of structures. Kyowa strain gages are available for measurement of varied types of strain, from static strain to dynamic strain occurring at higher than 100 kHz and impact-initiated strain. Kyowa strain gages also provide a wide range of applications and can conveniently be applied to structures of varied materials and shapes.
In addition, strain gages are used as sensing elements for measuring load, pressure, acceleration, displacement and torque. Thus, they are widely utilized not only in experiments and research but also for industrial measurement and control. Over 70 years ago Kyowa produced the first strain gages in Japan, and based on the abundant experience and technologies accumulated throughout these years, the company now manufactures various kinds of high-performance strain gages to cope with multiple application environments.

Fundamentals of Strain Gages

Metal changes its electrical resistance as it deforms. Strain gages take advantage of this property.

Generally, when metal deforms due to external force, its specific electrical resistance changes. The amount of electrical resistance is in inverse proportion to the cross-sectional area and is proportional to the length. If a metal wire is pulled, the cross-section becomes smaller and the length becomes longer, thereby making the resistance higher. If the wire is compressed, the resistance becomes lower. Elongation or shrinkage proportionally changes the electrical resistance of metal at a certain constant. By bonding the metal to the target structure, change in the electrical resistance of the metal is measured, thereby enabling detection of elongation or shrinkage, i.e. "strain" on the structure. The strain gage has fine wires or foil of such metal fixed onto an insulator base of resin, etc.

Resistance changes of strain gages bonded to the target object are extracted and amplified for stress measurement.

To obtain the internal stress of a structure, the external force-initiated minute elongation or shrinkage (strain) on the surface of the target object is measured. The measured strain is multiplied by Young's modulus to obtain the stress. For that purpose, the strain gage must elongate or shrink in tandem with the measuring object under testing, and thus it should be securely bonded using the dedicated adhesive. The resistance of a strain gage changes by one-millionths. For precise measurement of such resistance change, a bridge circuit is formed to convert the resistance change to voltage change. Usually, however, since the voltage is at a μV level, it is amplified by 5000 to 10000 times to be readable on analog and digital indicators.

Electrically amplified voltage changes are read out on a measuring instrument. Measured values are recorded and analyzed for multiple purposes.

The dedicated indicator enables direct reading of amplified voltages as strain quantity. Kyowa strain amplifiers have their amplifier circuitry and digital indicator incorporated into one package. It is difficult to read moving dynamic strain on indicators. Therefore, a recorder is usually used to obtain ever-changing strain quantity. In addition to conventional chart recorders, magnetic tape recorders and data loggers, Kyowa now has on the market a sensor interface which enables a PC to directly receive data from strain gages via a bridge box, as well as a memory recorder/analyzer equipped with high-speed A/D converter and large-capacity memory for storage and analysis of dynamic strain data.

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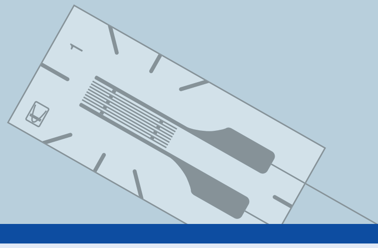

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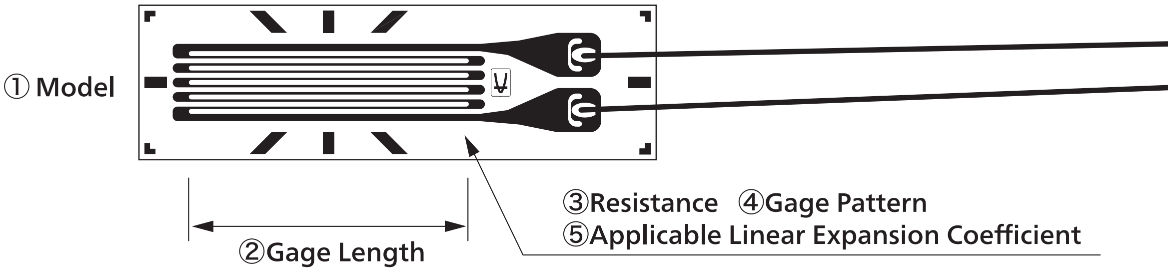
Strain Gage Model Name Coding System



KFGS - 2 -120 - C1 -

① Model

KFGS: General-purpose Foil Strain Gages
KFGT: Foil Strain Gages with a Temperature Sensor
KFR: Foil Strain Gages
KFWB: Waterproof Foil Strain Gages
KFWS: Small-sized Waterproof Foil Strain Gages
KCW: Weldable Waterproof Foil Strain Gages
KC: Wire Strain Gages
KM: Embedded Strain Gages
KMC: Concrete-embedded Strain Gages
KFRP: Foil Strain Gages for Composite Materials
KFRS Foil Strain Gages for Printed Boards
KFP: Foil Strain Gages for Plastics
KSPB: Semiconductor Strain Gages
KSN: Self-temperature-compensation Semiconductor Strain Gages
KSPH: High-output Semiconductor Strain Gages
KSPL: Ultra Linear Semiconductor Strain Gages
KHCX: Encapsulated Gages
KHCR: Encapsulated Gages
KHCV: Encapsulated Gages
KHCS: Encapsulated Gages
KHCM: Encapsulated Gages
KHC: Encapsulated Gages
KFU: High-temperature Foil Strain Gages
KH: High-temperature Foil Strain Gages
KFH: High-temperature Foil Strain Gages
KFL: Low-temperature Foil Strain Gages
KFEM: Ultrahigh-elongation Foil Strain Gages
KFEL: High-elongation Foil Strain Gages
KFN: Non-inductive Foil Strain Gages
KFS: Shielded Foil Strain Gages
KFV: Foil Strain Gage for Hydrogen Gas Environment
KFF: Foil Strain Gages for Bending Strain Measurement
KCH: Foil Strain Gages with a Protector
KMP: Embedded Gage
KV: Crack Gages

② Gage Length

015: 0.15 mm
02N: 0.2 mm
02: 0.2 mm
03: 0.3 mm
05: 0.5 mm
1N: 1 mm
1: 1 mm
1.5: 1.5 mm
2N: 2 mm
2: 2 mm
3: 3 mm
4N: 4 mm
4: 4 mm
5: 5 mm
6: 6 mm
7: 7 mm
9: 9 mm
10: 10 mm
20: 20 mm
30: 30 mm
60: 60 mm
70: 70 mm
80: 80 mm
120: 120 mm

*Suffix N indicates base and grid widths are narrow.

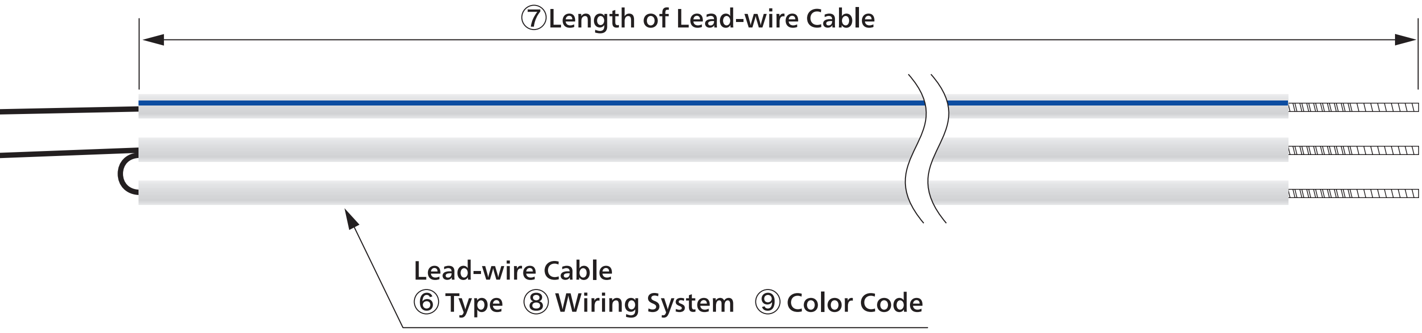
③ Resistance

60: 60 Ω
120: 120 Ω
350: 350 Ω
500: 500 Ω
1K: 1000 Ω
2K: 2000 Ω
10K: 10000 Ω

④ Gage Pattern

A1: Uniaxial, leads at one end (KC gage)
C1: Uniaxial, leads at one end (Foil gage)
C2: Uniaxial 90°, leads at both ends
C3: Uniaxial 0°, leads at both ends
C9: Uniaxial, leads at one end (KFN gage)
C11: Uniaxial, 2-element, 1 mm thick (KFF gage)
C12: Uniaxial, 2-element, 2 mm thick (KFF gage)
C15: Uniaxial right 45°, for shearing strain, leads at one end
C16: Uniaxial left 45°, for shearing strain, leads at one end
C20: Uniaxial, leads at one end (For bolt axial tension)
D1: Biaxial 0/90°, leads at both ends
D2: Biaxial 0/90°, leads at both ends (For torque)
D3: Triaxial 0/45/90°, leads at both ends, plane arrangement
D4: Triaxial 0/120/240°, plane arrangement
D6: Quadraxial 0/30/90/150°, plane arrangement
D9: Uniaxial 5-element 90°
D16: Biaxial 0/90° stacked rosette, round base
D17: Triaxial 0/45/90° stacked rosette, round base
D19: Uniaxial 5-element 0°
D20: Biaxial 0/90° (KFN gage)
D22: Triaxial 0/45/90°, plane arrangement
D25: Triaxial 0/45/90°, plane arrangement
D28: Triaxial 0/90/135°, plane arrangement (For boring)
D31: Biaxial 0/90°, leads at one end (For torque)
D34: Biaxial 0/90°, plane arrangement
D35: Triaxial 0/45/90°, plane arrangement
D39: Biaxial 5-element 0/90°, stacked rosette
E3: Uniaxial, leads at both ends (Semiconductor gage)
E4: Uniaxial, leads at one end (Semiconductor gage)
E5: Uniaxial, leads at both ends with no base (Semiconductor gage)
F2: Uniaxial 2-element (Semiconductor gage)
F3: Biaxial 0/90° (Semiconductor gage)
G4: Uniaxial, leads at one end (KH-G4)
G8: Uniaxial active-dummy 2-element, Inconel (For KHC)
G9: Uniaxial active-dummy 2-element, SUS (For KHC)
G10: Uniaxial (For KCW)
G12: Uniaxial active-dummy 2-element (For KHCS)
G13: Uniaxial active-dummy 2-element (For KHCX)
G15: Uniaxial active-dummy 2-element (For KHCM)
G16: Uniaxial active-dummy 2-element (For KHCR)
G17: Uniaxial active 1-element (For KHCV)
H1: Uniaxial (For KM-30)
H2: Uniaxial (For KM-120)
H3: Uniaxial (For KMC)
H4: Uniaxial with T thermocouple (For KMC)
J1 Uniaxial (For KFS)

To select the most suitable strain gages and related products, refer to page 18 and onward.



Lead-wire Cable

11 L 1M 3 R

⑤ Applicable Linear Expansion Coefficient

(x10⁻⁶/°C)

1: Composite materials such as CFRP
Amber (1.1)
Diamond (1.2)

3: Composite materials such as GFRP
Silicon (2.3)
Sulfur (2.7)

5: Composite materials such as GFRP
Tungsten (4.5)
Lumber [Wood] (5.0)
Molybdenum (5.2)
Zirconium (5.4)
Kovar (5.9)

6: Composite materials such as GFRP
28 Tantalum (6.6)

9: Composite materials such as CFRP, GFRP
Titanium alloy (8.5)
Platinum (8.9)
Soda-lime glass (9.2)

11: Common steel (11.7)
SUS631 (10.3)
SUS630 (10.6)
Cast iron (10.8)
Nickel-molybdenum steel (11.3)
Beryllium (11.5)
Inconel X (12.1)

13: Corrosion and heat-resistant alloys such as NCF
Nickel (13.3)
Printed circuit board (13.0)

16: Stainless steel SUS304 (16.2)
Beryllium steel (16.7)
Copper (16.7)

23: 2014-T4 aluminum (23.4)
Brass (21.0)
Tin (23.0)
2024-T4 aluminum (23.2)

27: Magnesium alloy (27.0)
Composite material. GFRP (35.0)

65: Acrylic resin (65.0)
Polycarbonate (66.6)

⑥ Type

C: MI cable (for KHC, KHCX, KHCR, KHCS, KHCM and KHCV gages)
D: Glass-coated cable of 3 Ni-clad copper wires
F: Fluoroplastic-coated high/low temp. 3-wire cable (equiv. to L-3 lead-wire cable)
G: Chloroprene-coated 3-wire cable
H: High/low temp. 3-wire cable (equiv. to L-17 lead-wire cable)
J: Vinyl-coated normal temp. low-noise 3-wire cable (equiv. to L-13 lead-wire cable)
L: Vinyl-coated flat 2 or 3-wire cable (L-6, L-7, L-9 or L-10)
N: Polyester-coated copper wires
R: Mid-temp. 2 or 3-wire cable (L-11 or L-12)
W: Vinyl-coated flat 3-wire cable (for KM-120)
Y: Vinyl-coated flat 2-wire cable (for KM-30)

⑦ Length

C: Centimeter
e.g. 30C = 30 cm
M: Meter
e.g. 3M = 3 m

⑧ Wiring System

2: 2-wire system
3: 3-wire system
In the case of encapsulated gage
Number: Length of soft cable
V: With bridge adapter
F: With compression fitting
FV: With both bridge adapter and compression fitting

⑨ Color Code

Color codes for lead-wire cables are available only for vinyl-coated flat cables.

2-wire system (Vinyl-coated flat cables)
R: Red
W: White*
B: Black*
G: Green*
Y: Yellow*
*Custom-made
S: Multi-axial gages (Standard)
- Biaxial (D16)
  0° (1st axis): Red
  90° (2nd axis): White
- Triaxial (D17)
  0° (1st axis): Red
  45° (3rd axis): Green
  90° (2nd axis): White

3-wire system (Vinyl-coated flat cables)
The insulator color is white and the stripe color code is as follows.
R: Red
L: Blue*
B: Black*
G: Green*
Y: Yellow*
*Custom-made
S: Multi-axial gages (Standard)
- Biaxial (D16)
  0° (1st axis): Red
  90° (2nd axis): Yellow
- Triaxial (D17)
  0° (1st axis): Red
  45° (3rd axis): Blue
  90° (2nd axis): Yellow

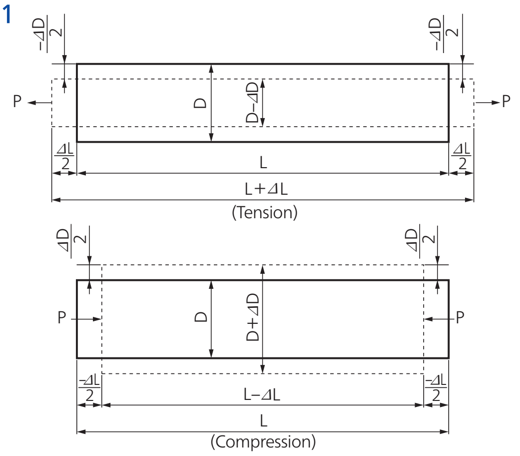
Note: Combination of codes is limited and menu options cannot freely be selected.

Principles of Strain Gages

Strain, Stress, and Poisson's Ratio

When tensile force P is applied to a material, it has stress σ that corresponds to the applied force. In proportion to the stress, the cross section contracts and the length elongates by ΔL from the length L the material had before receiving the tensile force. (See the upper illustration in Fig. 1.)

Fig.1



The ratio of the elongation to the original length is called a tensile strain and is expressed as follows:

$$\varepsilon = \frac{\Delta L}{L}$$

ε: Strain
L: Original length
ΔL: Elongation

See the lower illustration in Fig. 1. If the material receives compressive force, it bears compressive strain expressed as follows:

$$\varepsilon = -\frac{\Delta L}{L}$$

For example, if a tensile force makes a 100 mm long material elongate by 0.01 mm, the strain initiated in the material is as follows:

$$\varepsilon = \frac{\Delta L}{L} = \frac{0.01}{100} = 0.0001 = 100\ \mu m/m$$

Thus, strain is an absolute number and is expressed with a numeric value with x10^{-6} strain, $\mu\varepsilon$ or µm/m suffixed.
Based on Hooke's law, the relation between stress and the strain initiated in a material by the applied force is expressed as follows:

$$\sigma = E \cdot \varepsilon$$

σ: Stress
E : Young's modulus
ε : Strain

Stress is thus obtained by multiplying strain by the Young's modulus. When a material receives tensile force P, it elongates in the axial direction while contracting in the transverse direction. Elongation in the axial direction is called longitudinal strain and contraction in the transverse direction, transverse strain. The absolute value of the ratio between the longitudinal strain and transverse strain is called Poisson's ratio, which is expressed as follows:

$$\nu = \left| \frac{\varepsilon_2}{\varepsilon_1} \right|$$

ν : Poisson's ratio

ε_1: Longitudinal strain $\frac{\Delta L}{L}$ or $-\frac{\Delta L}{L}$ (See Fig. 1)

ε_2: Transverse strain $-\frac{\Delta D}{D}$ or $\frac{\Delta D}{D}$ (See Fig. 1)

Poisson's ratio differs depending on the material.
For major industrial materials and their mechanical properties including Poisson's ratio, see the following table.

●Mechanical Properties of Industrial Materials

$G = \frac{E}{2(1+\nu)}$

Material	Young's Modulus E (GPa)	Shearing Modulus G (GPa)	Tensile Strength (MPa)	Poisson's Ratio ν
Carbon steel (C0.1 to 0.25%)	205	78	363 to 441	0.28 to 0.3
Carbon steel (C > 0.25%)	206	79	471 to 569	0.28 to 0.3
Spring steel (Quenched)	206 to 211	79 to 81	588 to 1667	0.28 to 0.3
Nickel steel	205	78	549 to 657	0.28 to 0.3
Cast iron	98	40	118 to 235	0.2 to 0.29
Brass (Casting)	78	29	147	0.34
Phosphor bronze	118	43	431	0.38
Aluminum	73	27	186 to 500	0.34
Concrete	20 to 29	9 to 13	–	≈ 0.2

Principles of Strain Gages

If external tensile force or compressive force increases or decreases, the resistance proportionally increases or decreases. Suppose that original resistance R changes by ΔR because of strain ε: the following equation is set up.

$$\frac{\Delta R}{R} = Ks \cdot \frac{\Delta L}{L} = Ks \cdot \varepsilon$$

Where, Ks is a gage factor, expressing the sensitivity coefficient of strain gages. General-purpose strain gages use copper-nickel or nickel-chrome alloy for the resistive elements, and the gage factor provided by these alloys is approximately 2.

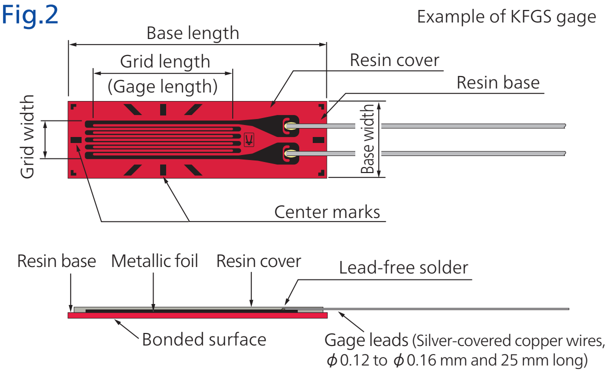
Types of Strain Gages

Types of strain gages are classified into foil strain gages, wire strain gages, and semiconductor strain gages, etc.

Structure of a Strain Gage

A strain gage has a grid-shaped metallic foil photo-etched onto the base material (thin resin or similar electric insulator), to which gage leads are attached, as shown in Fig. 2 below.

Fig.2



The strain gage is bonded to the measuring object with a dedicated adhesive. Strain occurring on the measuring site is transferred to the strain sensing element via adhesive and the resin base. For accurate measurement, the strain gage and adhesive should be compatible with the measuring material and operating conditions such as temperature, etc. Refer to page 13, "Typical Strain Gage Bonding Method and Dampproofing Treatment," for details on bonding strain gages to metallic objects.

Principles of Strain Measurement

Strain-initiated resistance change is extremely small. Thus, for strain measurement a Wheatstone bridge is formed to convert the resistance change to a voltage change. Suppose in Fig. 3 resistances (Ω) are R_1, R_2, R_3 and R_4 and the excitation voltage (V) is E. Then, the output voltage e_o (V) is obtained by the following equation:

$$e_0=\frac{R_1R_3-R_2R_4}{(R_1+R_2)\ (R_3+R_4)}\cdot E$$

Suppose the resistance R_1 is a strain gage and it changes by $\varDelta R$ due to strain. Then, the output voltage is,

$$e_0=\frac{(R_1+\varDelta R)\ R_3-R_2R_4}{(R_1+\varDelta R+R_2)\ (R_3+R_4)}\cdot E$$

If $R_1 = R_2 = R_3 = R_4 = R$ in the initial condition,

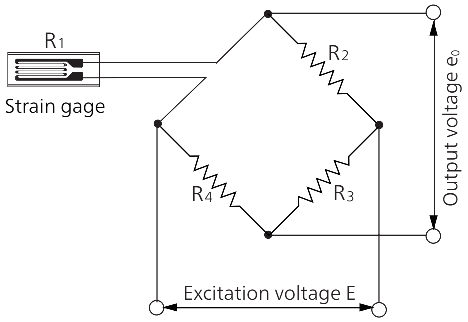
$$e_0=\frac{R^2+R\varDelta R-R^2}{(2R+\varDelta R)\ 2R}\cdot E$$

Since R may be regarded extremely larger than $\varDelta R$,

$$e_0 \fallingdotseq \frac{1}{4}\cdot\frac{\varDelta R}{R}\cdot E=\frac{1}{4}\cdot Ks\cdot\varepsilon\cdot E$$

Thus obtained is an output voltage that is proportional to a change in resistance, i.e. a change in strain. This microscopic output voltage is amplified for analog recording or digital indication for strain measurement.

Fig.3



Strain Gage Wiring System

A strain gage Wheatstone bridge is configured with a quarter, half, or full bridge according to the measuring purpose. The typical wiring systems are shown in Figs. 4, 5 and 6. For various strain gage bridge systems, see pages 14 and 15.

●Quarter-bridge system (1-gage system)

With the quarter-bridge system, a strain gage is connected to one leg of the bridge and a fixed resistor is connected to each of the other 3 legs. This system will be easily configured, and thus it is widely used for general stress or strain measurement. The quarter-bridge 2-wire system shown in Fig. 4-1 is largely affected by leads. Therefore, if a big temperature change is expected or if the lead-wire length is long, then the quarter-bridge 3-wire system shown in Fig. 4-2 must be used. For the quarter-bridge 3-wire system, See "Compensation Methods of Temperature Effect of Lead Wires" (Page 10).

Fig.4-1

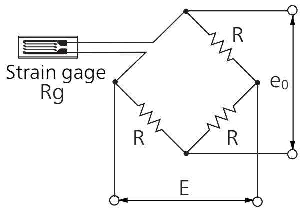
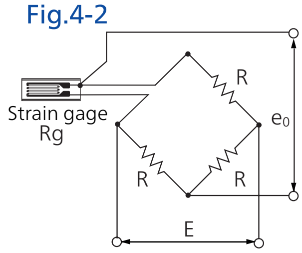


Fig.4-2



●Half-bridge system (2-gage system)

With the half-bridge system, 2 strain gages are connected to the bridge, one each to adjacent or opposite legs with fixed resistors inserted in the other legs. See Figs. 5-1 and 5-2. There is the active-dummy system, where one strain gage serves as a dummy gage for temperature compensation, and the active-active system, where both gages serve as active gages. The half-bridge system is used to eliminate strain components other than the target strain; according to the measuring purpose, 2 gages are connected to the bridge in different ways. For details, see "How to Form Strain-gage Bridge Circuits"(Pages 14 and 15).

Fig.5-1

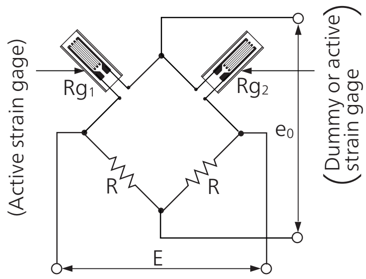
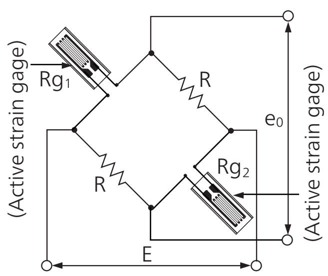


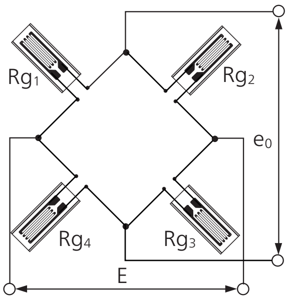
Fig.5-2



●Full-bridge system (4-gage system)

See Fig. 6. The full-bridge system has 4 strain gages connected one each to all 4 legs of the bridge. This circuit ensures large output of strain-gage transducers, improves temperature compensation and eliminates strain components other than the target strain. For details, see "How to Form Strain-gage Bridge Circuits" (Pages 14 and 15).

Fig.6



Equation of Strain on Beams

Strain ε_0 on the beam is obtained by the following equation :

$$\varepsilon_0 = \frac{M}{ZE}$$

where, M: Bending moment (See Table 1)
Z: Section modulus (See Table 2)
E: Young's modulus (See table "Mechanical Properties of Industrial Materials," on page 6)

Typical shapes of beams, their bending moments M and section modulus Z are shown in Tables 1 and 2.

●Typical Measurements with Strain Gages

Bending Stress Measurement

(1) Quarter-bridge System

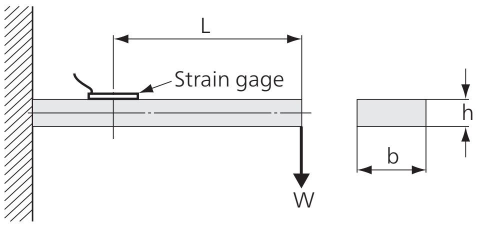
See the figure below. If a strain gage is bonded on the surface of a rectangular section of a cantilever of which one side end is fixed and load W is applied to another side, the surface stress σ which the bonded strain gage will detect is as follows:

$$\sigma = \varepsilon_0 \cdot E$$

Strain ε_0 is obtained by the following equation:

$$\varepsilon_0 = \frac{6WL}{Ebh^2}$$

where, b: Width of the cantilever
h: Thickness of the cantilever
L: Distance from the load point to the center of strain gage



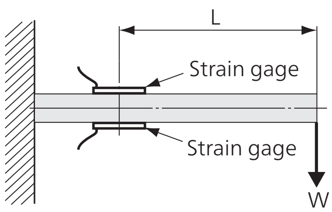
Bending Stress Measurement (with Quarter-bridge System)

(2) Half-bridge System (Adjacent-leg Bridge Connection)

As illustrated below, strain gages bonded symmetrically on the front and rear surfaces of the cantilever output positive and negative signals, respectively, with an equal absolute value. If these 2 gages are connected to adjacent legs of the bridge, the output of the bridge corresponding to the bending strain is doubled and the surface stress σ at the strain-gage bonding site is obtained by the following equation:

$$\sigma = \frac{\varepsilon_0}{2} \cdot E$$

The adjacent-leg active half-bridge system cancels out the output of the strain gage corresponding to the force applied in the axial direction of the cantilever.



Bending Stress Measurement (with Half-bridge System)

Table 1. Typical Equations to Calculate Bending Moment

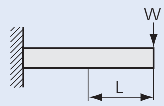
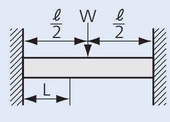
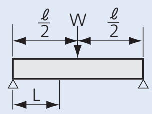
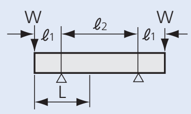
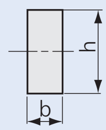
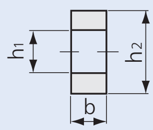
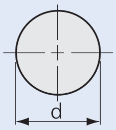
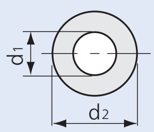
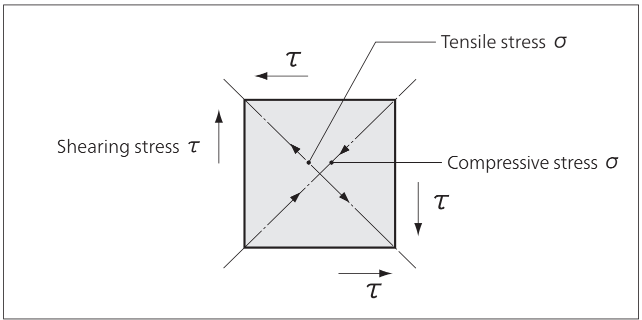
Shape of Beam	Bending Moment M
	$M = WL$
	$0 \leq L \leq \frac{\ell}{2} \rightarrow M = \frac{W\ell}{2}\left(\frac{1}{4} - \frac{L}{\ell}\right)$ $L = 0 \quad L = \frac{\ell}{2} \rightarrow M = \pm\frac{W\ell}{8}$ $\frac{\ell}{2} \leq L \leq \ell \rightarrow M = \frac{W\ell}{2}\left(\frac{L}{\ell} - \frac{3}{4}\right)$
	$0 \leq L \leq \frac{\ell}{2} \rightarrow M = -\frac{WL}{2}$ $L = \frac{\ell}{2} \rightarrow M = -\frac{W\ell}{4}$ $\frac{\ell}{2} \leq L \leq \ell \rightarrow M = -\frac{W(\ell - L)}{2}$
	$0 \leq L \leq \ell_1 \rightarrow M = WL$ $\ell_1 \leq L \leq (\ell_1 + \ell_2) \rightarrow M = W\ell_1$

Table 2. Typical Equations to Calculate Section Modulus

Cross Section	Section Modulus Z
	$\frac{1}{6} bh^2$
	$\frac{1}{6} \cdot \frac{b\ (h_2^3 - h_1^3)}{h_2}$
	$\frac{\pi}{32} d^3$
	$\frac{\pi}{32} \cdot \frac{d_2^4 - d_1^4}{d_2}$

Torsional and Shearing Stress Measurement of Axis

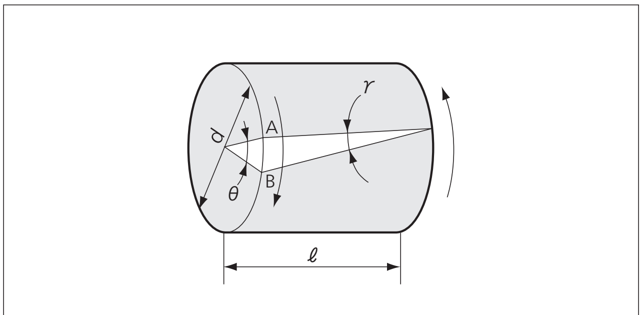
When an object is twisted, shearing stress τ occurs. At the same time, tensile stress and compressive stress, which are equivalent to the shearing stress, occur in 2 directions inclined by 45° from the axial line.
In measurement of axial twist under simple shearing stress condition, a strain gage does not directly measure the shearing stress. Instead, a strain gage detects tensile or compressive strain resulting from tensile or compressive stress simultaneously generated with the shearing stress.
These stress conditions on a surface of axis are illustrated below.



Shearing stress γ is defined as illustrated below, and the magnitude is calculated by the following equation:

$$\gamma = \frac{\tau}{G}$$

where, G: Shearing modulus (See table "Mechanical Properties of Industrial Materials," on page 6)
τ: Shearing stress



When the axis is twisted, point A moves to point B, thereby initiating torsional angle θ.

$$\theta = \frac{\ell\gamma}{\left(\frac{d}{2}\right)} = \frac{2\ell\gamma}{d}$$

(1) Stress Measurement with Quarter-bridge System

Bond the strain gage on the twisted axis in the direction inclined by 45° from the axial line. The relations between strain ε_0 and stress σ are expressed with the following equation to calculate tensile or compressive stress σ:

$$\sigma = \frac{\varepsilon_0 \cdot E}{1+\nu}$$

where, ε_0: Indicated strain
E: Young's modulus (See table "Mechanical Properties of Industrial Materials," on page 6)
ν: Poisson's ratio

Stress σ and shearing stress τ are equal in magnitude, and thus,

$$\tau = \sigma$$

(2) Stress Measurement with Half-bridge or Full-bridge System

Half-bridge or full-bridge systems increase strain output by 2 (half-bridge system) or 4 times (full-bridge system), because each strain gage in the half-bridge or full-bridge system detects equal strain. To calculate real strain, divide measured strain by 2 (half-bridge system) or 4 (full-bridge system).

(3) Application to Torque Measurement

Strain on the surface of the axis is proportional to the torque applied to the axis. Thus, the torque is obtained by detecting the strain on the surface.
Shearing stress distributed on the lateral section is balanced with the applied torque T, establishing the following equation:

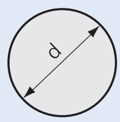
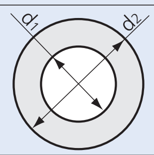
$$T = \tau \cdot Z_p$$

where, Z_p: Polar modulus of section

Converting shearing stress in the above equation to tensile strain produces an equation as follows:

$$T = \frac{\varepsilon_0 \cdot E \cdot Z_p}{1+\nu}$$

The polar modulus of the section is specific to each shape of the cross-section as follows:

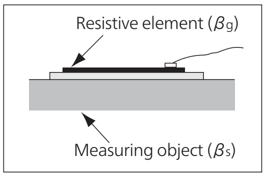
Cross Section	Polar Modulus of Section Z_p
	$\frac{\pi d^3}{16}$
	$\frac{\pi}{16}\left(\frac{d_2^4 - d_1^4}{d_2}\right)$

A strain gage torque transducer is designed using the above relational expression of ε_0 and T.
Obtain ε_0 from the allowable stress for the material, and determine the width d of the axis which is matched with the magnitude of the applied torque. Then, amplify the strain output with a strain amplifier and read the output voltage with a measuring instrument.

●Principles of Self-temperature-compensation Gages (SELCOM Gages)

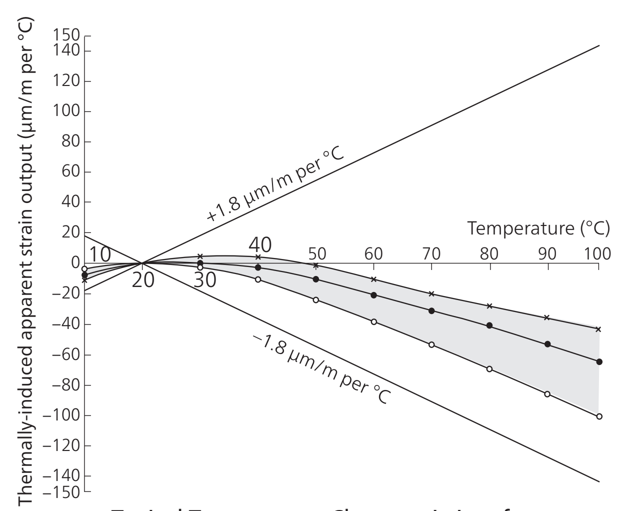
The measuring object and the resistive element of the strain gage have linear expansion coeffcients β_S and β_g, respectively. The strain gage bonded on the surface of the object provides a thermally-induced apparent strain ε_T per °C that is expressed with the following equation:

$$\varepsilon_T = \frac{\alpha}{Ks} + (\beta_S - \beta_g)$$



where,
- α : Resistive temperature coeffcient of resistive element
- Ks: Gage factor of strain gage

Self-temperature-compensation strain gages are designed to adjust the resistive temperature coeffcient of their resistive elements to match the linear expansion coefficient of the measuring objects in order to get ε_T close to zero.
When bonded to a suitable material, Kyowa's self-temperature-compensation gage (SELCOM gage) minimizes apparent strain in the compensated temperature range to ±1.8 μm/m per °C. (Graph below shows apparent strain output of 3-wire strain gages.)



Typical Temperature Characteristics of Self-temperature-compensation Foil Gage

●Linear Expansion Coefficients of Materials

(x10⁻⁶/°C)

Material	Linear Exp. Coef.	Material	Linear Exp. Coef.
Quartz glass	0.4	Beryllium	11.5
Amber	1.1	Common steel	11.7
Brick	3.0 to 5.0	Inconel X	12.1
Tungsten	4.5	Nickel	13.3
Lumber (grain dir.)	5.0	Gold	14.0
Molybdenum	5.2	SUS 304	16.2
Zirconium	5.4	Beryllium copper	16.7
Kovar	5.9	Copper	16.7
Concrete	6.8 to 12.7	Brass	21.0
Titanium alloy	8.5	A2024-T4	23.2
Platinum	8.9	A2014-T4	23.4
Soda-lime glass	9.2	Magnesium alloy	27.0
SUS 631	10.3	Lead	29.0
SUS 630	10.6	Acrylic resin	≈ 65 to 100
Cast iron	10.8	Polycarbonate	66.6
NiCrMo steel	11.3	Rubber	≈ 77

●Temperature Effect on Lead Wires with 2-wire System

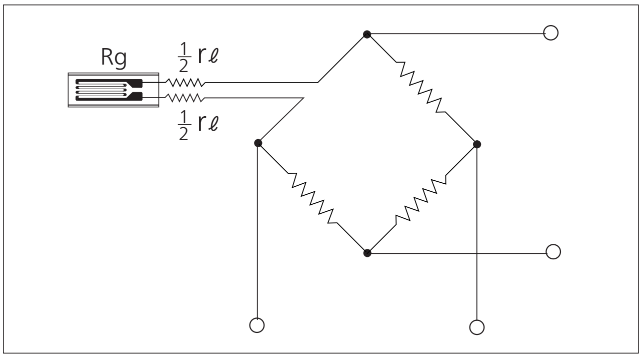
Lead Wire Model	Cross-section Area of Conductor (mm²)	Reciprocating Resistance of 1 m long lead wire (Ω)	Apparent Strain* with 1 m Extension (μm/m per °C)
L-5	0.5	≈ 0.07	≈ 1.13
L-9	0.11	≈ 0.32	≈ 5.06
L-6	0.08	≈ 0.44	≈ 6.90
N (Polyester-coated copper cable)	0.015	≈2.24	≈35.7

*120 Ω gage

Thermally-induced apparent strain ε_r (μm/m per °C) is calculated by the following equation.

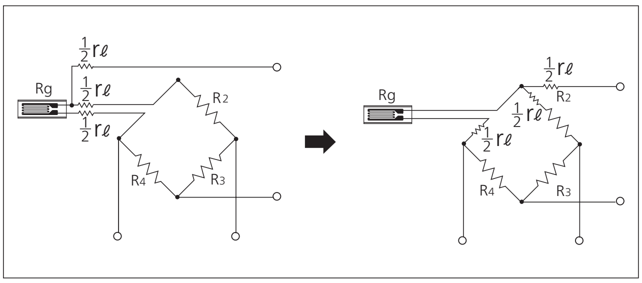
$$\varepsilon_r = \frac{r\ell}{Rg + r\ell} \cdot \frac{\alpha}{Ks}$$

where, Rg: Resistance of strain gage (Ω)
$r\ell$: Resistance of lead wires (Ω)
Ks: Preset gage factor of strain amplifier, usually 2.00
α : Resistive temperature coefficient of copper wire ($\Delta R/R$ per °C), 3.9 x10⁻³/°C



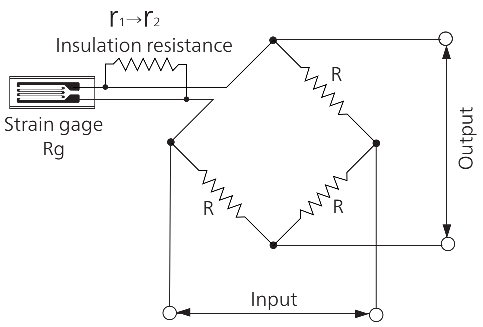
●Compensation Methods of Temperature Effect of Lead Wires (3-wire System)

For effective self-temperature-compensation, SELCOM gages adopt the quarter-bridge system. However, if the lead wire cable is the 2-wire system, strain output from the bridge is affected by the temperature effect of the lead wire.
To avoid such adverse effect, the 3-wire system is adopted.
If 3 lead wires are connected to a strain gage as shown below, a half lead wire resistance is applied to the adjacent side of a bridge to compensate for the temperature effect of lead wires in bridge output. The temperature effect of the lead wires connected to a measuring instrument outside of the bridge is ignored because the input impedance of the measuring instrument is high.
As a precaution when using the 3-wire system, the 3 lead wires should be the same type, length, and cross-section to equalize temperature effects of each lead wire. If lead wires are directly exposed to sunlight, the coating color should also be the same.



●Influence of Insulation Resistance

Insulation resistances of strain gages including lead wires do not affect measured values if they are higher than 100 MΩ. However, if they change drastically during measurement, errors may occur in measured values.



Bridge Circuit Designed with Insulation Resistance

If the isolation resistance descends from r_1 to r_2 in the figure above, error strain ε is:

$$\varepsilon \fallingdotseq \frac{Rg(r_2 - r_1)}{Ks\,r_1 r_2}$$

For example,

Rg = 120 Ω (Resistance of strain gage)
Ks = 2.00 (Gage factor of strain gage)
r_1 = 1000 MΩ (Original insulation resistance)
r_2 = 10 MΩ (Changed insulation resistance)

Then, the error strain is approximately -6 μm/m.
Such error is no matter in general strain measurement.
In practice, however, if insulation resistance is lowered, r_2 will no longer be constant and will change drastically due to environmental changes such as temperature and humidity.
In addition, it will be impossible to specify where insulation resistance, r, is being added to the circuit. Thus, be careful about the influence of insulation resistance.

●Resistance Change of Strain Gages Bonded to Curved Surfaces

The strain ε_c occurring on the resistive element of a strain gage bonded to a curved surface may be expressed by the following equation:

$$\varepsilon_c = \frac{t}{2r+t}$$

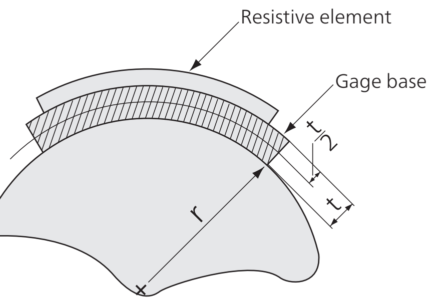
where, t: Thickness of gage base plus adhesive layer
r: Radius of gage-bonded surface

For example, if a uniaxial KFGS gage, of which the gage base including the adhesive layer is 0.015 mm thick, is bonded to a curved surface of 1.5r, the strain gage already receives strain of approximately 5000 μm/m.
If the gage factor Ks is 2.00,

$$\Delta R/R \fallingdotseq 10000\ \mu m/m$$

since $\Delta R/R = \varepsilon \cdot Ks$.

If the gage resistance is 120 Ω, it increases by approximately 1.2 Ω. If the gage is bonded inside the curve, the resistance decreases.



Strain Gage Bonded on the Curved Surface

●Compensation Methods of Different Gage Factors

If the gage factor of the strain gage (2.00) is different from that of the strain amplifier, the real strain ε is obtained by the following equation:

$$\varepsilon = \frac{2.00}{Ks} \times \varepsilon_0$$

where, ε_0: Measured strain
Ks : Gage factor of strain gage

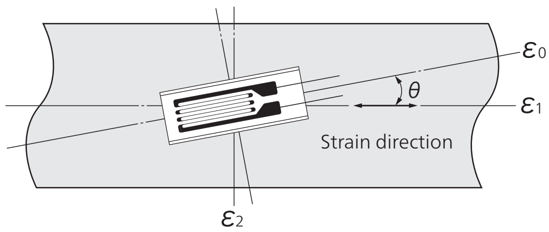
●Misalignment Effect of Bonding Strain Gages

Strain ε_0 misaligned by angle θ from the direction of the principal strain ε_1 is calculated by the following equation:

$$\varepsilon_0 = \frac{1}{2}\{(\varepsilon_1 + \varepsilon_2) + (\varepsilon_1 - \varepsilon_2)\ \cos 2\theta\}$$

If $\varepsilon_2 = -\nu\varepsilon_1$ (ν: Poisson's ratio) under the uniaxial stress condition,

$$\varepsilon_0 = \frac{1}{2}\varepsilon_1\{\ (1-\nu)\ +\ (1+\nu)\cos 2\theta\}$$



●Compensation Methods of Effect on Lead Wire Extension

If the lead wire or cable is extended with the quarter-bridge or half-bridge system, additional resistance is initiated in series to the strain gage, thereby decreasing the apparent gage factor. For example, if a 10 m long lead wire with 0.3 mm^2 conductors is used, the gage factor decreases by 1%. In the case of the full-bridge system (transducer), the extension decreases the excitation voltage too. In these cases, the real strain ε is obtained by the following equation (Supposing the gage factor Ks is 2.00):

$$\varepsilon = \left(1 + \frac{r\ell}{Rg}\right) \times \varepsilon_i$$

where, ε_i: Measured strain
Rg: Resistance of strain gage
$r\ell$: Total resistance of lead wires (For reciprocating resistance, see the table on the following page.)
One-way resistance in the case of 3-wire system

Lead wire resistance values

Cross Section (mm^2)	Number of Strands/ Wire Diam. (mm)	Reciprocating Resistance per 10 m (Ω)	Remarks
0.08	7/ϕ0.12	4.4	L-6
0.11	10/ϕ0.12	3.2	L-9
0.3	12/ϕ0.18	1.2	L-2
0.5	20/ϕ0.18	0.7	L-5

●Compensation Methods of Nonlinearity Error of Quarter-bridge System

An error of nonlinearity in high-elongation strain measurement with quarter-bridge system is found by calculating real strain ε in the following equation:

$$\varepsilon = \frac{\varepsilon_0}{1-\varepsilon_0}$$

where, ε_0: Measured strain

Example: If $\varepsilon_0 = 2000$ μm/m,

$$\varepsilon = \frac{2000\times10^{-6}}{1-2000\times10^{-6}}$$

$$= \frac{0.002}{1-0.002}$$

$$= 2004 \ \mu m/m$$

●Methods of Obtaining Magnitude and Direction of Principal Stress (Rosette Analysis)

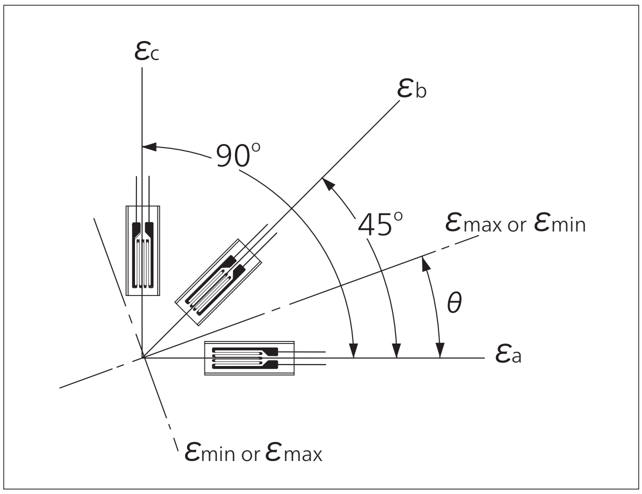
Generally, if the direction of principal stress is uncertain in structure stress measurement, a triaxial rosette gage is used and measured strain values are calculated in the following equation to find the direction of the principal stress. (The following equation is only for specified angle triaxial rosette gages.)

Precautions in Analysis

(1) Regard $\varepsilon_a \rightarrow \varepsilon_b \rightarrow \varepsilon_c$ as the forward direction.

(2) Angle θ is:

Angle of the maximum strain to the ε_a axis when $\varepsilon_a > \varepsilon_c$.
Angle of the minimum strain to the ε_a axis when $\varepsilon_a < \varepsilon_c$.
Comparison between ε_a and ε_c in magnitude includes plus and minus signs.



Max. principal strain $\varepsilon_{max} = \frac{1}{2}\left[\varepsilon_a+\varepsilon_c+\sqrt{2\{(\varepsilon_a-\varepsilon_b)^2+(\varepsilon_b-\varepsilon_c)^2\}}\right]$

Min. principal strain $\varepsilon_{min} = \frac{1}{2}\left[\varepsilon_a+\varepsilon_c-\sqrt{2\{(\varepsilon_a-\varepsilon_b)^2+(\varepsilon_b-\varepsilon_c)^2\}}\right]$

Direction of principal strain (from ε_a axis) $\theta = \frac{1}{2}\tan^{-1}\left[\frac{2\varepsilon_b-\varepsilon_a-\varepsilon_c}{\varepsilon_a-\varepsilon_c}\right]$

Max. shearing strain $\gamma_{max} = \sqrt{2\{(\varepsilon_a-\varepsilon_b)^2+(\varepsilon_b-\varepsilon_c)^2\}}$

Max. principal stress $\sigma_{max} = \frac{E}{2(1-\nu^2)}\left[(1+\nu)(\varepsilon_a+\varepsilon_c)+(1-\nu)\times\sqrt{2\{(\varepsilon_a-\varepsilon_b)^2+(\varepsilon_b-\varepsilon_c)^2\}}\right]$

Min. principal stress $\sigma_{min} = \frac{E}{2(1-\nu^2)}\left[(1+\nu)(\varepsilon_a+\varepsilon_c)-(1-\nu)\times\sqrt{2\{(\varepsilon_a-\varepsilon_b)^2+(\varepsilon_b-\varepsilon_c)^2\}}\right]$

Max. shearing stress $\tau_{max} = \frac{E}{2(1+\nu)}\times\sqrt{2\{(\varepsilon_a-\varepsilon_b)^2+(\varepsilon_b-\varepsilon_c)^2\}}$

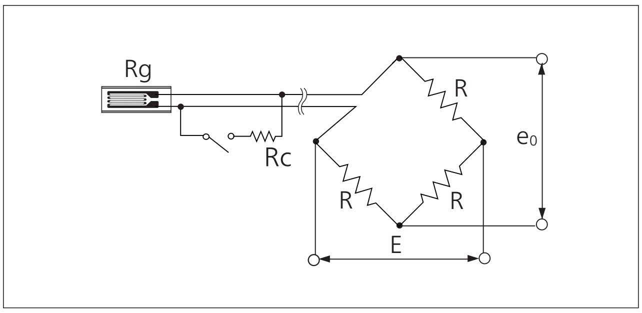
ν: Poisson's ratio
E: Young's modulus
(See table "Mechanical Properties of Industrial Materials," on page 6.)

●Generating Calibration Values based on the Tip Parallel Resistance Method

When extending lead wires by several hundred meters or finding accurate calibration values, the tip parallel resistance method is adopted. The parallel resistance Rc is calculated by the following equation:

$$Rc = \frac{Rg}{Ks \cdot \varepsilon} - Rg$$

where, Rg: Resistance of strain gage
Ks: Gage factor of strain gage
ε: Calibration strain value

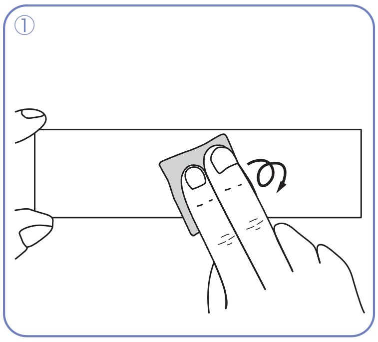


Examples of Calibration Strain Value and Resistance (Rg = 120 Ω, Ks = 2.00)

Calibration Strain Value ε	Resistance Rc
100 μm/m	≈ 600kΩ
200 μm/m	≈ 300kΩ
500 μm/m	≈ 120kΩ
1000 μm/m	≈ 60kΩ
2000 μm/m	≈ 30kΩ

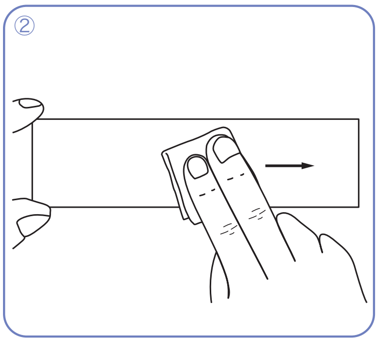
Typical Strain Gage Bonding Method and Dampproofing Treatment

The strain gage bonding method differs depending on the type of adhesive applied. The description below applies to a case where the lead-wire-equipped KFGS gage is bonded to a mild steel test piece with a typical cyanoacrylate adhesive, CC-33A. The dampproofing treatment shows a scenario using a butyl rubber coating agent.

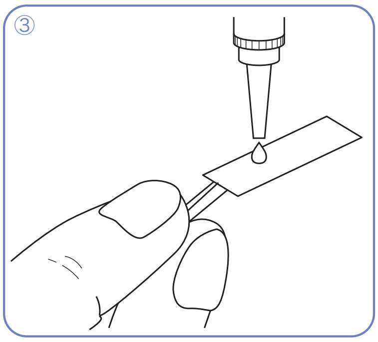


Using sandpaper (#320 grade or similar), polish the bonding site with circular motions across a considerably wider area than the strain gage size.

(If the measuring object is a practical structure, wipe off paint, rust and plating with a grinder or sand blast. Then, polish with sandpaper.)

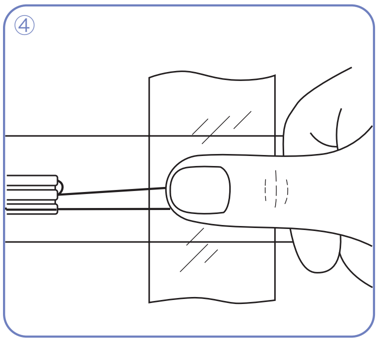


Using an absorbent cotton, gauze or SILBON paper dipped in a highly volatile solvent that dissolves oils and fats such as acetone, strongly wipe the bonding site in a single direction to remove oils and fats. Reciprocated wiping does not clean the surface. After cleaning, mark the strain gage bonding position.

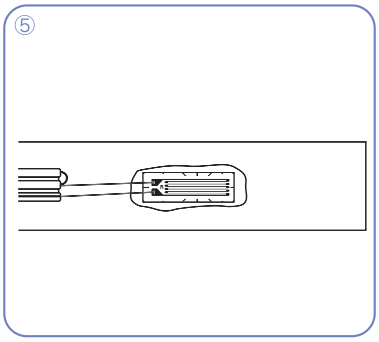


Make sure of the front (metal foil part) and the rear of the strain gage. Apply a drop of adhesive to the rear face and immediately put the strain gage on the bonding site.

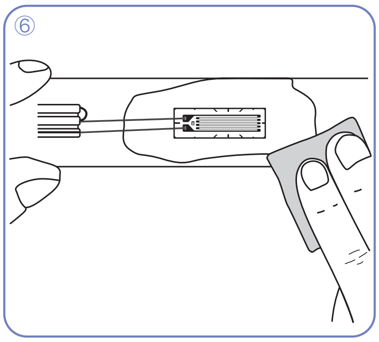
(Do not spread the adhesive over the rear face, as doing so may cause the adhesive to cure too quickly to adhere to the bonding site.)



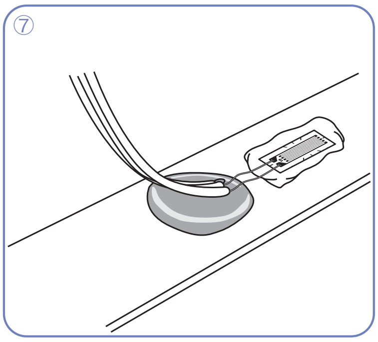
Cover the strain gage with the accessory polyethylene sheet and strongly press the strain gage over the sheet with a thumb for approximately 1 minute (Do not remove your thumb partway through). Perform steps 3 and 4 quickly, or the adhesive will cure prematurely. Once the strain gage is put on the bonding site, do not lift it up to adjust the position.



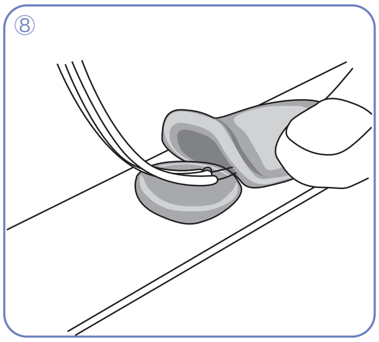
When the adhesive is cured, remove the polyethylene sheet and check the bonding condition. Ideally, the adhesive should be protruding slightly from around the strain gage.



If the adhesive is protruding excessively from around the gage base, remove the protruding adhesive with a cutter or sandpaper. Place the gage leads in a slightly slackened condition.

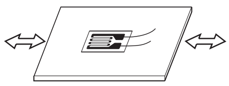
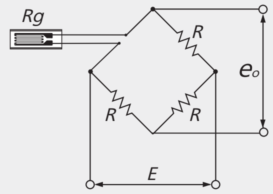
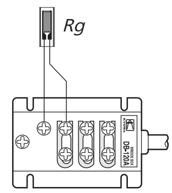
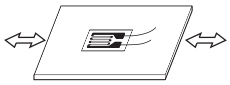
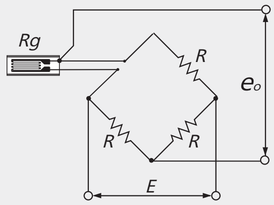
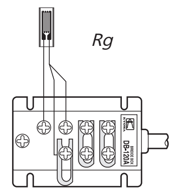
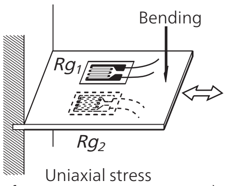
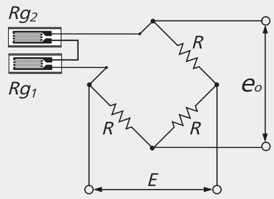
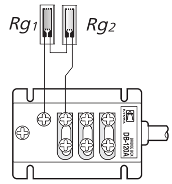
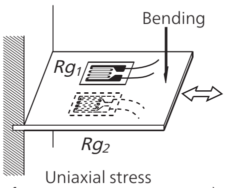
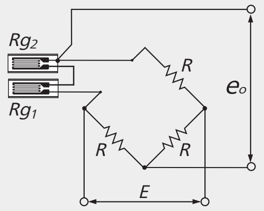
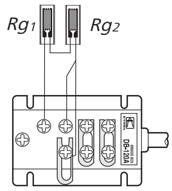
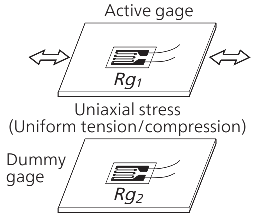
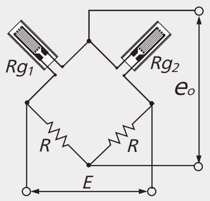
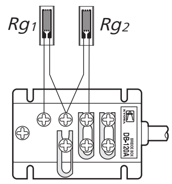
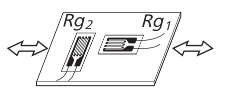
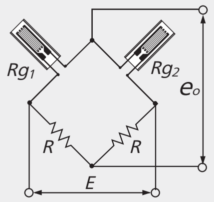
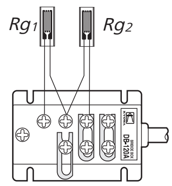
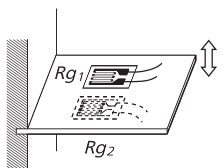
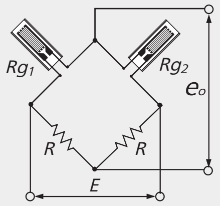
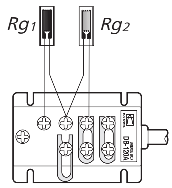
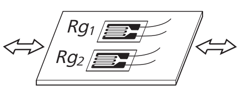
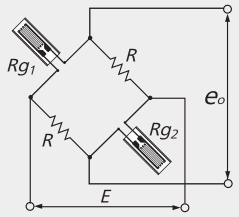
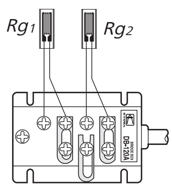


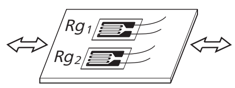
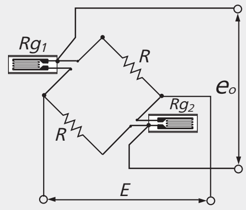
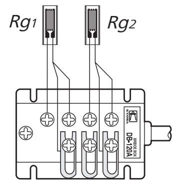
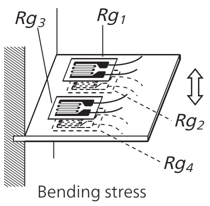
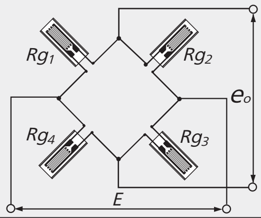
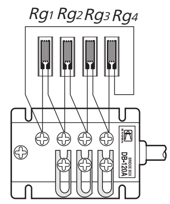
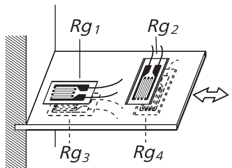
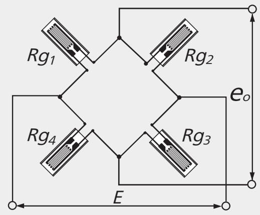
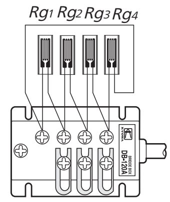
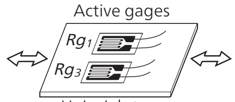
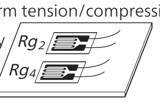
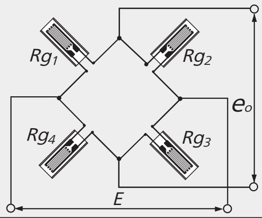
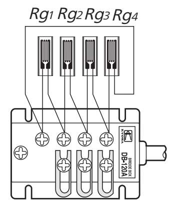
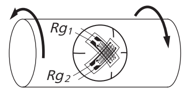
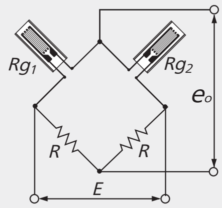
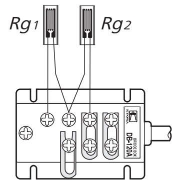
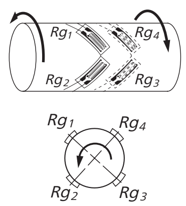
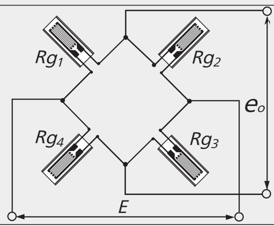
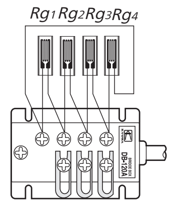
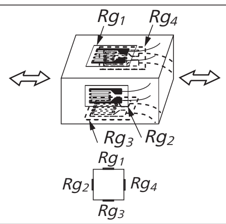
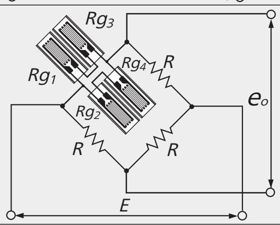
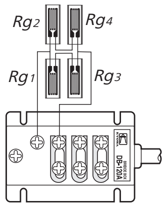
Lift up the lead wire to the point where the adhesive is applied. Place a block of the coating agent below the lead wire with the gage leads slightly loose.



Completely cover the strain gage, protruding adhesive and part of the lead wires with another block of the coating agent. Without tearing the block into small pieces, slightly flatten it with a finger to fully cover the strain gage and part of the lead wires. Completely hide protrusions including gage leads behind the coating agent.

How to Form Strain-gage Bridge Circuits

No.	Names	Sample Application	Circuits	Output	Remarks	Bridge Box DB-120A,350A
1	Active quarter-bridge 2-wire system Number of gages: 1	 Uniaxial stress (Uniform tension/compression)		$e_o=\frac{E}{4}K_s\cdot\varepsilon_o$ Ks: Gage factor ε_o: Strain E: Excitation voltage e_o: Output voltage Rg: Gage resistance R: Fixed resistance	Suitable for environments with little ambient temperature change; no temperature compensation. x 1 output	
2	Active quarter-bridge 3-wire system Number of gages: 1	 Uniaxial stress (Uniform tension/compression)		$e_o=\frac{E}{4}K_s\cdot\varepsilon_o$ Ks: Gage factor ε_o: Strain E: Excitation voltage e_o: Output voltage Rg: Gage resistance R: Fixed resistance	No temperature compensation; thermal effect of lead wires cancelled. x 1 output	
3	Active quarter-bridge (Dual series gages) 2-wire system (For canceling bending strain) Number of gages: 2	 Uniaxial stress (Uniform tension/compression)		$e_o=\frac{E}{4}K_s\cdot\varepsilon_o$ Rg_1……Strain: ε_1 Rg_2……Strain: ε_2 $\varepsilon_o=\frac{\varepsilon_1+\varepsilon_2}{2}$ R: Fixed resistance $R=Rg_1+Rg_2$ e.g. Rg_1 & Rg_2 are 60-ohm gages, if using a DB-120A.	No temperature compensation; bending strain cancelled. x 1 output	
4	Active quarter-bridge (Dual series gages) 3-wire system (For canceling bending strain) Number of gages: 2	 Uniaxial stress (Uniform tension/compression)		$e_o=\frac{E}{4}K_s\cdot\varepsilon_o$ Rg_1……Strain: ε_1 Rg_2……Strain: ε_2 $\varepsilon_o=\frac{\varepsilon_1+\varepsilon_2}{2}$ R: Fixed resistance $R=Rg_1+Rg_2$ e.g. Rg_1 & Rg_2 are 60-ohm gages, if using a DB-120A.	No temperature compensation; bending strain cancelled; thermal effect of lead wires cancelled. x 1 output	
5	Active-dummy half-bridge system Number of gages: 2			$e_o=\frac{E}{4}K_s\cdot\varepsilon_o$ Ks: Gage factor ε_o: Strain E: Excitation voltage e_o: Output voltage Rg_1……Strain: ε_o R: Fixed resistance Rg_2……Strain: 0	Temperature compensation; thermal effect of lead wires cancelled. x 1 output	
6	Orthogonal* active half-bridge system Number of gages: 2 * at a right angle	 Uniaxial stress (Uniform tension/compression)		$e_o=\frac{(1+\nu)E}{4}K_s\cdot\varepsilon_o$ ν: Poisson's ratio Rg_1, Rg_2: Gage resistance Rg_1……Strain: ε_o Rg_2…Strain: $-\nu\varepsilon_o$ R: Fixed resistance	Temperature compensation; thermal effect of lead wires cancelled. x $(1+\nu)$ output	
7	Active half-bridge system (For bending strain measurement) Number of gages: 2	 Bending stress		$e_o=\frac{E}{2}K_s\cdot\varepsilon_o$ Rg_1……Strain: ε_o Rg_2…Strain: $-\varepsilon_o$ R: Fixed resistance	Temperature compensation; thermal effect of lead wires cancelled; compressive/tensile strain cancelled. x 2 output	
8	Opposite-leg active half-bridge 2-wire system Number of gages: 2	 Uniaxial stress (Uniform tension/compression)		$e_o=\frac{E}{2}K_s\cdot\varepsilon_o$ Rg_1……Strain: ε_o Rg_2……Strain: ε_o R: Fixed resistance	No temperature compensation; x 2 output bending strain cancelled by bonding to the front and rear.	

No.	Names	Sample Application	Circuits	Output	Remarks	Bridge Box DB-120A,350A
9	Opposite-leg active half-bridge 3-wire system Number of gages: 2	 Uniaxial stress (Uniform tension/compression)		$e_o = \frac{E}{2} K_s \cdot \varepsilon_o$ Rg_1……Strain: ε_o Rg_2……Strain: ε_o R: Fixed resistance	No temperature compensation; thermal effect of lead wires cancelled; x 2 output bending strain cancelled by bonding to the front and rear.	
10	Active full-bridge system (For bending strain measurement) Number of gages: 4	 Bending stress		$e_o = K_s \cdot \varepsilon_o \cdot E$ Rg_1, Rg_3…… Bending strain: ε_o Rg_2, Rg_4…… Bending strain: $-\varepsilon_o$	Temperature compensation; thermal effect of lead wires cancelled; compressive/ tensile strain cancelled. x 4 output	
11	Orthogonal active full-bridge system Number of gages: 4	 Uniaxial stress (Uniform tension/compression)		$e_o = \frac{(1+\nu)E}{2} K_s \cdot \varepsilon_o$ ν: Poisson's ratio Rg_1, Rg_3…… Strain: ε_o Rg_2, Rg_4…… Strain: $-\nu\varepsilon_o$	Temperature compensation; thermal effect of lead wires cancelled. x2 (1+v) output	
12	Active-dummy full-bridge system Number of gages: 4	Active gages  Uniaxial stress (Uniform tension/compression) Dummy gages 		$e_o = \frac{E}{2} K_s \cdot \varepsilon_o$ Rg_1, Rg_3…… Strain: ε_o Rg_2, Rg_4…… Strain: 0	Temperature compensation; thermal effect of lead wires cancelled; x 2 output bending strain cancelled by bonding to the front and rear.	
13	Active half-bridge system (For twisting strain measurement) Number of gages: 2			$e_o = \frac{E}{2} K_s \cdot \varepsilon_o$ Rg_1…… Twisting strain: ε_o Rg_2…… Twisting strain: $-\varepsilon_o$ R: Fixed resistance	Temperature compensation; thermal effect of lead wires cancelled. x 2 output	
14	Active full-bridge system (For twisting strain measurement) Number of gages: 4			$e_o = K_s \cdot \varepsilon_o \cdot E$ Rg_1, Rg_3…… Twisting strain: ε_o Rg_2, Rg_4…… Twisting strain: $-\varepsilon_o$	Temperature compensation; thermal effect of lead wires cancelled. bending strain cancelled; compressive/ tensite strain cancelled. x 4 output	
15	4-active quarter-bridge system (For average strain measurement) Number of gages: 4			$e_o = \frac{E}{4} K_s \cdot \varepsilon_o$ $\varepsilon_o = \frac{\varepsilon_1+\varepsilon_2+\varepsilon_3+\varepsilon_4}{4}$ R: Fixed resistance $Rg = R$ $R = Rg_1 = Rg_2 = Rg_3 = Rg_4$	No temperature compensation; average strain x 1 output	

●Relationship between strain and voltage

The output of a strain-gage bridge is expressed as equivalent strain (×10⁻⁶ strain) or an output voltage (mV/V or μV/V) against the excitation voltage. The strain quantity and the output voltage have the following relation:

$$e_o = \frac{E}{4} K_s \cdot \varepsilon_o$$

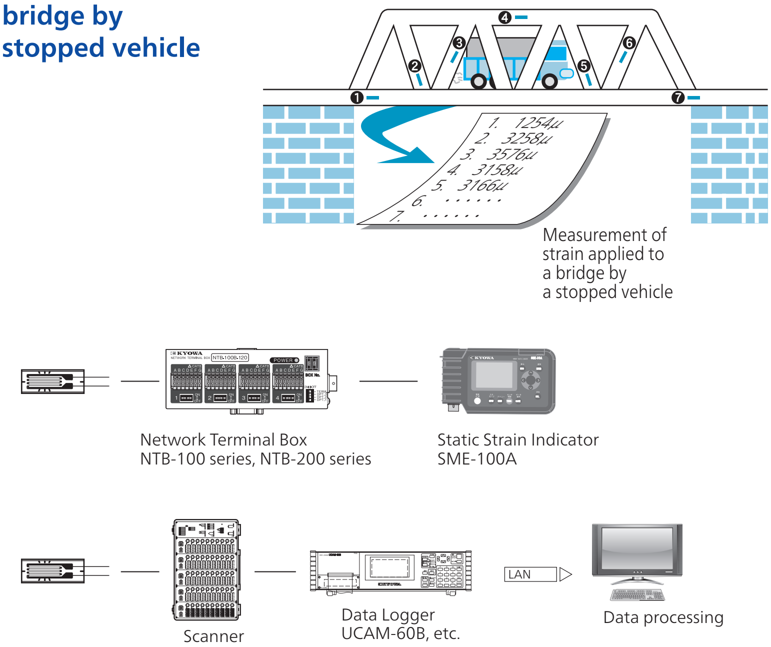
If the excitation voltage E = 1 V and the gage factor Ks = 2.00, $2e_o = \varepsilon_o$.
Thus, strain output is always 2 times larger than bridge output voltage.
e.g. 1.5 mV/V = 1500 μV/V → 3000×10^{-6} strain

Static Strain and Dynamic Strain

Static Strain Measurement

Static strain is a strain whose magnitude does not change as time passes or changes extremely slowly. If the force applied to a structure is constant, the strain is constant, making it possible to be read on an analog or digital indicator. In many cases, however, static strain measurement is performed on multiple channels, and thus scanners, channel selector switch boxes, and strain indicators are used in combination.

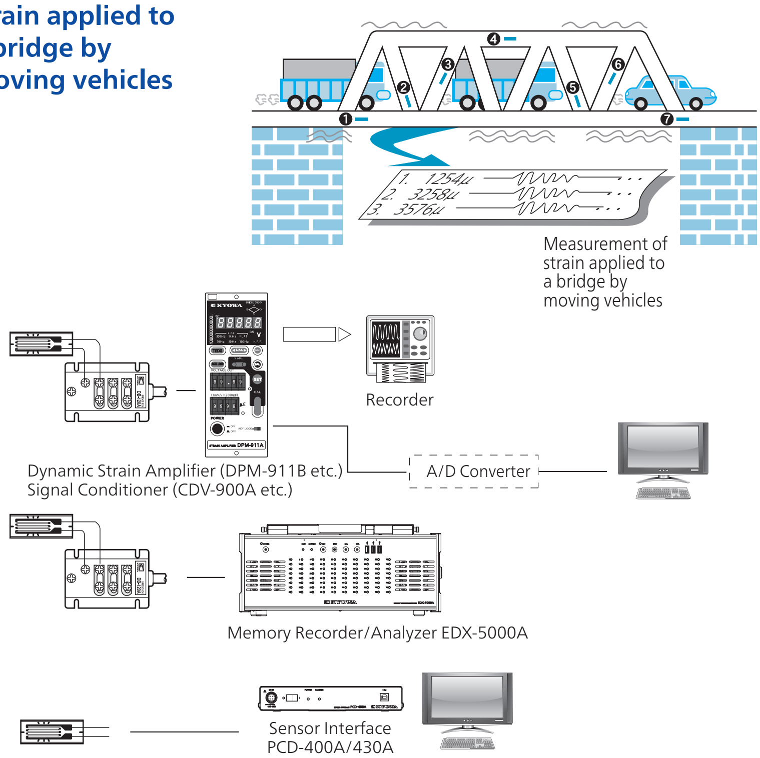
Measurement of strain applied to a bridge by a stopped vehicle



Dynamic Strain Measurement

Dynamic strain is a strain whose magnitude changes as time passes or is initiated by vibration or impact. Since ever-changing strain cannot be read out on analog and digital indicators, a data recorder or analog recorder has been used to obtain the detected data. Recently, a high-speed interface that connects the dynamic strain amplifier with a PC or a multichannel digital memory recorder analyzer that has a high-speed A/D converter and large-capacity memory is used to acquire and analyze the detected data.

Measurement of strain applied to a bridge by moving vehicles



Uses of Strain Gages

Simple static strain measurement with digital indicator

Strain values are measured with a digital static strain indicator SME-100A, etc. For multichannel measurement, multiple switch boxes are used.

Multichannel measurement in short time and for data processing

UCAM series data loggers that enable correction, calculation and automatic measurement are used together with applicable USB scanners.
The UCAM-60B is used if the PC is not used in conjunction, and the UCAM-65B is used for online measurement with the PC connected constantly. The UCAM-550A enables simultaneous sampling on all channels and is used for measurement of static to quasi-dynamic phenomena fluctuating at several cycles per second. Acquired data can be graphically displayed and analyzed on the PC.

Simple measurement of dynamic strain initiated by vibration, etc.

Dynamic strain fluctuating at up to 200 Hz can be measured simply with the PCD-400A or PCD-430A sensor interface. The sensor interface is equipped with bridge circuits, dynamic strain amplifiers and A/D converters, which enable its direct connection with the PC. Acquired data can be displayed in either graphic or digital format and processed on the PC.

Measurement of various signals including impact-initiated dynamic strain

Kyowa provides measuring instruments which enable data acquisition for quick phenomena such as impact-initiated waveform as well as simultaneous input of voltage, thermocouple, pulse and digital signals together with strain gage and strain gage transducer signals. A dedicated software program is available for PC-aided analysis of acquired digital data of dynamic phenomena.

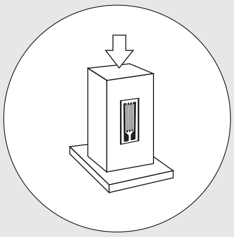
As sensing elements for transducers

Based on strain gages, various kinds of transducers are manufactured. These transducers are intended not to obtain strain data but to measure physical quantities such as load, pressure, acceleration, displacement and torque. For direct reading of such physical quantities, measuring instruments are available for connection to transducers.

Various applications of strain gages

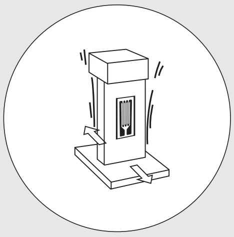
Load Measurement

A strain gage bonded to a pillar enables detection of the force and load applied to the pillar.



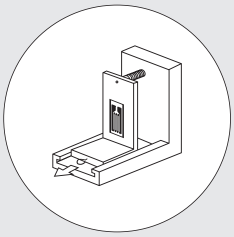
Vibration/Acceleration Measurement

A strain gage bonded to a thin leaf spring enables detection of the cycle, frequency and magnitude of the vibration and acceleration the leaf spring receives.



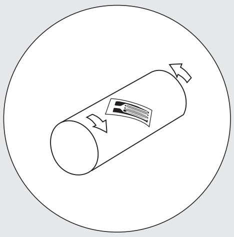
Displacement Measurement

A strain gage bonded to a thin leaf spring detects the bending strain the leaf spring receives, thereby enabling measurement of the amount of movement or displacement the spring is undergoing.



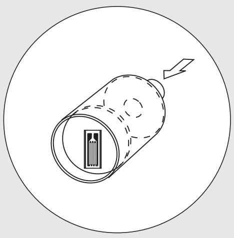
Torque Measurement

A strain gage bonded to an automobile propeller shaft or the rotating shaft of a drilling machine enables measurement of the transmission force, i.e. the torque, the shaft provides.



Pressure Measurement

A strain gage bonded to a diaphragm enables detection of the fluid or air pressure the diaphragm receives. As a rule, the strain gage is bonded to the rear of the diaphragm so that the strain gage will not be damaged by directly receiving pressure.



Selecting Strain Gages

Select the most suitable strain gage for the measuring purpose, with the measuring object and conditions taken into account.
Select the lead-wire cable and adhesive which meet the measuring environment.
Also, consider various accessories available for protection against severe environments and for labor saving.

1 Selecting a strain gage based on operating temperatures and other measuring conditions

➜P.19

Basically, a strain gage is selected based on the material of the measuring object and the operating environmental temperature.
This section facilitates selection of a strain gage based on each measuring material and temperature range.

2 Selecting a strain gage based on operating environment and purpose

➜P.20

This section describes the materials and features of strain gages, and provides data such as self-temperature-compensation ranges. Consult this section to select a suitable strain gage based on its specific characteristics.

3 Selecting the type and the length of lead-wire cable for the gage selected in 1 or 2

➜P.22

After selecting a strain gage, select the type and length of lead-wire cable by referring to this section.

4 Selecting a lead-wire cable based on operating temperature range and connection examples

➜P.24

From among various types available for high- to low-temperature applications, select the most suitable lead-wire cable for the measuring purpose.

5 Adhesives and bonding tools

➜P.26

Select a suitable adhesive for each measuring environment by referring to this section.

6 Gage terminals and other accessories

➜P.30

If required, select a gage terminal and coating agent by referring to this section.

1 Selecting a strain gage based on operating temperatures and other measuring conditions

°C: −300, −200, −100, 0, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000
°F: −508, −328, −148, 32, 212, 392, 572, 752, 932, 1112, 1292, 1472, 1652, 1832

General stress measurement	KFGS	Measurement under general environment ➡P.32
	KFGS T-F7	Residual stress measurement by cutting method ➡P.43
	KFGS D28	Residual stress measurement by boring method ➡P.44
	KFG C20	Bolt axial force internal strain measurement ➡P.45
	KFGT	Simultaneous measurement of strain and temperature ➡P.46
	KFR	Measurement at middle temperatures up to 150°C ➡P.47
	KFWB	For simplified waterproof treatment ➡P.51
	KFWS	For simplified waterproof treatment ➡P.53
	KCW	For simplified waterproof treatment and long-term stability ➡P.54
Measurement on concrete and mortar	KFGS	Measurement under general environment ➡P.55
	KC	Surface strain measurement ➡P.56
	KM	Internal strain measurement ➡P.57
	KMC	Self-contraction strain measurement ➡P.58
For composite materials, plastics and rubber	KFRP	Applicable linear expansion coefficients 1, 3, 6, 9 x10⁻⁶/°C ➡P.59
	KFRS	Measurement of printed boards ➡P.61
	KFP	Applicable linear expansion coefficients 65 x10⁻⁶/°C ➡P.63
Ultra-small strain measurement (semiconductor gages)	KSPL ➡P.67, KSN ➡P.65, KSPB ➡P.64	Measurement of less than 100 μm/m in environments with little ambient temperature change
	KSPH	Impact-initiated strain measurement with no amplifier ➡P.66
Measurement at high temperatures	KFU	Measurement at: −30 to 350°C ➡P.68
	KH	Measurement at: −50 to 350°C ➡P.70
	KFH	Measurement at: −196 to 250°C ➡P.71
	Encapsulated gages	Measurement at: −196 to 950°C ➡P.86
Measurement at low temp.	KFL	Measurement up to −269°C ➡P.74
Large strain measurement	KFEM	Elongation measurement up to approx. 20 to 30% ➡P.77
	KFEL	Elongation measurement up to approx. 10 to 15% ➡P.78
For magneto-resistance	KFN	Measurement under AC magnetic field ➡P.79
	KFS	Measurement under high electric field generating inductive noise ➡P.80
Measurement under other conditions	KFV	For measurements under other conditions ➡P.81
	KFF	Internal strain measurement ➡P.82
	KCH	Simplified bonding, wiring, waterproof treatment ➡P.83
	KMP	Internal strain measurement of resin ➡P.84
	KV	Measurement of progress and propagation velocity of crack ➡P.85

* The temperatures stated above are operating temperatures.

2 Selecting a strain gage based on operating environment and purpose

Application	Models/ series designation		Materials: Resistive elements	Materials: Bases	Operating temperature in combination with major adhesives after curing (°C) *1	Self-temperature-compensation (°C)	Applicable linear expansion coefficients ($\times 10^{-6}$/°C)	Strain limits at normal temp. (Approx.) *2	Fatigue lives at normal temp. (Times) *3	Pages
For general stress measurement	General-purpose Foil Strain Gages KFGS	For general purpose	CuNi alloy foil	Polyimide	CC-33A -196 to 120 CC-36 -30 to 100 EP-340 -55 to 150 PC-600 -196 to 150	10 to 100	5, 11, 16, 23, 27	5.0%	1.2×10^{7}	➡P.32
For general stress measurement	General-purpose Foil Strain Gages KFGS	For sensing element of transducers	CuNi alloy foil	Polyimide	PC-600 -196 to 150 EP-340 -55 to 150	10 to 100	11, 16, 23, 27	5.0%	1.2×10^{7}	➡P.42
For general stress measurement	General-purpose Foil Strain Gages KFGS	For concrete	CuNi alloy foil	Polyimide	CC-35 -10 to 80	10 to 100	11	5.0%	1.2×10^{7}	➡P.55
For general stress measurement	General-purpose Foil Strain Gages KFGS	Concentrated stress measurement	CuNi alloy foil	Polyimide	CC-33A -196 to 120 CC-36 -30 to 100 EP-340 -55 to 150 PC-600 -196 to 150	10 to 100	11, 16, 23, 27	—	—	➡P.38
For general stress measurement	General-purpose Foil Strain Gages KFGS	Residual stress measurement	CuNi alloy foil	Polyimide	CC-33A -196 to 120 CC-36 -30 to 100 EP-340 -55 to 150 PC-600 -196 to 150	10 to 100	11, 16, 23, 27	—	—	➡P.43
For general stress measurement	General-purpose Foil Strain Gages KFG	Bolt axial tension measurement	CuNi alloy foil	Polyimide	EP-370 Normal temp. to 50	20 to 50	11	—	—	➡P.45
For general stress measurement	Foil Strain Gages with a Temperature Sensor KFGT		CuNi alloy foil	Polyimide	CC-33A -10 to 120 CC-36 -10 to 100 EP-340 -10 to 120	10 to 100	11, 16, 23, 27	3%	1×10^{6}	➡P.46
For general stress measurement	Foil Strain Gages KFR	Strain measurement at mid temperature; for transducers	NiCr alloy foil	Polyimide	PC-600 -196 to150 CC-33A -196 to120 EP-340 -55 to150	0 to 150	11, 16, 23	2.2%	1×10^{6}	➡P.47
For general stress measurement	Foil Strain Gages KFR	Concentrated stress measurement	NiCr alloy foil	Polyimide	PC-600 -196 to150 CC-33A -196 to120 EP-340 -55 to150	0 to 150	11, 16, 23	—	—	➡P.50
For general stress measurement	Waterproof Foil Strain Gages KFWB		CuNi alloy foil	Polyimide	CC-33A -10 to 80 CC-36 -10 to 80 EP-340 -10 to 80	10 to 80	11, 16, 23	2.8%	3×10^{4}	➡P.51
For general stress measurement	Small-sized Waterproof Foil Strain Gages KFWS		CuNi alloy foil	Polyimide	CC-33A -10 to 80	10 to 80	11, 16, 23	5.0%	3×10^{4}	➡P.53
For general stress measurement	Weldable Waterproof Foil Strain Gages KCW		NiCr alloy foil	Stainless steel	(Spot welding) -20 to 100	10 to 90	11	—	—	➡P.54
For general stress measurement	Wire Strain Gages KC		CuNi alloy wire	Paper base + phenol-epoxy	CC-35 -30 to 120	10 to 60	11	1.8%	1.5×10^{5}	➡P.56
For general stress measurement	Embedded Strain Gages KM		CuNi alloy	Acrylate	(Embedment) -10 to 70	0 to 50	11	0.3%	—	➡P.57
For general stress measurement	Concrete-embedded Strain Gages KMC		CuNi alloy wire	Silicone	(Embedment) Normal temp. to 70	—	—	0.3%	—	➡P.58
For composite materials, plastics and rubber	Foil Strain Gages for Composite Materials KFRP		NiCr alloy foil	Polyimide	EP-34B -55 to 200 CC-33A -196 to 120	0 to 150	1, 3, 6, 9	2.2%	1×10^{6}	➡P.59
For composite materials, plastics and rubber	Foil Strain Gages for Printed Boards KFRS		NiCr alloy foil	Polyimide	CC-33A -196 to 120 PC-600 -196 to 150	-30 to 120	13	1.6%	2×10^{6}	➡P.61
For composite materials, plastics and rubber	Foil Strain Gages for Plastics KFP		CuNi alloy foil	Polyimide	EP-34B -20 to 80 CC-33A -20 to 80 CC-36 -20 to 80	10 to 80	65	3.0%	1×10^{6}	➡P.63
For ultra-small strain measurement	Semiconductor Strain Gages KSPB	Ultra-small strain; For sensing element of highly sensitive transducers	P type Si	Polyimide	CC-33A -50 to 120 EP-340 -50 to 150	—	—	0.3%	*A 2×10^{6}	➡P.64
For ultra-small strain measurement	Semiconductor Strain Gages KSPB	Ultra-small strain; 2-element, temperature-compensation type	P type Si N type Si	Polyimide	CC-33A -50 to 120 EP-340 -50 to 150	20 to 70	11.7	0.15%	*A 2×10^{6}	➡P.64
For ultra-small strain measurement	Self-temperature-compensation Semiconductor Strain Gages KSN		N type Si	Paper base + phenol-epoxy	CC-33A -50 to 120 CC-36 -30 to 100	20 to 70	11, 16	0.1%	*A 2×10^{6}	➡P.65
For ultra-small strain measurement	High-output Semiconductor Strain Gages KSPH		P type Si	Paper base + phenol-epoxy	CC-33A -50 to 120 CC-36 -30 to 100	—	—	0.3%	*A 2×10^{6}	➡P.66
For ultra-small strain measurement	Ultra Linear Semiconductor Strain Gages KSPL		P type Si	Paper base + phenol-epoxy	CC-33A -50 to 120 CC-36 -30 to 100	—	—	0.3%	*A 2×10^{6}	➡P.67

Notes

*1. Underlined adhesives are those used for strain limit tests and fatigue life tests at normal temperature.

*2. Typical values with uniaxial gages. Strain limit is the mechanical limit where the difference between the strain reading and mechanical strain initiated by applying tension load exceeds 10%.

*3. Typical values with uniaxial gages. Strain level: ±1500 μm/m ; *A: ±1000 μm/m; *B: ±500 μm/m.

Category	Models/ series designation	Materials: Resistive elements	Materials: Bases	Operating temperature in combination with major adhesives after curing (°C) *1	Self-temperature-compensation (°C)	Applicable linear expansion coefficients ($\times10^{-6}$/°C)	Strain limits at normal temp. (Approx.) *2	Fatigue lives at normal temp. (Times) *3	Pages
For high temperature	Encapsulated Gages KHCX	Heat-resistant special alloy wire	Heat-resistant metal	(Spot welding) -196 to 950	25 to 950	11, 13	—	—	➡P.86
For high temperature	Encapsulated Gages KHCV	Heat-resistant special alloy wire	Heat-resistant metal	(Spot welding) 25 to 800	—	— (Dynamic measurement)	—	—	➡P.86
For high temperature	Encapsulated Gages KHCR	Heat-resistant special alloy wire	Heat-resistant metal	(Spot welding) 25 to 750	25 to 750	11, 13, 16	—	—	➡P.86
For high temperature	Encapsulated Gages KHCS	Heat-resistant special alloy wire	Heat-resistant metal	(Spot welding) -196 to 750	25 to 750	11, 13, 16	—	—	➡P.86
For high temperature	Encapsulated Gages KHCM	Heat-resistant special alloy wire	Heat-resistant metal	(Spot welding) -196 to 650	25 to 650	11, 13, 16	—	—	➡P.86
For high temperature	Encapsulated Gages KHC	NiCr alloy wire	Heat-resistant metal	(Spot welding) -196 to 550	Normal temp. to 500	11, 13, 16	—	—	➡P.86
For high temperature	High-temperature Foil Strain Gages KFU	NiCr alloy wire	Polyimide	PI-32 -30 to 350	10 to 300	11, 16, 23	1.9%	*A 1.5×10^5 (300°C)	➡P.68
For high temperature	High-temperature Foil Strain Gages KH	NiCr alloy wire	Stainless steel	(Spot welding) -50 to 350	10 to 300	11, 16	0.5%	*B 1×10^7	➡P.70
For high temperature	High-temperature Foil Strain Gages KFH	NiCr alloy wire	Polyimide	PC-600 -196 to 250 EP-34B -55 to 200 PI-32 -196 to 250	10 to 250	11, 16, 23	2.1%	2×10^5	➡P.71
For low temp.	Low-temperature Foil Strain Gages KFL	NiCr alloy wire	Polyimide	PC-600 -269 to 150 EP-270 -269 to 30 CC-33A -196 to 120	-196 to 50	5, 11, 16, 23	2.2%	1×10^6	➡P.74
For large strain measurement	Ultrahigh-elongation Foil Strain Gages KFEM	CuNi alloy foil	Polyimide	CC-36 -20 to 80	—	—	20 to 30%	—	➡P.77
For large strain measurement	High-elongation Foil Strain Gages KFEL	CuNi alloy foil	Polyimide	CC-36 -10 to 80	—	—	10 to 15%	1×10^6	➡P.78
For antimagnetic applications	Non-inductive Foil Strain Gages KFN	NiCr alloy wire	Polyimide	PC-600 -196 to 150 CC-33A -196 to 120	0 to 150	11, 16, 23	1%	1×10^4	➡P.79
For antimagnetic applications	Shielded Foil Strain Gages KFS	CuNi alloy foil (120 Ω) NiCr alloy foil (350 Ω)	Polyimide	PC-600 -196 to 150 CC-33A -196 to 120 EP-340 -55 to 150	10 to 100	11, 16, 23	0.5%	1×10^4	➡P.80
For hydrogen gas environments	Foil Strain Gage for Hydrogen Gas Environment KFV	Special alloy foil	Polyimide	PC-600 -30 to 80	—	—	—	—	➡P.81
Internal strain	Foil Strain Gages for Bending Strain Measurement KFF	CuNi alloy foil	Acrylate	CC-33A -50 to 80 EP-340 -50 to 80	20 to 60	11, 16, 23	0.2%	*B 4×10^6	➡P.82
With protector	Foil Strain Gages with a Protector KCH	CuNi alloy foil	Polyimide	Protector: Stud bolt Strain gage EP-340, CC-33A -40 to 100	—	11	1%	*A 1.2×10^6	➡P.83
Embedded	Embedded Gage KMP		Aluminum	—	20 to 120	—	—	—	➡P.84
Crack	Crack Gages KV	CuNi alloy foil	Paper base+ phenol-epoxy	CC-33A CC-36 PC-600	—	—	—	—	➡P.85

Notes

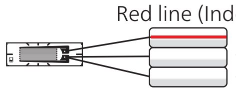
*1. Underlined adhesives are those used for strain limit tests and fatigue life tests at normal temperature.

*2. Typical values with uniaxial gages. Strain limit is the mechanical limit where the difference between the strain reading and mechanical strain initiated by applying tension load exceeds 10%. *1% = 10000 μm/m

*3. Typical values with uniaxial gages. Strain level: ±1500 μm/m; *A: ±1000 μm/m; *B: ±500 μm/m.

3 Selecting the type and the length of lead-wire cable for the gage selected in 1 or 2

Virtually all Kyowa strain gages are delivered with a lead-wire cable pre-attached to ensure labor saving in gage bonding works by eliminating the need for soldering.
Types and lengths of the lead-wire cable for each gage are as follows.

Models of Strain Gage	KFGS,KFR,KFRP,KFRS, KFP,KFL,KFEM,KFEL		KFGS,KFR,KFWB,KFWS,KC, KFRP,KFRS,KFP,KFEM,KFEL			
Type of lead-wire cables	 2 polyester-coated copper wires -196 to 150°C	 3 polyester-coated copper wires -196 to 150°C	 Vinyl-coated flat 2-wire cable -10 to 80°C		 Vinyl-coated flat 3-wire cable -10 to 80°C	
			Uniaxial	Multiaxial	Uniaxial	Multiaxial
Lengths of lead-wire cable (*) 15 cm	N15C2	N15C3	L15C2R	L15C2S	L15C3R	L15C3S
30	N30C2	N30C3	L30C2R	L30C2S	L30C3R	L30C3S
1 m	N1M2	N1M3	L1M2R	L1M2S	L1M3R	L1M3S
3	———	———	L3M2R	L3M2S	L3M3R	L3M3S
5	———	———	L5M2R	L5M2S	L5M3R	L5M3S
Models, etc.	Twisted for ≥ 50 cm		L-6 L-9 for ≥ 6 m		L-7 L-10 for ≥ 6 m	
Coating color	* KFEL, KFEM are only 2-wire type		 Red Red		Red line (Independent)  White White	

*For other lead-wire cable lengths, contact us.

- ●For 2-wire gages, the gage resistance indicated on the package includes that of the lead-wires.
- ●For 3-wire gages, the gage resistance indicated on the package is only for the gage itself, and does not include that of the lead-wires.
- ●KFU and KFH: The advanced ribbon wire section is covered with glass-cloth tape for reinforcement. (See the right figure.)
- ●Encapsulated gages are provided standard with an MI cable 2 m long and a soft cable 50 cm long.

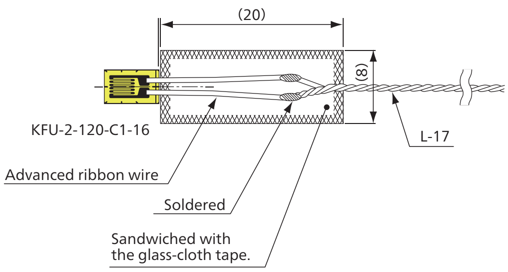


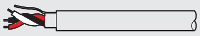
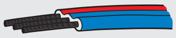
Figure: Example lead-wire cable of a KFU gage

See page 54 for KCW, page 57 for KM, page 71 for KH.

When ordering, specify the model of the strain gage and the code of the lead-wire cable with a space in between.

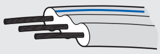
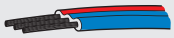
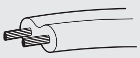
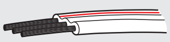
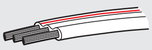
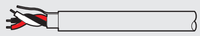
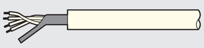
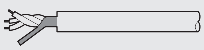
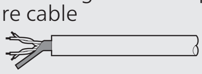
e.g.

Model of strain gage	Code of lead-wire cable
KFGS-2-120-C1-11	**L1M3R**

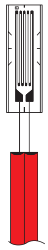
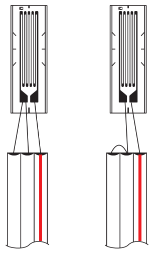
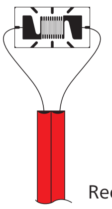
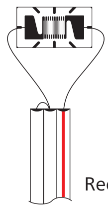
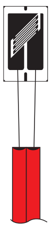
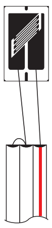
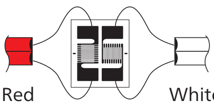
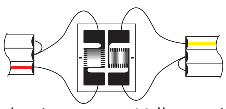
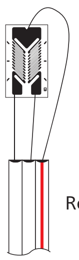
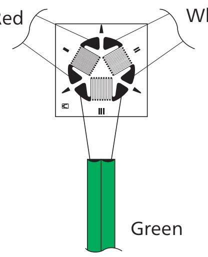
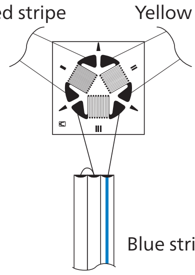
KFGS,KFR,KFRP,KFL		KFN,KFS	KFRP,KFH,KFL	KFU,KFH
 Mid-temperature 2-wire cable -100 to 150°C	 Mid-temperature 3-wire cable -100 to 150°C	 Vinyl-coated low-noise 3-wire cable -10 to 80°C	 Fluoroplastic-coated high/low-temp. 3-wire cable -269 to 250°C	 High-temperature lead-wire cable -269 to 350°C
R15C2	R15C3	J15C3	F15C3	H15C3
R30C2	R30C3	J30C3	F30C3	H30C3
R1M2	R1M3	J1M3	F1M3	H1M3
R3M2	R3M3	J3M3	F3M3	H3M3
R5M2	R5M3	J5M3	F5M3	H5M3
L-11	L-12	L-13	L-3	L-17
Grey Grey	Red (Independent) White Black	Red (Independent) White Black	Red (Independent) Blue Blue	Black (Independent) Yellow Green

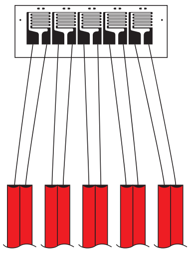
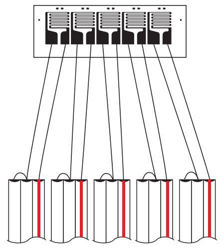
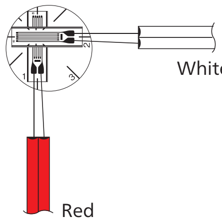
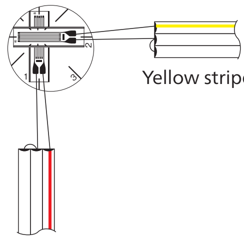
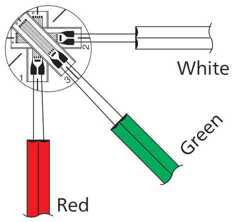
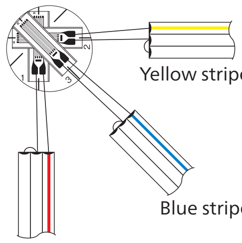
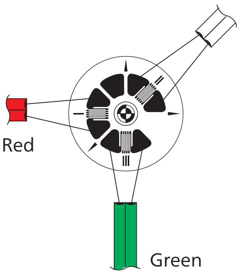
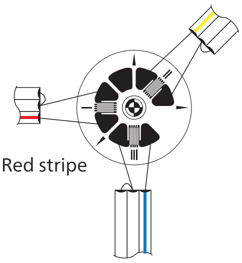
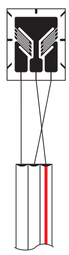
4 Selecting a lead-wire cable based on operating temperature range and connection examples

L-type lead-wire cables

Operating Temperature (°C)	Models	Types	Conductor Materials	Nominal Cross Section of Conductor (mm²)	Number of Strands/ Wire Diam. (mm)	Reciprocating Resistance per Meter (Ω)	Coated Wire Diameter (mm)	Lengths (m)
Normal temp. to 350	**L-1**	High-temperature lead wire 	CuNi alloy	0.07	1／φ0.30	14.20	φ0.50	50
−10 to 80	**L-2**	Vinyl-coated flat 3-wire cable 	Copper	0.30	12／φ0.18	0.12	φ2.30	100
−269 to 250	**L-3**	Fluoroplastic-coated high/low-temp. 3-wire cable 	Silver-plated copper	0.14	7／φ0.16	0.28	φ0.98	50
Normal temp. to 350	**L-4**	High-temperature lead-wire cable 	Nickel-clad copper	0.20	1／φ0.50	0.18	φ0.70	30
−10 to 80	**L-5**	Vinyl-coated flat 2-wire cable 	Copper	0.50	20／φ0.18	0.07	φ2.50	
−10 to 80	**L-6** (*1)	Vinyl-coated flat 2-wire cable 	Copper	0.08	7／φ0.12	0.44	φ1.00	
−10 to 80	**L-7** (*2)	Vinyl-coated flat 3-wire cable 	Copper	0.08	7／φ0.12	0.44	φ1.00	
−10 to 80	**L-9** (*1)	Vinyl-coated flat 2-wire cable 	Copper	0.11	10／φ0.12	0.32	φ1.00	
−10 to 80	**L-10** (*2)	Vinyl-coated flat 3-wire cable 	Copper	0.11	10／φ0.12	0.32	φ1.00	100
−100 to 150	**L-11**	Mid-temperature 2-wire cable 	Tin-plated copper	0.08	7／φ0.12	0.44	φ0.86	
−100 to 150	**L-12**	Mid-temperature 3-wire cable 	Tin-plated copper	0.08	7／φ0.12	0.44	φ0.86	
−10 to 80	**L-13**	Vinyl-coated normal-temperature low-noise 3-wire cable 	Tin-plated copper	0.09	7／φ0.13	0.46	φ3.50	
−50 to 90	**L-14**	Chloroprene-coated normal-temperature low-noise 4-wire cable 	Tin-plated copper	0.08	7／φ0.12	0.48	φ4.00	
−269 to 250	**L-15**	Fluoroplastic-coated high/low-temp. low-noise 3-wire cable 	Silver-plated copper	0.08	7／φ0.12	0.48	φ2.50	10
−269 to 250	**L-16**	Fluoroplastic-coated high/low-temp. low-noise 4-wire cable 	Silver-plated copper	0.08	7／φ0.12	0.48	φ3.30	
−269 to 350	**L-17**	High/low-temperature 3-wire cable 	Nickel-plated copper	0.07	1／φ0.30	0.50	φ0.38	30

*1. These models have a suffix R, W, G, Y or B indicating the coating color; red, white, green, yellow or black. e.g. L-6B: Black vinyl coated.
*2. These models have a suffix WR, WL or WY indicating the stripe color; red, blue or yellow on white vinyl coating.
e.g. L-7WR: Red stripes on white coating.

Cord / Type	2-wire	3-wire
C1	 Red	 Red stripe; Red stripe 2 connection methods depending on the models. (Same as D16 and D17.) *KFGS: Right only.
C2 • C3	 Red	 Red stripe
C15 • C16	 Red	 Red stripe
D1	 Red; White	 Red stripe; Yellow stripe
D2		 Red stripe
D4	 Red; White; Green	 Red stripe; Yellow stripe; Blue stripe

Cord / Type	2-wire	3-wire
D9 • D19 • D39	 Red	 Red stripes
D16	 White; Red	 Yellow stripe; Red stripe
D17	 White; Green; Red	 Yellow stripe; Blue stripe; Red stripe
D28	 White; Red; Green	 Yellow stripe; Red stripe; Blue stripe
D31		 Red stripe

Selecting Strain Gages

5 Adhesives and bonding tools

To obtain good measurement results, the strain gage must be bonded firmly to the measuring object. Thus, it is important to select an adhesive suitable for the materials of both the object being measured and the gage base, as well as for the measuring conditions.

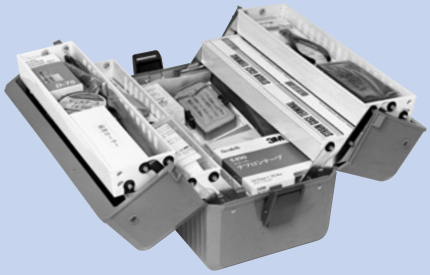
	Models	Types	Operating Temperature (°C)	Major Applicable Materials	Curing Requirements
	CC-33A	Instantaneous adhesive cured at normal temperature	-196 to 120 (Regular temperature: 20 to 80)	•Metals (Steel, stainless steel, copper, aluminum alloys A1050, A2024, etc.) •Plastics (Acrylate, PVC, nylon, etc.) •Composite materials (CFRP, GFRP, PCB, etc.) •Rubber	•Apply finger pressure (100 to 300 kPa) for 15 to 60 seconds. Then, leave the gage as it is for 1 hour. *The finger pressure application time differs depending on temperature and humidity conditions. The lower the temperature and humidity, the longer the finger pressure application time required.
	CC-35	Instantaneous adhesive cured at normal temperature	-30 to 120 (Regular temperature: 20 to 80)	•Concrete •Mortar •Wood	•Apply finger pressure (100 to 300 kPa) for 30 to 60 seconds. Then, leave the gage as it is for 1 hour or more. *The finger pressure application time differs depending on temperature and humidity conditions. The lower the temperature and humidity, the longer the finger pressure application time required.
	CC-36	Instantaneous adhesive cured at normal temperature	-30 to 100 (Regular temperature: 20 to 80)	•Metals (Steel, stainless steel, copper, aluminum alloys A1050, A2024, A7075, magnesium alloy, etc.) •Plastics (Acrylate, PVC, nylon, polypropylene, etc.) •Composite materials (CFRP, GFRP, PCB, etc.) •Concrete •Mortar •Wood •Rubber	•Apply finger pressure (100 to 300 kPa) for 30 to 180 seconds. Then, leave the gage as it is for 1 hour or more. *The finger pressure application time differs depending on temperature and humidity conditions. The lower the temperature and humidity, the longer the finger pressure application time required.
	EP-270	Cured at normal temperature	-269 to 30	•Metals (Steel, stainless steel, aluminum alloy, etc.)	•Apply pressure (50±20 kPa) for 24 hours at approx. 25°C
	EP-340	Cured at normal temperature or by heating	-55 to 150	•Metals (Steel, stainless steel, aluminum alloy, etc.)	•Apply pressure (100±50 kPa) for 24 hours at approx. 25°C or for 2 hours at 80°C. •Pressing is possible with tape.
	EP-34B	Cured at normal temperature or by heating	-55 to 200	•Metals (Steel, stainless steel, copper, aluminum alloy, etc.) •Plastics (Acrylate, PVC, etc.) •Composite materials (CFRP, GFRP, PCB, etc.)	•Apply pressure (30 to 50 kPa) for 24 hours at approx. 25°C or for 2 hours at 80°C. •Pressing is possible with tape.
	NEW EP-370	Cured by heating	Normal temp. to 50	•Metals (Steel, stainless steel, copper, aluminum alloy, etc.) •Plastics (Acrylate, PVC, etc.)	•Keep at normal temperature for 24 hours and heat it for 5 hours at 80°C.
	PC-600	Cured by heating	-269 to 250	•Metals (Steel, stainless steel, copper, aluminum alloy, etc.)	•Apply Pressure (150 to 300 kPa) for 1 hour at 80°C, →2 hours at 130°C →2 hours at 150°C
	PI-32	Cured by heating	-269 to 350	•Metals (Steel, stainless steel, copper, aluminum alloy, etc.)	•Apply pressure (200 to 500 kPa) for 1 hour at 100°C, →2 hours at 200°C →2 hours at the operating temperature with the pressure removed. *If it is difficult to heat to 200°C, 2 h at 200°C may be changed to 5 h at 160°C with all other conditions followed.

Note: The stated operating temperature range is for the adhesive only, and may differ depending on combinations with gages. When using the adhesives and gages together, read the attached instruction manual carefully.

Category	Capacity	Features	Major Applicable Gages
1 type of cyanoacrylate liquid	2 g × 1 or 2 g × 5	•Suitable for bonding general-purpose gages which are used for general stress measurement at normal temperature. •Quick curing ensures smooth bonding workability. •Enables measurement in approximately 1 hour from bonding.	KFGS KFGT KFR KFWB KFWS KFRP KFRS KFP KSPB KSN (Excl. E5) KSPH KSPL KFL KFN KFS KFF KCH KV
1 type of cyanoacrylate liquid	2 g × 1 or 2 g × 5	•High viscosity makes it suitable for bonding to porous materials such as lumber and concrete. •Suitable for bonding general-purpose gages which are used for general stress measurement at normal temperature.	KFGS KFGT KFR KC KFRP KFP
1 type of cyanoacrylate liquid	2 g × 1 or 2 g × 5	•Suitable for bonding a high-elongation gage (such as KFEM and KFEL) at normal temperature. •Suitable for bonding to non-adhesive materials such as aluminum alloy (A7075) and magnesium alloy. •High peeling resistance, high impact resistance and less aging deterioration of bonding strength	KFEM KFEL KFGS KFGT KFR KFWB KFWS KFRP KFRS KFP KSPB KSN (Excl. E5) KSPH KSPL KFF KV
2 types of epoxy liquid mixed	50 g (Main agent: 25 g Curing agent: 25 g)	•Suitable for bonding gages for strain measurement at very low temperature.	KFL
2 types of epoxy liquid mixed	30 g (Main agent: 6 g × 4 Curing agent: 1.5 g × 4)	•Suitable for bonding gages for strain measurement at mid temperature.	KFGS KFR KFWB KFGT KFF KFS
2 types of epoxy liquid mixed	30.8 g (Main agent: 5.6 g × 4 Curing agent: 2.1 g × 4)	•Suitable for bonding gages for strain measurement at mid temperature and for bonding gages for transducers.	KFRP KFP KFH
2 types of epoxy liquid mixed	40 g (Main agent: 30 g Curing agent: 10 g)	•Low viscosity makes it suitable for bonding gages (KFG-C20) in bolts.	KFG (C20)
1 heating type of phenol liquid	100 g	•Suitable for bonding gages for strain measurement at low, mid and high temperatures and for bonding gages for transducers.	KFGS KFR KFH KFL KFN KFS
1 heating type of polyimide liquid	20 g	•Suitable for bonding gages for strain measurement at high temperature.	KFU KFH

Gage Bonding Tool Kit

Note: Cleaner, strain gages and adhesives are not included. Please prepare them separately.



●GTK-77 Tool Kit

This kit includes almost all tools, gage terminals, solder and other expendables required for gage bonding work.

Contents
Tool box, screwdriver set, tweezers (2 PC.), nippers, radio pliers, tape measure (2 m), stainless steel scale, protractor, sandpaper (#100, #320, 3 PC. each), soldering iron tip cleaner, knife, utility knife, scriber, soldering iron (40 W), compass, marking pencil, mending tape, pencils (4H, 6H, 2 PC. each), scissors, cotton swabs, clean paper, high-temperature solder, flux for high-temperature solder, heat-resistant glass tube, gage terminals (T-P1, T-P4, T-P5, T-P6, T-P7, T-P8, T-P9, T-P10, T-F2B, T-F3B, T-F7B, T-F8B, TF10B, T-F13B, T-F17B, T-F25 and T-F28), hair dryer (1200 W), insulation vinyl tape, table tap (2.5 m), soldering iron (ANTEX), silicon rubber (10 PC.), fluoroplastic sheets (10 PC.), gage presser (G-MATE-B, 1 PC.)

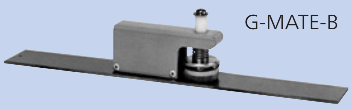
Note: The power supply of the electric goods is set to 100 VAC, as per Japanese specifications.

●GTK-55K Tool Kit NEW

This portable kit includes almost all items required for gage bonding work

Contents
Tool box, tweezers (2 PC.), nippers, radio pliers, stainless steel scale, sandpaper (#180, #320, #600, and #1000, 4 PC. each), utility knife, scriber, pencils (4H, 3PC.), tape, scissors, small scissors, cotton swabs, clean paper, gage terminals (T-F7B, T-F17B) vinyl tape, silicone rubber (10 PC.), fluoroplastic sheets (10 PC.), polyethylene sheets (SKF-28284, 100 PC.), gage presser (G-MATE-B, 1 PC.)

Gage Presser



G-MATE-B

●Gage Presser G-MATE

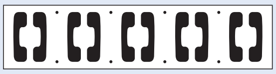
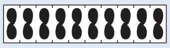
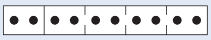
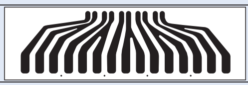
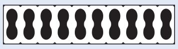
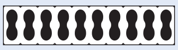
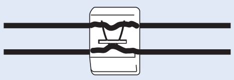
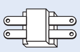
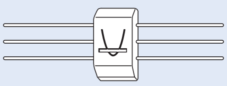
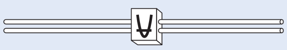
The G-MATE applies pressure to a bonded strain gage continuously until the adhesive is cured. It consists of a frame equipped with a strong ferrite magnet to firmly fix the object under testing and a pressure disk equipped with silicon sponge rubber and a coil spring to apply constant pressure to the strain gage.

Name	Models	Applications
Gage Mate	G-MATE-B	For normal temperature (Up to approx. 80 °C)
High-temperature Gage Mate	G-MATE-H	For high temperature (Up to approx. 150 °C)

6 pc/pkg

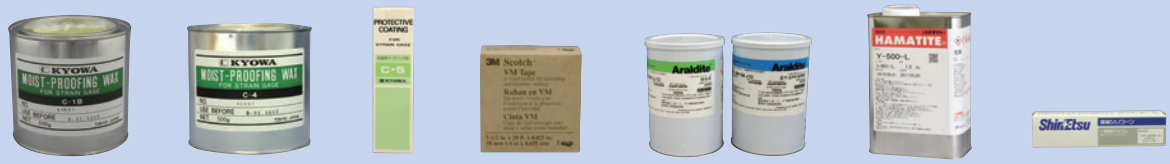
Gage Terminals

A gage terminal is for connecting a strain gage and lead wires to protect the gage leads. It prevents the strain gage from receiving force and the gage leads from breaking or peeling off if the lead wires are pulled to some extent.

	Models		Dimensions (mm) (W x L x T)	Base Materials	Conductor Materials	Qty per Pack	Operating Temperature (°C)	Recom-mended Adhesives	Remarks
Foil types		T-F2B NEW CE	5-pole 14×55×0.1 1-pole 14×11×0.1	Glass epoxy	Copper foil	20 sheets (5 poles/ sheet)	-196 to 120	CC-33A EP-34B	
		T-F3B NEW CE	5-pole 14×65×0.1 1-pole 14×13×0.1	Glass epoxy	Copper foil	20 sheets (5 poles/ sheet)	-196 to 120	CC-33A EP-34B	For 3-wire system
		T-F13B NEW CE	5-pole 14×65×0.15 1-pole 14×13×0.15	Glass epoxy + double-sided adhesive tape			-30 to 50	Not required	Self-bonding
		T-F7B NEW CE	5-pole 6×25×0.1 1-pole 6×5×0.1	Glass epoxy	Copper foil	20 sheets (5 poles/ sheet)	-196 to 120	CC-33A EP-34B	
		T-F17B NEW CE	5-pole 6×25×0.15 1-pole 6×5×0.15	Glass epoxy + double-sided adhesive tape			-30 to 50	Not required	Self-bonding
		T-F8B NEW CE	5-pole 4×30×0.1 1-pole 4×6×0.1	Glass epoxy	Copper foil	20 sheets (5 poles/ sheet)	-196 to 120	CC-33A EP-34B	
		T-F10B NEW CE	15×50×0.1	Glass epoxy	Copper foil	10 sheets	-196 to 120	CC-33A EP-34B	Mainly for 5-element gages
		T-F23 CE	5-pole 14×55×0.1 1-pole 14×11×0.1	Polyimide	Copper foil	20 sheets (5 poles/ sheet)	–196 to 200, –196 to 120 with CC-33A	CC-33A EP-34B	For high temperature
		T-F24 CE	5-pole 9×40×0.1 1-pole 9×8×0.1						
		T-F25 CE	5-pole 6×25×0.1 1-pole 6×5×0.1						
		T-F26 CE	5-pole 14×55×0.1 1-pole 14×11×0.1	Polyimide	Copper foil	20 sheets (5 poles/ sheet)	-196 to 350	PI-32	For high temperature
		T-F27 CE	5-pole 9×40×0.1 1-pole 9×8×0.1						
		T-F28 CE	5-pole 6×25×0.1 1-pole 6×5×0.1						
		T-F29 NEW CE	Outer: ϕ6 Inner: ϕ2.5	Glass epoxy	Copper foil	20 sheets	-196 to 120	EP-340, 370 CC-33A	For measuring axial tension of bolts
Mold types		T-P1	14×10×4	Styrol	Tin-plated copper wire	20 PC.	-30 to 80	CC-33A	Self-bonding
		T-P4	14×10×4.5	Styrol + double-sided adhesive tape			-30 to 50	Not required	Self-bonding
		T-P5	6×6×2	ABS	Tin-plated copper wire	20 PC.	-30 to 120	CC-33A	
		T-P6	6×6×2.5	ABS + double-sided adhesive tape			-30 to 50	Not required	Self-bonding
		T-P7	15×10×4	ABS	Tin-plated copper wire	20 PC.	-30 to 80	CC-33A	For 3-wire system
		T-P8	15×10×4.5	ABS + double-sided adhesive tape			-30 to 50	Not required	Self-bonding
		T-P9	6×5×4	Heat-resistant styrol	Tin-plated copper wire	40 PC.	-30 to 90	CC-33A	
		T-P10	6×5×6	Heat-resistant styrol + rubber					Rubber on the rear face

Coating Agents

Coating agents are applied to gages and gage terminals to prevent gages from adsorbing moisture in outdoor or long-term measurements.



C-1B | C-4 | C-5 | VMTAPE | ARALDITE-C | HAMATITE Y-500-L | KE-4898-W

Models	C-1B	C-4	C-5	AK22	VMTAPE	ARALDITE	HAMATITE Y-500-L	KE-4898-W
Types	Hot-melt type	Hot-melt type	Rubber solvent type	Special clay	Press-fitting rubber type	2-liquid type (1:1)	Rubber solvent type	Silicon solvent type
Operating Temperature	–30 to 40°C	–50 to 60°C	–269 to 60°C	–30 to 120°C	–30 to 80°C	–50 to 100°C	–20 to 70°C	–50 to 200°C
Curing Requirements	Heat-melted & cured at normal temp.	Heat-melted & cured at normal temp.	Cured at normal temp.	Press-fitted	Press-fitted	24 h at normal temp.	Cured at normal temp.	Cured at normal temp.
Moisture & Water-proofness	◎	◎	◎	◎	○	△	○	△
Mechanical Protection	△	△	△	△	△	◎	△	△
Oil Resistance	△	△	△	△	△	○	△	△
Alcohol Resistance	○	○	○	○	○	○	○	○
Toluene Resistance	×	×	×	×	×	○	×	×
Alkalescent Resistance	○	○	○	○	○	○	△	△
Weak-acid Resistance	○	○	○	○	○	○	△	△
Contents	500 g	500 g	100 g	1 kg	38 mm×6 m	1.8 kg	1.5 kg	100 g
Materials	Paraffin wax	Microcrystalline wax	Butyl rubber	Butyl rubber + inorganic additive	Butyl rubber	Epoxy	Chloroprene rubber	Silicon
Color	White	White	Light yellow	Dark green	Black	Main agent: Light milk white Curing agent: Light yellow	Black	Milk white
Features	To be applied with a brush after heat melting. Suitable as an underlayer of multilayer coating.	Excellent cohesiveness makes it suitable for application to wall surfaces.	Minimal restriction in ultra-low temperature applications.	The clay-like shape ensures easy coating work.	The tape shape facilitates coating work.	Highly effective mechanical protection makes it suitable as an upper layer of multilayer coating.	Suitable as an final finish of multi-layer coating.	Highly heat-resistant coating agent.
Kyowa Models	C-1B	C-4	C-5	AK22	VMTAP	ARALDITE-C	HAMATITE Y-500-L	KE-4898W

◎: Excellent
○: Rather excellent
△: Rather inferior
×: Inferior

*When using, read the attached instruction manual carefully.

Accessories for High-temperature Gages

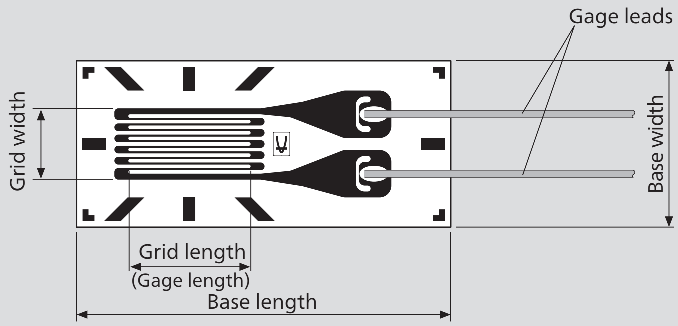
Accessories for high-temperatures gages.

●HTG Series Accessories for High-temperature Gages

Name	Models	Specifications	Qty
High-temperature solder	HTG-S-B	Fusion temperature: 309°C Maximum operating temperature: 300°C	40 cm long bar x 2
Flux for high-temperature solder	HTG-S-F	Ingredients: Inorganic acid + alcohol	20 g
Heat-resistant glass tube	HTG-G-TUBE	Inner diameter: 1.5 mm Length: 1 m	10 PC.
Heat-resistant teflon tape	HTG-T-TAPE	Heat resistance: 200°C Width: 12.7 mm	32.9 m long
Heat-resistant glass tape	HTG-G-TAPE	Heat resistance: 350°C Width: 25 mm	33 m long

*The heat resistance of 350°C for the heat-resistant glass tape is the specification for short-term operation.

Gages for General Stress Measurement KFGS

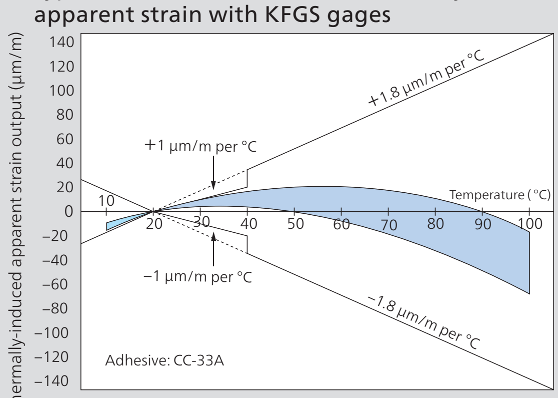


● Gage Factor		Approx. 2.1
● Applicable Linear Expansion Coefficients (x10^{-6}/°C)		5, 11, 16, 23, 27
● Self-temperature-compensation Range		10 to 100°C

Applicable Adhesives and Operating Temperature Ranges

CC-33A: –196 to 120°C
CC-35: –30 to 120°C
CC-36: –30 to 100°C
EP-340: –55 to 150°C
PC-600: –196 to 150°C

■Typical characteristic curve of thermally-induced apparent strain with KFGS gages



Strain gages with 3-wire cable attached

■General-purpose Foil Strain Gages

CE NEW

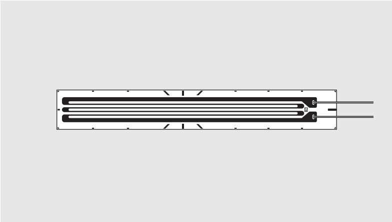
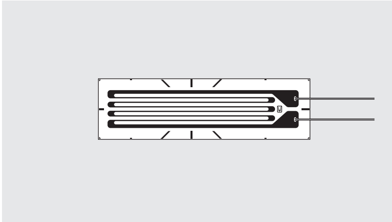
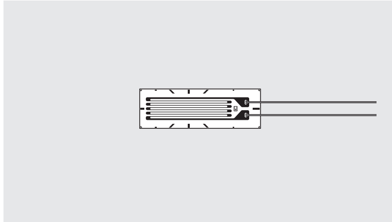
The KFGS series gages use polyimide resin for the base that is approx. 13 μm thick. It ensures excellent flexibility. The outstanding moisture proof enables the KFGS gages to operate effectively both indoors and outdoors. Unless directly exposed to water droplets, no coating treatment is required.

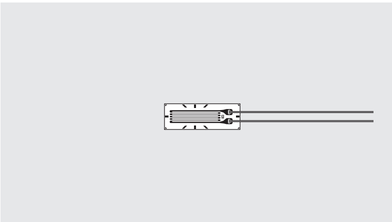
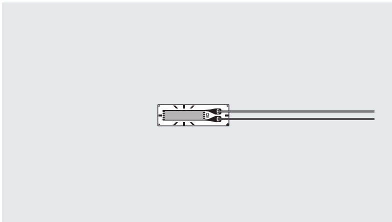
- Various lengths and patterns are available to cope with multiple applications.
- Excellent moisture resistance.
- The thin gage base provides less resiliency, and thus ensures excellent workability and easy bonding to curved surfaces.
- Compensated temperature range is as wide as 10 to 100°C and thermal effect in a range of 20 to 40°C is as small as ±1 μm/m/°C.
- Strain limit at room temperatures is approximately 5% and fatigue life is 1.2 x10^7 times (uniaxial gages), making them suitable for material tests.
- For gages with a 2-wire cable, the resistance and the gage factor are as stated including the lead-wire cables.
- For gages with a 3-wire cable, the gage factor is as stated including the lead-wire cables but the stated resistance does not include the effect of the lead-wire cables.

■Types, lengths and codes of lead-wire cables pre-attached to KFGS series gages

Type / Length	2 polyester-coated copper wires	3 polyester-coated copper wires	Vinyl-coated flat 2-wire cables		Vinyl-coated flat 3-wire cables		Mid-temperature 2-wire cables	Mid-temperature 3-wire cables
	C1,C2,C3,C15, C16,D1,D2,D3, D4,D6,D9,D16, D17,D19,D28, D31,D39	C1,C2,C3, C15,C16, D1,D4,D9, D16,D17,D19, D28,D39	C1,C2,C3, C15,C16, D9,D19	D1,D4, D16,D17, D28,D39	C1,C2,C3, C15,C16, D2,D9,D19, D31	D1,D4, D16,D17, D28,D39	C1,C2,C3,C15, C16,D1,D4,D9, D16,D17,D19, D28,D39	C1,C2,C3,C15, C16,D1,D2,D4, D9,D16,D17, D19,D28, D31,D39
15cm	N15C2	N15C3	L15C2R	L15C2S	L15C3R	L15C3S	R15C2	R15C3
30	N30C2	N30C3	L30C2R	L30C2S	L30C3R	L30C3S	R30C2	R30C3
1m	N1M2	N1M3	L1M2R	L1M2S	L1M3R	L1M3S	R1M2	R1M3
3			L3M2R	L3M2S	L3M3R	L3M3S	R3M2	R3M3
5			L5M2R	L5M2S	L5M3R	L5M3S	R5M2	R5M3
Operating temp.	–196 to 150°C		–10 to 80°C				–100 to 150°C	
Remarks	Twisted for ≥ 50 cm (There are exceptions.)		L-6 L-9 for ≥ 6 m		L-7 L-10 for ≥ 6 m		L-11	L-12

* For other lead-wire cables, please contact us.

			
Models	KFGS-30-120-C1- 11 16 23 27	KFGS-20-120-C1- 11 16 23 27	KFGS-10-120-C1- 11 16 23 27
Pattern	Uniaxial	Uniaxial	Uniaxial
Base	37 × 5.2 mm	28 × 8 mm	16 × 5.2 mm
Grid	30 × 3.3 mm	20 × 5 mm	10 × 3 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	10

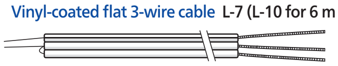
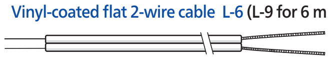
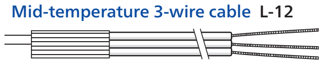
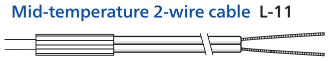
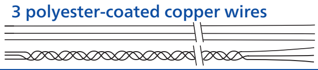
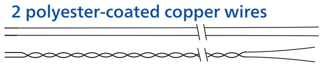
			
Models	KFGS-6-120-C1- 11 16 23 27	KFGS-5-120-C1- 5 11 16 23 27	KFGS-4N-120-C1- 11 16 23 27
Pattern	Uniaxial	Uniaxial	Uniaxial
Base	10 × 3.4 mm	9.4 × 2.8 mm	8 × 1.4 mm
Grid	6 × 1.7 mm	5 × 1.4 mm	4 × 0.7 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	10

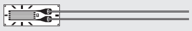
When ordering,
specify the model number as follows.

KFGS-□-120-C1-□ Lead-wire Cable Code

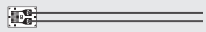
(e.g.)

KFGS-30-120-C1-11 L1M3R

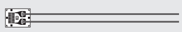
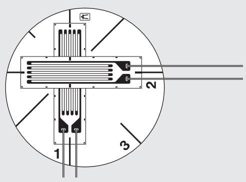
Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
Vinyl-coated flat 3-wire cable L-7 (L-10 for 6 m or longer) 	−10 to 80°C	1 m	L1M3R
		3 m	L3M3R
		5 m	L5M3R
Vinyl-coated flat 2-wire cable L-6 (L-9 for 6 m or longer) 	−10 to 80°C	1 m	L1M2R
		3 m	L3M2R
		5 m	L5M2R
Mid-temperature 3-wire cable L-12 	−100 to 150°C	1 m	R1M3
		3 m	R3M3
		5 m	R5M3
Mid-temperature 2-wire cable L-11 	−100 to 150°C	1 m	R1M2
		3 m	R3M2
		5 m	R5M2
3 polyester-coated copper wires  30 cm / 50 cm, 1 m	−196 to 150°C	30 cm	N30C3
		50 cm	N50C3
		1 m	N1M3
2 polyester-coated copper wires  30 cm / 50 cm, 1 m	−196 to 150°C	30 cm	N30C2
		50 cm	N50C2
		1 m	N1M2
Silver-covered copper wires 	−196 to 150°C	25 mm	

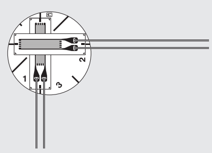



Models	KFGS-3-120-C1- 11 16 23 27	KFGS-2-120-C1- 5 11 16 23 27	KFGS-2N-120-C1- 11 16 23 27
Pattern	Uniaxial	Uniaxial	Uniaxial
Base	7.4 × 2.8 mm	6.3 × 2.8 mm	5.3 × 1.4 mm
Grid	3 × 1.3 mm	2 × 1.2 mm	2 × 0.84 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	10

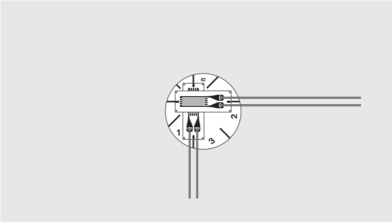
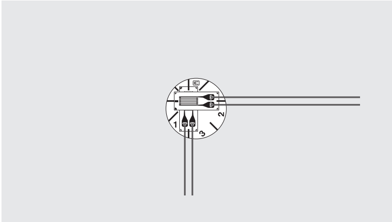
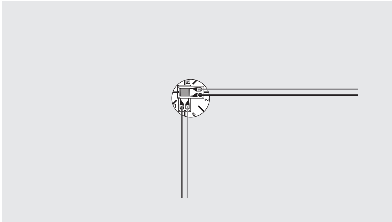


Models	KFGS-1-120-C1- 11 16 23 27	KFGS-1N-120-C1- 11 16 23 27	KFGS-03-120-C1- 11 16 23 27
Pattern	Uniaxial	Uniaxial	Uniaxial
Base	4.8 × 2.4 mm	4.2 × 1.4 mm	3.5 × 2.4 mm
Grid	1 × 1.1 mm	1 × 0.65 mm	0.3 × 1.4 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	10



Models	KFGS-02-120-C1- 11 16 23 27	KFGS-10-120-D16- 11 16 23 27	KFGS-5-120-D16- 11 16 23 27
Pattern	Uniaxial	Biaxial, 0°/90° stacked rosette	Biaxial, 0°/90° stacked rosette
Base	3.3 × 2.4 mm	ϕ21	ϕ11
Grid	0.2 × 1.4 mm	10 × 3 mm	5 × 1.4 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	10

			
Models	KFGS-3-120-D16- 11 16 23 27	KFGS-2-120-D16- 11 16 23 27	KFGS-1-120-D16- 11 16 23 27
Pattern	Biaxial, 0°/90° stacked rosette	Biaxial, 0°/90° stacked rosette	Biaxial, 0°/90° stacked rosette
Base	ϕ10	ϕ8	ϕ5
Grid	3 × 1.3 mm	2 × 1.2 mm	1 × 1.1 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	10

When ordering, specify the model number as follows.

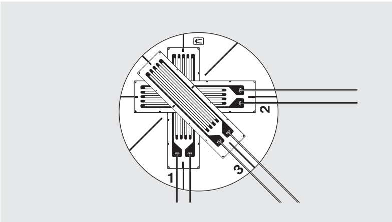
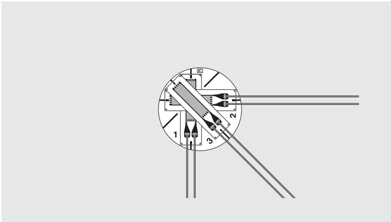
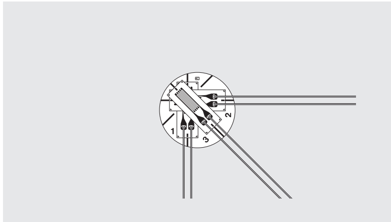
KFGS-□-120-□-□ Lead-wire Cable Code

(e.g.)

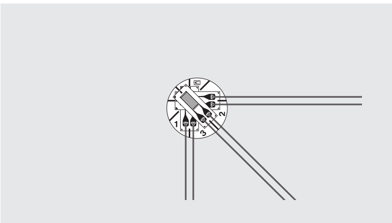
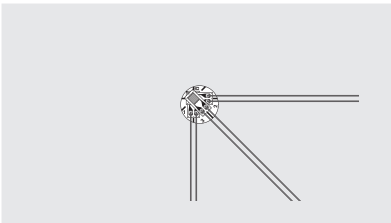
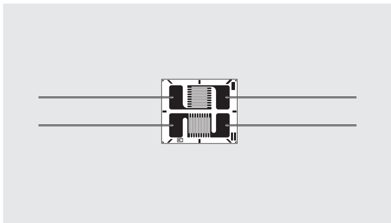
KFGS-1-120-D16-11 L1M3S

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
Vinyl-coated flat 3-wire cable L-7 (L-10 for 6 m or longer)	−10 to 80°C	1 m	L1M3R L1M3S
		3 m	L3M3R L3M3S
		5 m	L5M3R L5M3S
Vinyl-coated flat 2-wire cable L-6 (L-9 for 6 m or longer)	−10 to 80°C	1 m	L1M2R L1M2S
		3 m	L3M2R L3M2S
		5 m	L5M2R L5M2S
Mid-temperature 3-wire cable L-12	−100 to 150°C	1 m	R1M3
		3 m	R3M3
		5 m	R5M3
Mid-temperature 2-wire cable L-11	−100 to 150°C	1 m	R1M2
		3 m	R3M2
		5 m	R5M2
3 polyester-coated copper wires (30 cm; 50 cm, 1 m)	−196 to 150°C	30 cm	N30C3
		50 cm	N50C3
		1 m	N1M3
2 polyester-coated copper wires (30 cm; 50 cm, 1 m)	−196 to 150°C	30 cm	N30C2
		50 cm	N50C2
		1 m	N1M2
Silver-covered copper wires	−196 to 150°C	25 mm	

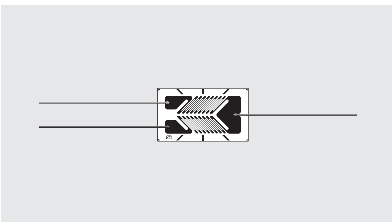
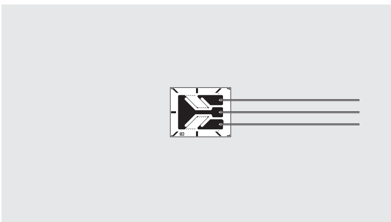
KFGS ●Triaxial, Biaxial, Biaxial for Torque Measurement

Models	KFGS-10-120-D17- 11 16 23 27	KFGS-5-120-D17- 11 16 23 27	KFGS-3-120-D17- 11 16 23 27
Pattern	Triaxial, 0°/90°/45° stacked rosette for stress analysis	Triaxial, 0°/90°/45° stacked rosette for stress analysis	Triaxial, 0°/90°/45° stacked rosette for stress analysis
Base	ϕ21	ϕ11	ϕ10
Grid	10 × 3 mm	5 × 1.4 mm	3 × 1.3 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	10

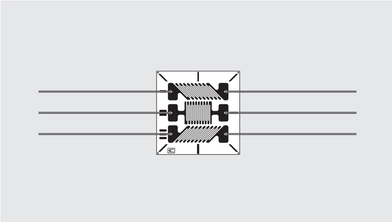
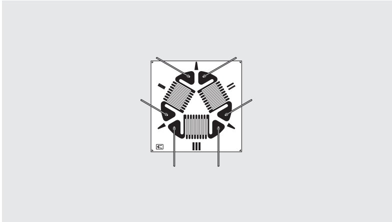
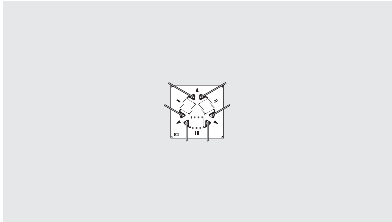




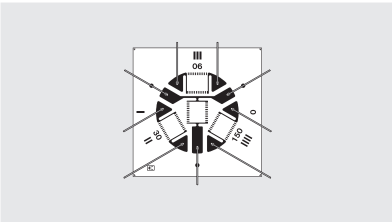
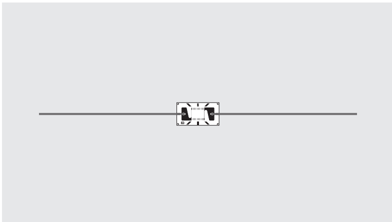
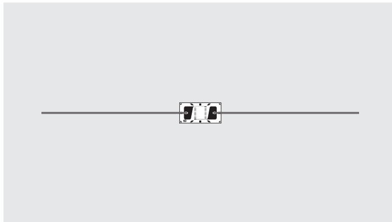
Models	KFGS-2-120-D17- 11 16 23 27	KFGS-1-120-D17- 11 16 23 27	KFGS-2-120-D1- 11 16 23 27
Pattern	Triaxial, 0°/90°/45° stacked rosette for stress analysis	Triaxial, 0°/90°/45° stacked rosette for stress analysis	Biaxial, 0°/90° plane arrangement
Base	ϕ8	ϕ5	10 × 8.5 mm
Grid	2 × 1.2 mm	1 × 1.1 mm	2 × 3.2 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	10

Models	KFGS-2-120-D2- 11 16 23 27	KFGS-2-120-D31- 11 16 23 27
Pattern	Biaxial, 0°/90° plane arrangement for torque measurement	Biaxial, 0°/90° plane arrangement for torque measurement
Base	12 × 7 mm	8 × 6.5 mm
Grid	2 × 3.4 mm	2 × 1.2 mm
Resistance	120 Ω	120 Ω
Pieces per Pack	10	10

KFGS ●Triaxial, Quadraxial, Uniaxial with gage leads at both ends

			
Models	KFGS-2-120-D3- 11 / 16 / 23 / 27	KFGS-2-120-D4- 11 / 16 / 23 / 27	KFGS-1-120-D4- 11 / 16 / 23 / 27
Pattern	Triaxial, 0°/90°/45° plane arrangement	Triaxial, 0°/120°/240° plane arrangement	Triaxial, 0°/120°/240° plane arrangement
Base	11 × 11 mm	12 × 12 mm	7 × 7 mm
Grid	2 × 3.6 mm	2 × 3.4 mm	1 × 1.7 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	10

			
Models	KFGS-2-120-D6- 11 / 16 / 23 / 27	KFGS-1-120-C2- 11 / 16 / 23 / 27	KFGS-1-120-C3- 11 / 16 / 23 / 27
Pattern	Quadraxial, 0°/30°/90°/150° plane arrangement	Uniaxial, gage leads at both ends	Uniaxial, gage leads at both ends
Base	17 × 17 mm	5.6 × 3 mm	5.5 × 2.7mm
Grid	2 × 3.1 mm	1 × 1.8 mm	1 × 1.8 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	10

When ordering, specify the model number as follows.

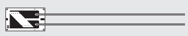
KFGS-□-120-□-□ Lead-wire Cable Code

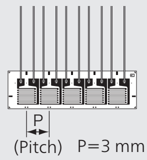
(e.g.)

KFGS-1-120-C3-11 L1M3R

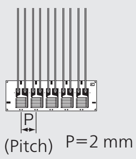
Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
Vinyl-coated flat 3-wire cable L-7 (L-10 for 6 m or longer)	−10 to 80°C	1 m	L1M3R L1M3S
		3 m	L3M3R L3M3S
		5 m	L5M3R L5M3S
Vinyl-coated flat 2-wire cable L-6 (L-9 for 6 m or longer)	−10 to 80°C	1 m	L1M2R L1M2S
		3 m	L3M2R L3M2S
		5 m	L5M2R L5M2S
Mid-temperature 3-wire cable L-12	−100 to 150°C	1 m	R1M3
		3 m	R3M3
		5 m	R5M3
Mid-temperature 2-wire cable L-11	−100 to 150°C	1 m	R1M2
		3 m	R3M2
		5 m	R5M2
3 polyester-coated copper wires (30 cm; 50 cm, 1 m)	−196 to 150°C	30 cm	N30C3
		50 cm	N50C3
		1 m	N1M3
2 polyester-coated copper wires (30 cm; 50 cm, 1 m)	−196 to 150°C	30 cm	N30C2
		50 cm	N50C2
		1 m	N1M2
Silver-covered copper wires	−196 to 150°C	25 mm	

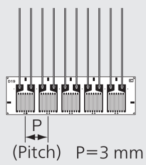
KFGS ●Uniaxial, Uniaxial for shearing strain, Uniaxial 5-element for concentrated stress, Biaxial 5-element

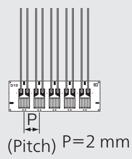




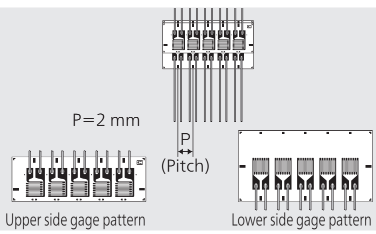
Models	KFGS-2-120-C15- 11 / 16 / 23 / 27 (Torque measurement possible in combination with C16)	KFGS-2-120-C16- 11 / 16 / 23 / 27 (Torque measurement possible in combination with C15)	KFGS-2-120-D9- 11 / 16 / 23 / 27 (Pre-attached type: 2 polyester-coated copper wires (10 cm) + the specified lead-wire cable)
Pattern	Uniaxial, for shearing strain measurement	Uniaxial, for shearing strain measurement	Uniaxial 5-element, for concentrated stress measurement
Base	5.2 × 3 mm	5.2 × 3mm	17 × 5 mm
Grid	2 × 0.8 mm	2 × 0.8 mm	2 × 2.2 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	5

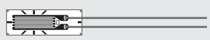


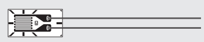




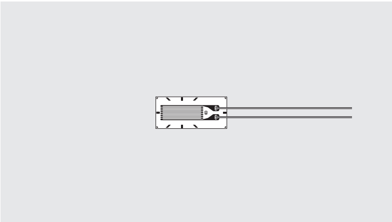
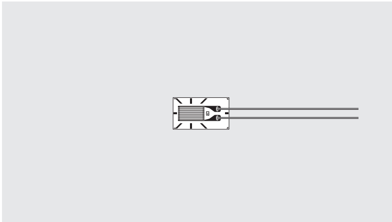
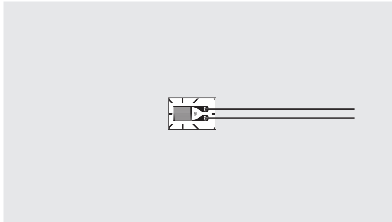
Models	KFGS-1-120-D9- 11 / 16 / 23 / 27 (Pre-attached type: 2 polyester-coated copper wires (10 cm) + the specified lead-wire cable)	KFGS-2-120-D19- 11 / 16 / 23 / 27 (Pre-attached type: 2 polyester-coated copper wires (10 cm) + the specified lead-wire cable)	KFGS-1-120-D19- 11 / 16 / 23 / 27 (Pre-attached type: 2 polyester-coated copper wires (10 cm) + the specified lead-wire cable)
Pattern	Uniaxial 5-element, stacked rosette for concentrated stress measurement	Uniaxial 5-element, for concentrated stress measurement	Uniaxial 5-element, for concentrated stress measurement
Base	12 × 4 mm	17 × 5 mm	12 × 4 mm
Grid	1 × 1.4 mm	2 × 2.5 mm	1 × 1.5 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	5	5	5



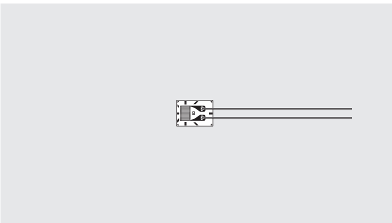




Models	KFGS-1-120-D39- 11 / 16 / 23 / 27 (Pre-attached type: 2 polyester-coated copper wires (10 cm) + the specified lead-wire cable)	KFGS-5-60-C1- 11 / 16 / 23 / 27 (Use 2 gages in series connection)	KFGS-2-60-C1- 11 / 16 / 23 / 27 (Use 2 gages in series connection)
Pattern	Biaxial 5-element, stacked rosette for concentrated stress measurement	Uniaxial	Uniaxial
Base	12 × 6.4 mm	10 × 3.4 mm	7.2 × 3.7 mm
Grid	1 × 1.4 (1.5) mm *( ) indicates lower side gage.	5 × 2 mm	2 × 2.3 mm
Resistance	120 Ω	60 Ω	60 Ω
Pieces per Pack	5	10	10

Models	KFGS-5-350-C1- 11 16 23 27	KFGS-3-350-C1- 11 16 23 27	KFGS-2-350-C1- 11 16 23 27
Pattern	Uniaxial	Uniaxial	Uniaxial
Base	9.4 × 4.2 mm	7.4 × 4.2 mm	6.3 × 4.2 mm
Grid	5 × 2 mm	3 × 2 mm	2 × 2 mm
Resistance	350 Ω	350 Ω	350 Ω
Pieces per Pack	10	10	10



Models	KFGS-1-350-C1- 11 16 23 27
Pattern	Uniaxial
Base	4.8 × 3.4 mm
Grid	1 × 2 mm
Resistance	350 Ω
Pieces per Pack	10

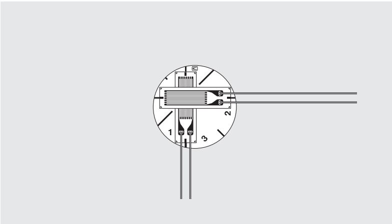
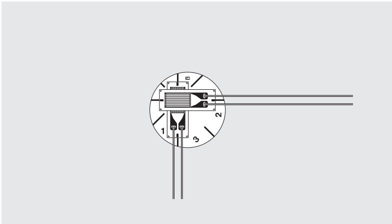
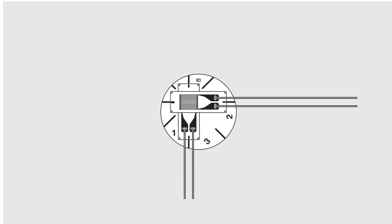
When ordering,
specify the model number as follows.

KFGS-□-350-□-□ Lead-wire Cable Code

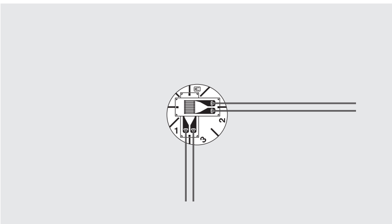
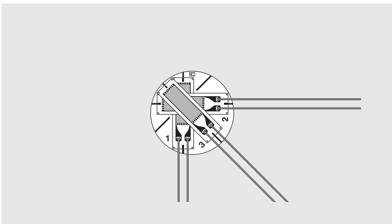
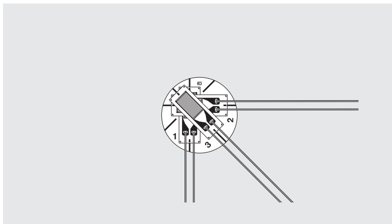
(e.g.)

KFGS-1-350-C1-11 L1M3R

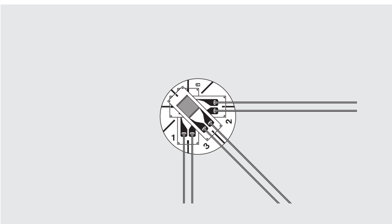
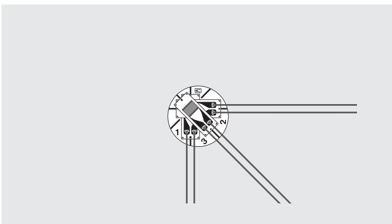
Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
Vinyl-coated flat 3-wire cable L-7 (L-10 for 6 m or longer)	−10 to 80°C	1 m	L1M3R
		3 m	L3M3R
		5 m	L5M3R
Vinyl-coated flat 2-wire cable L-6 (L-9 for 6 m or longer)	−10 to 80°C	1 m	L1M2R
		3 m	L3M2R
		5 m	L5M2R
Mid-temperature 3-wire cable L-12	−100 to 150°C	1 m	R1M3
		3 m	R3M3
		5 m	R5M3
Mid-temperature 2-wire cable L-11	−100 to 150°C	1 m	R1M2
		3 m	R3M2
		5 m	R5M2
3 polyester-coated copper wires (30 cm; 50 cm, 1 m)	−196 to 150°C	30 cm	N30C3
		50 cm	N50C3
		1 m	N1M3
2 polyester-coated copper wires (10 cm, 30 cm; 50 cm, 1 m)	−196 to 150°C	10 cm	N10C2
		30 cm	N30C2
		50 cm	N50C2
		1 m	N1M2
Silver-covered copper wires	−196 to 150°C	25 mm	

Models	KFGS-5-350-D16- 11 16 23 27	KFGS-3-350-D16- 11 16 23 27	KFGS-2-350-D16- 11 16 23 27
Pattern	Biaxial, 0°/90° stacked rosette	Biaxial, 0°/90° stacked rosette	Biaxial, 0°/90° stacked rosette
Base	ϕ11	ϕ10	ϕ10
Grid	5 × 2 mm	3 × 2 mm	2 × 2 mm
Resistance	350 Ω	350 Ω	350 Ω
Pieces per Pack	10	10	10

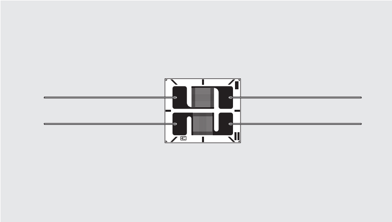
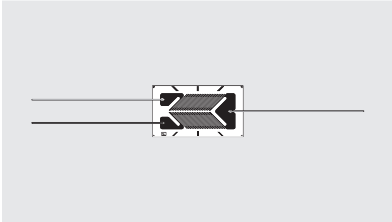
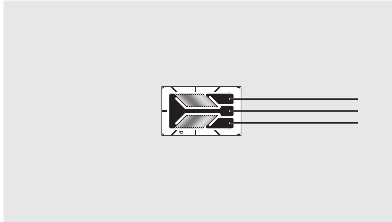




Models	KFGS-1-350-D16- 11 16 23 27	KFGS-5-350-D17- 11 16 23 27	KFGS-3-350-D17- 11 16 23 27
Pattern	Biaxial, 0°/90° stacked rosette	Triaxial, 0°/90°/45° stacked rosette for stress analysis	Triaxial, 0°/90°/45° stacked rosette for stress analysis
Base	ϕ8	ϕ11	ϕ10
Grid	1 × 1.8 mm	5 × 2 mm	3 × 2 mm
Resistance	350 Ω	350 Ω	350 Ω
Pieces per Pack	10	10	10

Models	KFGS-2-350-D17- 11 16 23 27	KFGS-1-350-D17- 11 16 23 27
Pattern	Triaxial, 0°/90°/45° stacked rosette for stress analysis	Triaxial, 0°/90°/45° stacked rosette for stress analysis
Base	ϕ10	ϕ8
Grid	2 × 2 mm	1 × 1.8 mm
Resistance	350 Ω	350 Ω
Pieces per Pack	10	10

KFGS ●Biaxial, Biaxial for torque measurement

			
Models	KFGS-2-350-D1- 11 / 16 / 23 / 27	KFGS-2-350-D2- 11 / 16 / 23 / 27	KFGS-2-350-D31- 11 / 16 / 23 / 27
Pattern	Biaxial, 0°/90° plane arrangement	Biaxial, 0°/90° plane arrangement for torque measurement	Biaxial, 0°/90° plane arrangement for torque measurement
Base	10 × 8.5 mm	12 × 6.8 mm	10.5 × 6.5 mm
Grid	2 × 3 mm	2 × 4 mm	2 × 3 mm
Resistance	350 Ω	350 Ω	350 Ω
Pieces per Pack	10	10	10

When ordering, specify the model number as follows.

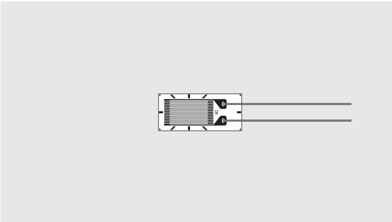
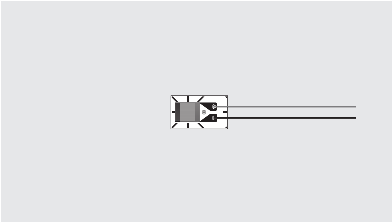
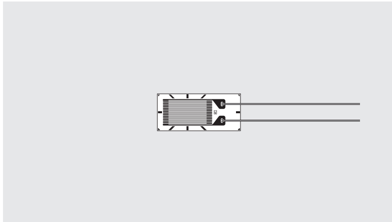
KFGS-□-350-□-□ Lead-wire Cable Code

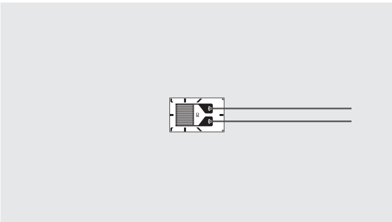
(e.g.)

KFGS-2-350-D31-11 L1M3S

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
Vinyl-coated flat 3-wire cable L-7 (L-10 for 6 m or longer)	−10 to 80°C	1 m	L1M3R / L1M3S
		3 m	L3M3R / L3M3S
		5 m	L5M3R / L5M3S
Vinyl-coated flat 2-wire cable L-6 (L-9 for 6 m or longer)	−10 to 80°C	1 m	L1M2R / L1M2S
		3 m	L3M2R / L3M2S
		5 m	L5M2R / L5M2S
Mid-temperature 3-wire cable L-12	−100 to 150°C	1 m	R1M3
		3 m	R3M3
		5 m	R5M3
Mid-temperature 2-wire cable L-11	−100 to 150°C	1 m	R1M2
		3 m	R3M2
		5 m	R5M2
3 polyester-coated copper wires (30 cm; 50 cm, 1 m)	−196 to 150°C	30 cm	N30C3
		50 cm	N50C3
		1 m	N1M3
2 polyester-coated copper wires (10 cm, 30 cm; 50 cm, 1 m)	−196 to 150°C	10 cm	N10C2
		30 cm	N30C2
		50 cm	N50C2
		1 m	N1M2
Silver-covered copper wires	−196 to 150°C	25 mm	

Strain Gages

			
Models	KFGS-5-500-C1- 11 16 23 27	KFGS-2-500-C1- 11 16 23 27	KFGS-5-1K-C1- 11 16 23 27
Pattern	Uniaxial, for transducers	Uniaxial, for transducers	Uniaxial, for transducers
Base	11 × 4.9 mm	7.5 × 4.4 mm	11 × 4.9 mm
Grid	5 × 3.5 mm	2 × 2.6 mm	5 × 3.5 mm
Resistance	500 Ω	500 Ω	1000 Ω
Pieces per Pack	10	10	10

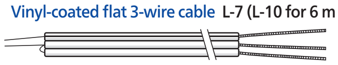
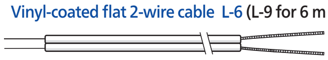
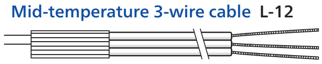
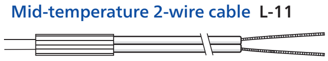
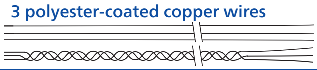
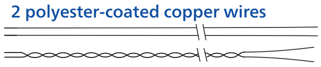
	
Models	KFGS-2-1K-C1- 11 16 23 27
Pattern	Uniaxial, for transducers
Base	7.2 × 4.5 mm
Grid	2 × 3 mm
Resistance	1000 Ω
Pieces per Pack	10

When ordering,
specify the model number as follows.

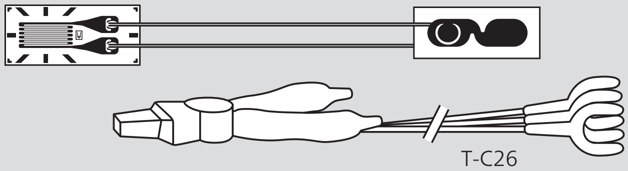
KFGS-□-□-C1-□ Lead-wire Cable Code

(e.g.)

KFGS-2-1K-C1-11 L1M3R

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
Vinyl-coated flat 3-wire cable L-7 (L-10 for 6 m or longer) 	−10 to 80°C	1 m	L1M3R
		3 m	L3M3R
		5 m	L5M3R
Vinyl-coated flat 2-wire cable L-6 (L-9 for 6 m or longer) 	−10 to 80°C	1 m	L1M2R
		3 m	L3M2R
		5 m	L5M2R
Mid-temperature 3-wire cable L-12 	−100 to 150°C	1 m	R1M3
		3 m	R3M3
		5 m	R5M3
Mid-temperature 2-wire cable L-11 	−100 to 150°C	1 m	R1M2
		3 m	R3M2
		5 m	R5M2
3 polyester-coated copper wires  30 cm 50 cm, 1 m	−196 to 150°C	30 cm	N30C3
		50 cm	N50C3
		1 m	N1M3
2 polyester-coated copper wires  30 cm 50 cm, 1 m	−196 to 150°C	30 cm	N30C2
		50 cm	N50C2
		1 m	N1M2
Silver-covered copper wires 	−196 to 150°C	25 mm	

Gages for Residual Stress Measurement KFGS



(When the clip-equipped dedicated cable is used, the operating temperature range of each adhesive after curing is –10 to 80°C.)

● Gage Factor	Approx. 2.1
● Applicable Linear Expansion Coefficients (x10⁻⁶/°C)	11, 16, 23
● Self-temperature-compensation Range	10 to 100°C

Applicable Adhesives and Operating Temperature Ranges

CC-33A: –196 to 120°C
CC-35: –30 to 120°C
CC-36: –30 to 100°C
EP-340: –55 to 120°C

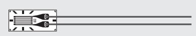
■Foil Strain Gages with Gage Terminal

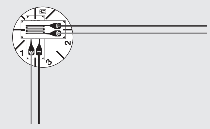
CE NEW

KFGS gages equipped with a gage terminal enable one-touch connection/disconnection of the lead-wire cable. They are suitable for residual stress measurement with the cutting method.
A clip-equipped dedicated cable T-C26 (Vinyl-coated, 2 m long) is optionally available.

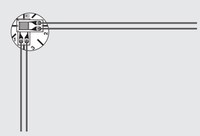
Lead-wire Cable Type and Shape	Oprg. Temp.	Length
Polyester-coated copper wires with gage terminal	–196 to 150°C	15 mm

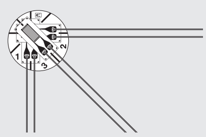
KFGS ●Uniaxial, Biaxial, Triaxial (With gage terminal)

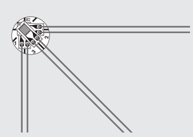




Models	KFGS-2-120-C1- 11 T-F7 16 23	KFGS-1-120-C1- 11 T-F7 16 23	KFGS-2-120-D16- 11 T-F7 16 23
Pattern	Uniaxial	Uniaxial	Biaxial, 0°/90° stacked rosette
Base	6.3 × 2.8 mm	4.8 × 2.4 mm	ϕ8
Grid	2 × 1.2 mm	1 × 1.1 mm	2 × 1.2 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	10







Models	KFGS-1-120-D16- 11 T-F7 16 23	KFGS-2-120-D17- 11 T-F7 16 23	KFGS-1-120-D17- 11 T-F7 16 23
Pattern	Biaxial, 0°/90° stacked rosette	Triaxial, 0°/90°/45° stacked rosette	Triaxial, 0°/90°/45° stacked rosette
Base	ϕ5	ϕ8	ϕ5
Grid	1 × 1.1 mm	2 × 1.2 mm	1 × 1.1 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	10

Gages for Residual Stress Measurement KFGS

● Gage Factor	Approx. 2.1
● Applicable Linear Expansion Coefficients (x10⁻⁶/°C)	11, 16, 23, 27
● Self-temperature-compensation Range	10 to 100°C

Applicable Adhesives and Operating Temperature Ranges

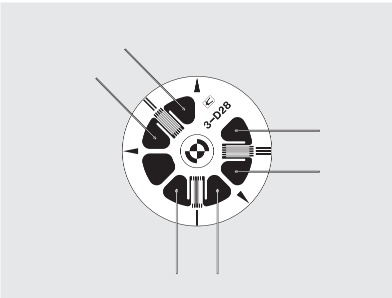
CC-33A: –196 to 120°C
CC-35: –30 to 120°C
CC-36: –30 to 100°C
EP-34B: –55 to 150°C
EP-340: –55 to 150°C
PC-600: –196 to 150°C

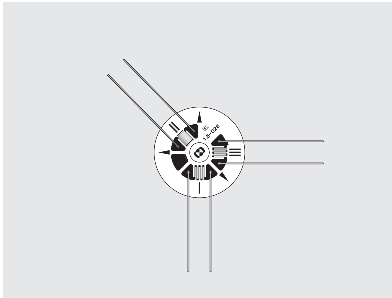
■Foil Strain Gages for Boring Method

CE NEW

Designed to measure residual stress released by the boring method.

KFGS ●Triaxial for boring method





Models	KFGS-3-120-D28- 11 / 16 / 23 / 27	KFGS-1.5-120-D28- 11 / 16 / 23 / 27
Pattern	Triaxial, 0°/135°/90° plane arrangement	Triaxial, 0°/135°/90° plane arrangement
Base	ϕ19.8	ϕ12
Grid	3 × 2 mm	1.5 × 1.3 mm
Resistance	120 Ω	120 Ω
Pieces per Pack	10	10
Gage Center Diameter	ϕ10.8	ϕ5.5

When ordering, specify the model number as follows.

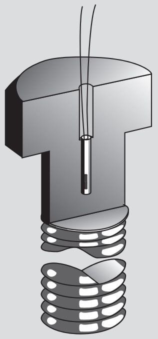
KFGS-□-120-D28-□ Lead-wire Cable Code

(e.g.)

KFGS-3-120-D28-11 L1M3S

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
Vinyl-coated flat 3-wire cable L-7 (L-10 for 6 m or longer)	–10 to 80°C	1 m	L1M3S
		3 m	L3M3S
		5 m	L5M3S
Vinyl-coated flat 2-wire cable L-6 (L-9 for 6 m or longer)	–10 to 80°C	1 m	L1M2S
		3 m	L3M2S
		5 m	L5M2S
Mid-temperature 3-wire cable L-12	–100 to 150°C	1 m	R1M3
		3 m	R3M3
		5 m	R5M3
Mid-temperature 2-wire cable L-11	–100 to 150°C	1 m	R1M2
		3 m	R3M2
		5 m	R5M2
2 polyester-coated copper wires (30 cm)	–196 to 150°C	5 cm	N5C2
		15 cm	N15C2
		30 cm	N30C2
Silver-covered copper wires	–196 to 150°C	25 mm	

Gages for Measuring Axial Tension of Bolt KFG



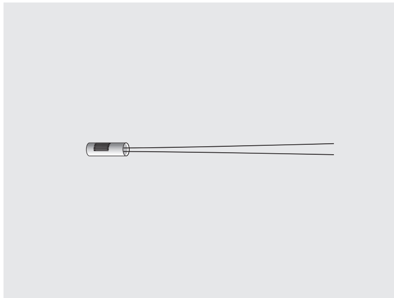
- Gage Factor: Approx. 1.9
- Applicable Linear Expansion Coefficients (x10⁻⁶/°C): 11

Applicable Adhesives and Operating Temperature Ranges
EP-370: Room temp. to 50°C

Foil Strain Gages for Measuring Axial Tension of Bolt

If it is difficult to bond a strain gage to the surface of a bolt for measuring the tightening stress, these gages enable measurement by embedding them into a hole, 2 mm diameter, bored through the top head of the bolt. They are applicable to materials having a linear expansion coefficient of 11 $x10^{-6}$/°C.

KFG ●Uniaxial



Models	KFG-3-120-C20-11	KFG-1.5-120-C20-11
Pattern	Uniaxial	Uniaxial
Base	11.5 × ϕ1.9 mm	5 × ϕ1.9 mm
Grid	3 × Approx. 6 mm	1.5 × Approx. 6 mm
Resistance	120 Ω	120 Ω
Pieces per Pack	5	5

When ordering, specify the model number as follows.

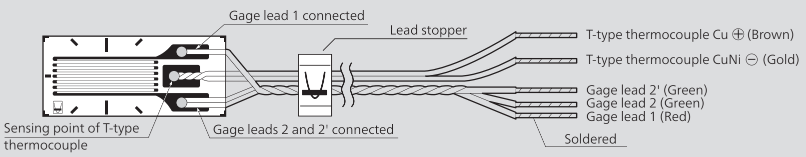
KFG-□-120-C20-11

(e.g.) KFG-3-120-C20-11

*We are able to mount and calibrate strain gages for measuring axial tension of bolts to your specified bolts.
For details, please contact Kyowa or our

Lead-wire Cable Type and Shape	Oprg. Temp.	Length
Polyester-coated copper wires (φ0.14) 5 cm long	Normal temp. to 50°C	5 cm

Gages for General Stress Measurement KFGT



■Foil Strain Gages with a Temperature Sensor

CE

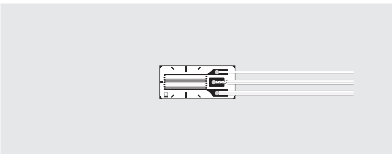
The KFGT gages are foil strain gages incorporating a T-type thermocouple for simultaneous measurement of strain and temperature. They ensure efficient strain measurement under environments where temperature change or temperature gradient requires simultaneous measurement of strain and temperature. They also provide highly precise compensation of thermally-induced apparent strain. It is recommended to use Kyowa data logger UCAM-60B and UCAM-65B as a measuring instrument.

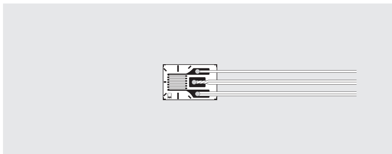
● Gage Factor	Approx. 2.1
● Applicable Linear Expansion Coefficients (x10^{-6}/°C)	11, 16, 23, 27
● Self-temperature-compensation Range	10 to 100°C
● Temperature Sensor	T-type thermocouple
● Accuracy	Within ±1.5 °C

Applicable Adhesives and Operating Temperature Ranges

CC-33A: −10 to 120°C
CC-35: −10 to 120°C
CC-36: −10 to 100°C
EP-340: −10 to 120°C

KFGT ●Uniaxial





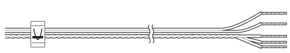
Models	KFGT-5-120-C1- 11 / 16 / 23 / 27	KFGT-2-120-C1- 11 / 16 / 23 / 27
Pattern	Uniaxial, 3 wires	Uniaxial, 3 wires
Base	10 × 4.5 mm	7 × 4.5 mm
Grid	5 × 2.1 mm	2 × 1.8 mm
Resistance	120 Ω	120 Ω
Pieces per Pack	5	5

When ordering, specify the model number as follows.

KFGT-□-120-C1-□ Lead-wire Cable Code

(e.g.)

KFGT-5-120-C1-11 N1M3

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
3 polyester-coated copper wires 	−10 to 120°C	1 m	N1M3

Standard accessories

Lead-wire stopper to prevent damage to the gage

Optional accessories

Extension Lead-wire cables

Model	Dimensions (mm)			Quantity per Pack	Remarks
	Length	Width	Thickness		
NT-1M	1000	7.2	1.2	5	With gage terminal T-F25
NT-2M	2000				
NT-4M	4000				

Gages for General Stress Measurement KFR

● Gage Factor	Approx. 1.9 to 2.1
● Applicable Linear Expansion Coefficients (x10^{-6}/°C)	11, 16, 23
● Self-temperature-compensation Range	0 to 150°C

Applicable Adhesives and Operating Temperature Ranges

CC-33A: –196 to 120°C
CC-35: –30 to 120°C
CC-36: –30 to 100°C
EP-340: –55 to 150°C
PC-600: –196 to 150°C

■Foil Strain Gages

The KFR series foil strain gages are durable and easy-to-use high-grade strain gages. The gage element is sandwiched between a heat-resistant polyimide base and cover, thereby letting it exhibit high performance in a wide temperature range.

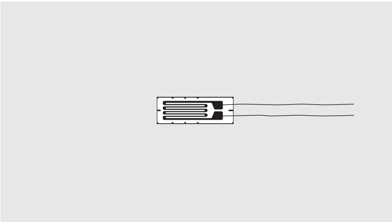
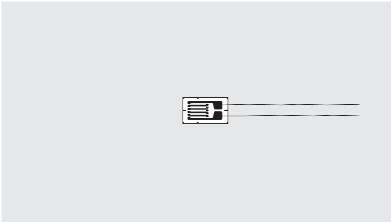
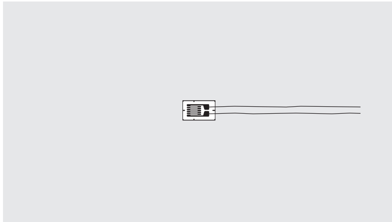
- Highly heat-resistant polyimide resin is used to make them durable.
- A wide compensated temperature range of 0 to 150°C makes them usable under diversified operating conditions.
- The resistive element is made of NiCr alloy foil, thereby ensuring minimal drift under high temperatures and excellent weather and moisture resistances.
- Suitable for incorporation into transducers

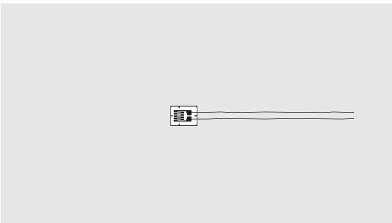
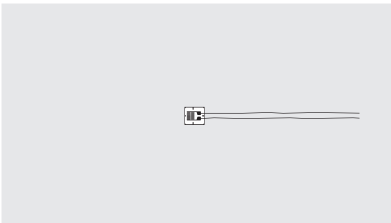
■Types, lengths and codes of lead-wire cables pre-attached to KFR gages

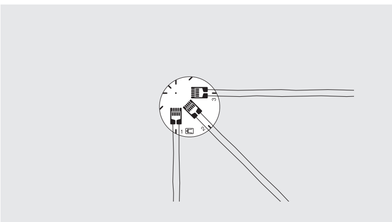
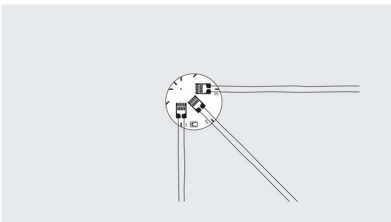
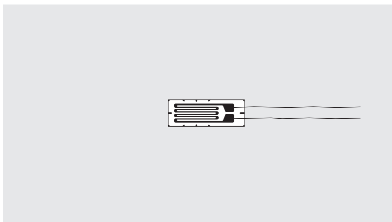
Type / Length	2 polyester-coated copper wires	3 polyester-coated copper wires*	Vinyl-coated flat 2-wire cable		Vinyl-coated flat 3-wire cable		Mid-temperature 2-wire cable	Mid-temperature 3-wire cable
	C1, D25	C1, D25	C1	D25	C1	D25	C1, D25	C1, D25
15cm	N15C2	N15C3	L15C2R	L15C2S	L15C3R	L15C3S	R15C2	R15C3
30	N30C2	N30C3	L30C2R	L30C2S	L30C3R	L30C3S	R30C2	R30C3
1m	N1M2	N1M3	L1M2R	L1M2S	L1M3R	L1M3S	R1M2	R1M3
3			L3M2R	L3M2S	L3M3R	L3M3S	R3M2	R3M3
5			L5M2R	L5M2S	L5M3R	L5M3S	R5M2	R5M3
Operating temp.	–196 to 150°C		–10 to 80°C				–100 to 150°C	
Remarks	Twisted for ≥ 50 (There are exceptions.)		L-6 L-9 for ≥ 6 m		L-7 L-10 for ≥ 6 m		L-11	L-12

* For the other types of lead-wire cables, please contact us.

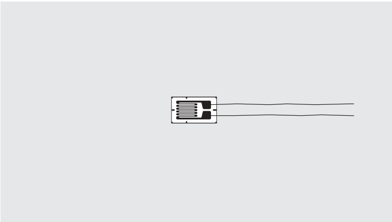
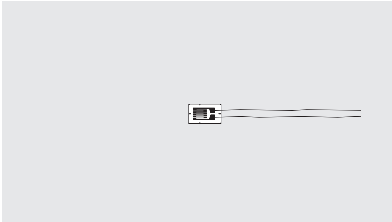
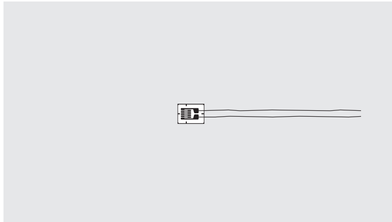
KFR ●Uniaxial, Triaxial

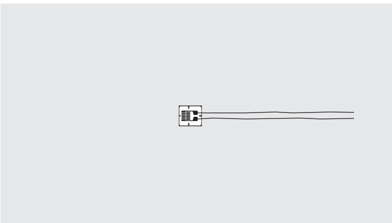
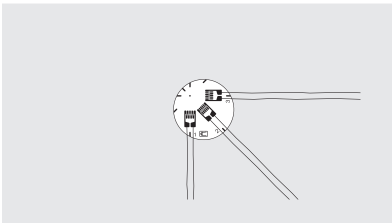
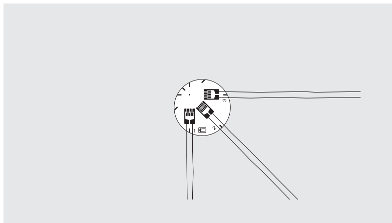
			
Models	KFR-5-120-C1- 11 16 23	KFR-2-120-C1- 11 16 23	KFR-1-120-C1- 11 16 23
Pattern	Uniaxial	Uniaxial	Uniaxial
Gage Factor	Approx. 2.1	Approx. 2.1	Approx. 2.1
Base	10 × 3.7 mm	6 × 3.7 mm	4 × 2.7 mm
Grid	5 × 2.5 mm	2 × 2.5 mm	1 × 1.5 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	10

			
Models	KFR-05-120-C1- 11 16 23	KFR-02-120-C1- 11 16 23	KFR-02N-120-C1- 11 16 23
Pattern	Uniaxial	Uniaxial	Uniaxial
Gage Factor	Approx. 2.1	Approx. 2.1	Approx. 1.9
Base	3.3 × 2.7 mm	2.5 × 2.2 mm	1.6 × 1.2 mm
Grid	0.5 × 1.4 mm	0.2 × 1 mm	0.2 × 0.9 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	10

			
Models	KFR-1-120-D25- 11 16 23	KFR-05-120-D25- 11 16 23	KFR-5-350-C1- 11 16 23
Pattern	Triaxial, 0°/90°/45°	Triaxial, 0°/90°/45°	Uniaxial
Gage Factor	Approx. 2.1	Approx. 2.1	Approx. 2.1
Base	ϕ8	ϕ7.5	10 × 3.7 mm
Grid	1 × 1.5 mm	0.5 × 1.4 mm	5 × 2.4 mm
Resistance	120 Ω	120 Ω	350 Ω
Pieces per Pack	5	5	10

KFR ●Uniaxial, Triaxial

			
Models	KFR-2-350-C1- 11 / 16 / 23	KFR-1-350-C1- 11 / 16 / 23	KFR-05-350-C1- 11 / 16 / 23
Pattern	Uniaxial	Uniaxial	Uniaxial
Base	6 × 3.7 mm	4 × 2.7 mm	3.5 × 2.7 mm
Grid	2 × 2.4 mm	1 × 1.5 mm	0.5 × 1.5 mm
Resistance	350 Ω	350 Ω	350 Ω
Pieces per Pack	10	10	10

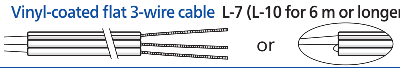
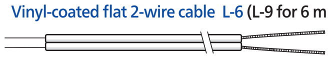
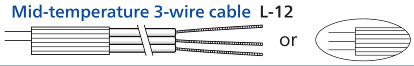
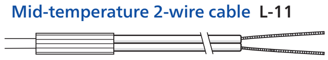
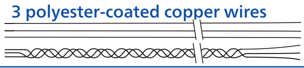
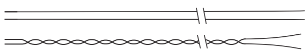
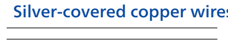
			
Models	KFR-02-350-C1- 11 / 16 / 23	KFR-1-350-D25- 11 / 16 / 23	KFR-05-350-D25- 11 / 16 / 23
Pattern	Uniaxial	Triaxial, 0°/90°/45°	Triaxial, 0°/90°/45°
Base	3 × 2.7 mm	ϕ8	ϕ7.5
Grid	0.2 × 1.5 mm	1 × 1.5 mm	0.5 × 1.5 mm
Resistance	350 Ω	350 Ω	350 Ω
Pieces per Pack	10	5	5

When ordering, specify the model number as follows.

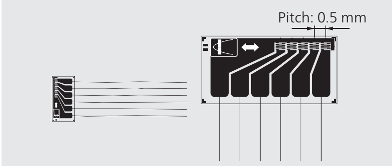
KFR-□-□-□-□ Lead-wire Cable Code

(e.g.)

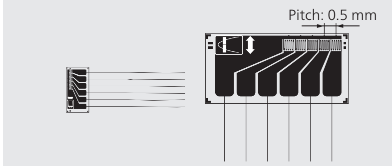
KFR-5-120-C1-11 L1M3R

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
Vinyl-coated flat 3-wire cable L-7 (L-10 for 6 m or longer)  or	−10 to 80°C	1 m	L1M3R¦L1M3S
		3 m	L3M3R¦L3M3S
		5 m	L5M3R¦L5M3S
Vinyl-coated flat 2-wire cable L-6 (L-9 for 6 m or longer) 	−10 to 80°C	1 m	L1M2R¦L1M2S
		3 m	L3M2R¦L3M2S
		5 m	L5M2R¦L5M2S
Mid-temperature 3-wire cable L-12  or	−100 to 150°C	1 m	R1M3
		3 m	R3M3
		5 m	R5M3
Mid-temperature 2-wire cable L-11 	−100 to 150°C	1 m	R1M2
		3 m	R3M2
		5 m	R5M2
3 polyester-coated copper wires  30 cm; 50 cm, 1 m	−196 to 150°C	30 cm	N30C3
		50 cm	N50C3
		1 m	N1M3
2 polyester-coated copper wires  10 cm, 30 cm; 50 cm, 1 m	−196 to 150°C	10 cm	N10C2
		30 cm	N30C2
		50 cm	N50C2
		1 m	N1M2
Silver-covered copper wires 	−196 to 150°C	25 mm	

●For concentrated stress measurement



With polyester-coated copper wires



With polyester-coated copper wires

Models	KFR-015-120-D9- 11 / 16 / 23	KFR-015-120-D19- 11 / 16 / 23
Pattern	Uniaxial 5-element, for concentrated stress measurement	Uniaxial 5-element, for concentrated stress measurement
Gage Factor	Approx. 1.95	Approx. 1.95
Base	6 × 3 mm	6 × 3 mm
Grid	0.15 × 0.34 mm	0.15 × 0.45 mm
Resistance	120 Ω	120 Ω
Pieces per Pack	5	5

When ordering, specify the model number as follows.

KFR-015-120-□ Lead-wire Cable Code

(e.g.)

KFR-015-120-D9 N10C2

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
2 polyester-coated copper wires 10 cm	−196 to 150°C	10 cm	N10C2

Waterproof Strain Gages KFWB

- **Gage Factor**: Approx. 2.1
- **Applicable Linear Expansion Coefficients** (x10^{-6}/°C): 11, 16, 23
- **Self-temperature-compensation Range**: 10 to 80°C

Applicable Adhesives and Operating Temperature Ranges
CC-33A: –10 to 80°C
CC-36: –10 to 80°C
EP-340: –10 to 80°C

■Waterproof Foil Strain Gages

CE NEW

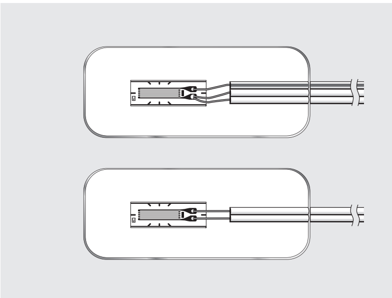
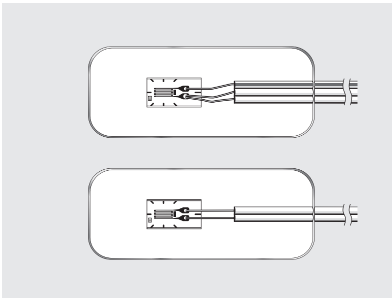
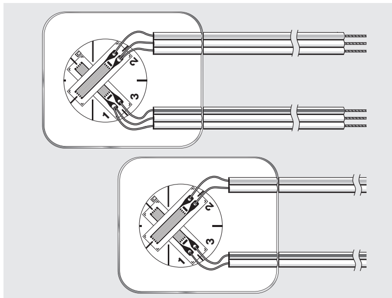
The surface of the KFWB series foil strain gage is covered with a special waterproof resin. The waterproof structure enables these gages to serve for outdoor or underwater measurement merely by being bonded to measuring objects. (The insulation resistance shows virtually no deterioration even after 100 hours of use under an underwater pressure of approximately 10 MPa.) In addition, the covering resin is flexible enough to enable easy bonding to curved surfaces.

■Types, lengths and codes of lead-wire cables pre-attached to KFWB series gages

Type / Length	Vinyl-coated flat 2-wire cable		Vinyl-coated flat 3-wire cable	
	C1	D16, D17	C1	D16, D17
15cm	L15C2R	L15C2S	L15C3R	L15C3S
30	L30C2R	L30C2S	L30C3R	L30C3S
1m	L1M2R	L1M2S	L1M3R	L1M3S
3	L3M2R	L3M2S	L3M3R	L3M3S
5	L5M2R	L5M2S	L5M3R	L5M3S
Operating temp.	–10 to 80°C			
Remarks	L-6 L-9 for ≥ 6 m		L-7 L-10 for ≥ 6 m	

*For the other lead-wire cables, please contact us.

KFWB ●Uniaxial, Biaxial

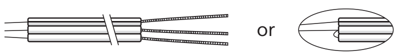
Models	KFWB-5-120-C1- 11 16 23	KFWB-2-120-C1- 11 16 23	KFWB-5-120-D16- 11 16 23
Pattern	Uniaxial	Uniaxial	Biaxial, 0°/90° stacked rosette
Base	30 × 12 mm	30 × 12 mm	21 × 18 mm
Grid	5 × 1.4 mm	2 × 1.2 mm	5 × 1.4 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	5

When ordering, specify the model number as follows.

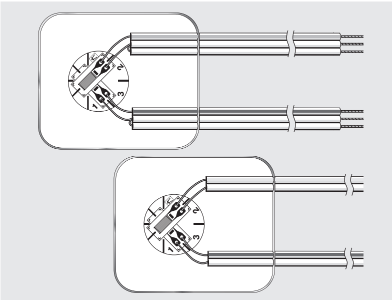
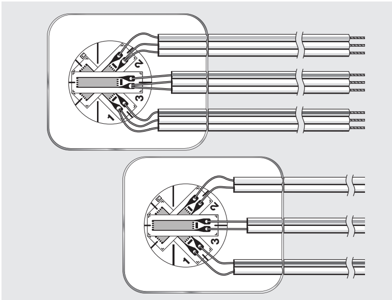
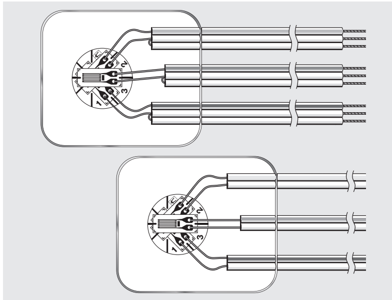
KFWB-□-120-□-□ Lead-wire Cable Code

(e.g.)

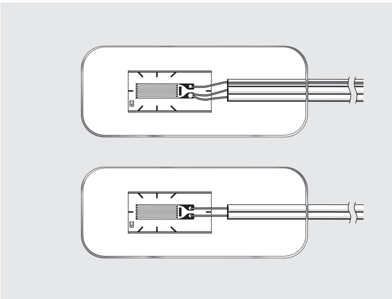
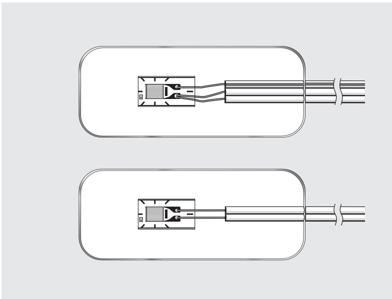
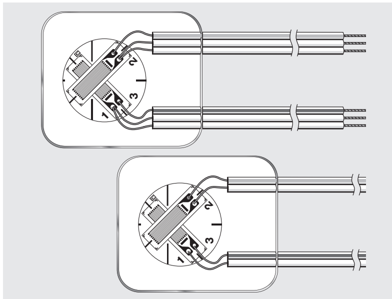
KFWB-5-120-C1-11 L1M3R

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
Vinyl-coated flat 3-wire cable L-7 (L-10 for 6 m or longer)  or	–10 to 80°C	1 m	L1M3R L1M3S
		3 m	L3M3R L3M3S
		5 m	L5M3R L5M3S
Vinyl-coated flat 2-wire cable L-6 (L-9 for 6 m or longer) 	–10 to 80°C	1 m	L1M2R L1M2S
		3 m	L3M2R L3M2S
		5 m	L5M2R L5M2S

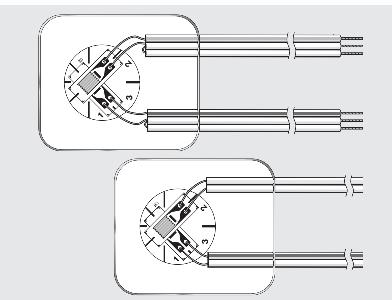
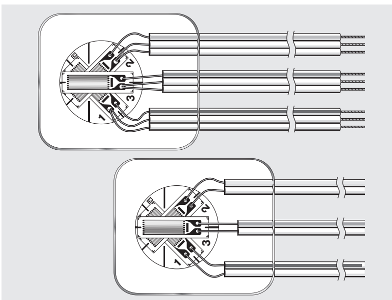
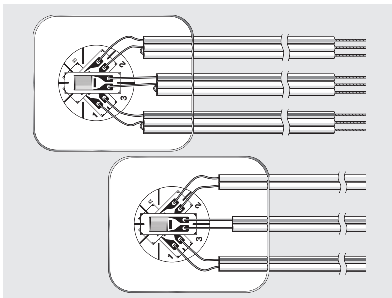
KFWB ●Uniaxial, Biaxial, Triaxial

Models	KFWB-2-120-D16- 11 16 23	KFWB-5-120-D17- 11 16 23	KFWB-2-120-D17- 11 16 23
Pattern	Biaxial, 0°/90° stacked rosette	Triaxial, 0°/45°/90° stacked rosette	Triaxial, 0°/45°/90° stacked rosette
Base	21 × 18 mm	21 × 18 mm	21 × 18 mm
Grid	2 × 1.2 mm	5 × 1.4 mm	2 × 1.2 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	5	5	5

Models	KFWB-5-350-C1- 11 16 23	KFWB-2-350-C1- 11 16 23	KFWB-5-350-D16- 11 16 23
Pattern	Uniaxial	Uniaxial	Biaxial, 0°/90° stacked rosette
Base	30 × 12 mm	30 × 12 mm	21 × 18 mm
Grid	5 × 2 mm	2 × 2 mm	5 × 2 mm
Resistance	350 Ω	350 Ω	350 Ω
Pieces per Pack	10	10	5

Models	KFWB-2-350-D16- 11 16 23	KFWB-5-350-D17- 11 16 23	KFWB-2-350-D17- 11 16 23
Pattern	Biaxial, 0°/90° stacked rosette	Triaxial, 0°/45°/90° stacked rosette	Triaxial, 0°/45°/90° stacked rosette
Base	21 × 18 mm	21 × 18 mm	21 × 18 mm
Grid	2 × 2 mm	5 × 2 mm	2 × 2 mm
Resistance	350 Ω	350 Ω	350 Ω
Pieces per Pack	5	5	5

Waterproof Strain Gages KFWS

- Gage Factor: Approx. 2.1
- Applicable Linear Expansion Coefficients (x10⁻⁶/°C): 11, 16, 23
- Self-temperature-compensation Range: 10 to 80°C

Applicable Adhesives and Operating Temperature Ranges
CC-33A: –10 to 80°C
CC-36: –10 to 80°C

■Small-sized Waterproof Foil Strain Gages

CE

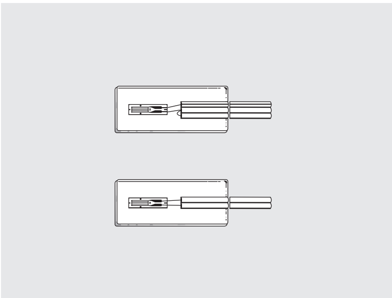
The KFWS series foil strain gages are small-sized waterproof gages suitable for outdoor or underwater strain measurement where gage bonding space is limited.
The waterproof resin is as thin as 1.3 mm, making them flexible enough to be bonded to a curved surface of 10 mm diameter.

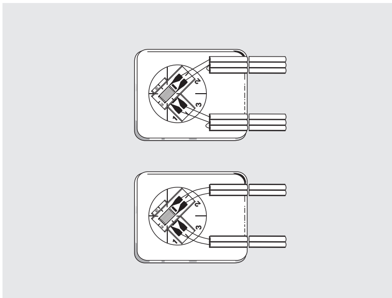
■Types, lengths and codes of lead-wire cables pre-attached to KFWS series gages

Type / Length	Vinyl-coated flat 2-wire cable		Vinyl-coated flat 3-wire cable	
	C1	D16	C1	D16
15cm	L15C2R	L15C2S	L15C3R	L15C3S
30	L30C2R	L30C2S	L30C3R	L30C3S
1m	L1M2R	L1M2S	L1M3R	L1M3S
3	L3M2R	L3M2S	L3M3R	L3M3S
5	L5M2R	L5M2S	L5M3R	L5M3S
Operating temp.	–10 to 80°C			
Remarks	L-6 L-9 for ≥ 6 m		L-7 L-10 for ≥ 6 m	

* For the other lead-wire cables, please contact us.

KFWS ●Uniaxial, Biaxial





Models	KFWS-2N-120-C1- 11 16 23	KFWS-2-120-D16- 11 16 23
Pattern	Uniaxial	Biaxial, 0°/90° stacked rosette
Base	15 × 6 mm	15 × 12 mm
Grid	2 × 0.84 mm	2 × 1.2 mm
Resistance	120 Ω	120 Ω
Pieces per Pack	10	10

When ordering, specify the model number as follows.

KFWS-□-120-□-□ Lead-wire Cable Code

(e.g.)

KFWS-2N-120-C1-11 L1M3R

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code	
Vinyl-coated flat 3-wire cable L-7 (L-10 for 6 m or longer) 	–10 to 80°C	1 m	L1M3R	L1M3S
		3 m	L3M3R	L3M3S
		5 m	L5M3R	L5M3S
Vinyl-coated flat 2-wire cable L-6 (L-9 for 6 m or longer) 	–10 to 80°C	1 m	L1M2R	L1M2S
		3 m	L3M2R	L3M2S
		5 m	L5M2R	L5M2S

Waterproof Strain Gages KCW

● Gage Factor	Approx. 2.2
● Applicable Linear Expansion Coefficients (x10⁻⁶/°C)	11
● Self-temperature-compensation Range	10 to 90°C
● Flange Size	21×5×0.1mm

Bonding Methods and Operating Temperature Ranges
Spot welding: –20 to 100°C

■Weldable Waterproof Foil Strain Gages

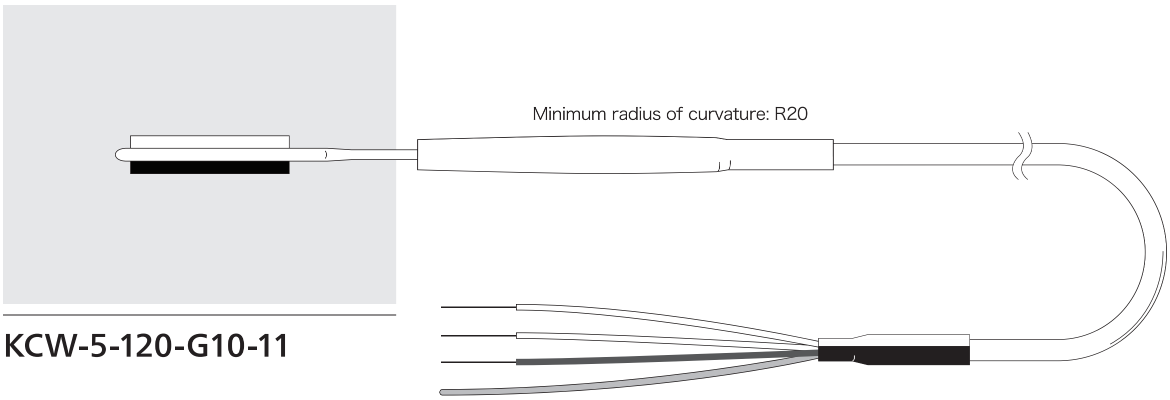
The KCW series foil strain gages are weldable gages, which do not require any coating treatment for use under high pressure or under water.
The G10 type endures a water pressure of approximately 10 MPa.

■Types, lengths and codes of lead-wire cables pre-attached to KCW gages

Type / Length	Chloroprene-coated 3-wire cable
	G10
15cm	G15C3S
30	G30C3S
1m	G1M3S
3	G3M3S
5	G5M3S
Operating temp.	–20 to 100°C

* For the other lead-wire cables, please contact us.

KCW ●Uniaxial



Models	KCW-5-120-G10-11
Pattern	Uniaxial
Base	21 × 5 mm
Grid	5 mm
Resistance	120 Ω
Pieces per Pack	2

When ordering, specify the model number as follows.

KCW-5-120-G10-11 Lead-wire Cable Code

(e.g.)

KCW-5-120-G10-11 G1M3S

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
Chloroprene-coated 3-wire cable Minimum radius of curvature: R20	–20 to 100°C	1 m	G1M3S
		3 m	G3M3S
		5 m	G5M3S

Strain Gages for Concrete KFGS

● Gage Factor	Approx. 2.1
● Applicable Linear Expansion Coefficients (x10⁻⁶/°C)	11
● Self-temperature-compensation Range	0 to 100°C

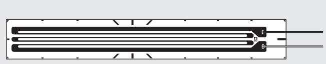
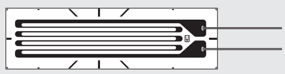
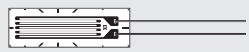
Applicable Adhesives and Operating Temperature Ranges
CC-35: –10 to 80°C

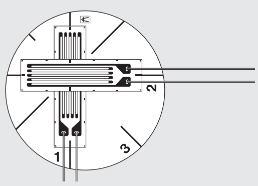
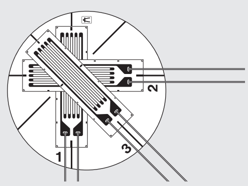
■General-purpose Foil Strain Gages

CE NEW

Listed here are the KFGS series gages with a suitable lead-wire cable for strain measurement of concrete.
*For the types and lengths of the lead-wire cables, refer to page 23.

KFGS ●Uniaxial, Biaxial, Triaxial

			
Models	KFGS-30-120-C1-11	KFGS-20-120-C1-11	KFGS-10-120-C1-11
Pattern	Uniaxial	Uniaxial	Uniaxial
Base	37 × 5.2 mm	28 × 8 mm	16 × 5.2 mm
Grid	30 × 3.3 mm	20 × 5 mm	10 × 3 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	10

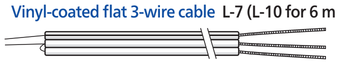
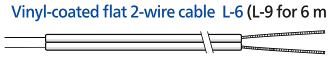
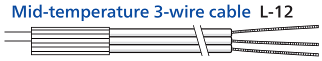
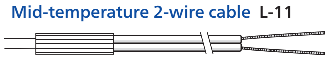
		
Models	KFGS-10-120-D16-11	KFGS-10-120-D17-11
Pattern	Biaxial, 0°/90° stacked rosette	Triaxial, 0°/90°/45° stacked rosette for stress analysis
Base	ϕ21	ϕ21
Grid	10 × 3 mm	10 × 3 mm
Resistance	120 Ω	120 Ω
Pieces per Pack	10	10

When ordering, specify the model number as follows.

KFGS-□-120-□-11 Lead-wire Cable Code

(e.g.)

KFGS-30-120-C1-11 L1M3R

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
Vinyl-coated flat 3-wire cable L-7 (L-10 for 6 m or longer) 	–10 to 80°C	1 m	L1M3R / L1M3S
		3 m	L3M3R / L3M3S
		5 m	L5M3R / L5M3S
Vinyl-coated flat 2-wire cable L-6 (L-9 for 6 m or longer) 	–10 to 80°C	1 m	L1M2R / L1M2S
		3 m	L3M2R / L3M2S
		5 m	L5M2R / L5M2S
Mid-temperature 3-wire cable L-12 	–100 to 150°C	1 m	R1M3
		3 m	R3M3
		5 m	R5M3
Mid-temperature 2-wire cable L-11 	–100 to 150°C	1 m	R1M2
		3 m	R3M2
		5 m	R5M2

Strain Gages for Concrete

KC

● Gage Factor	Approx. 2.1
● Applicable Linear Expansion Coefficients (x10⁻⁶/°C)	11
● Self-temperature-compensation Range	10 to 60°C

Applicable Adhesives and Operating Temperature Ranges

CC-35: –30 to 120°C

■Wire Strain Gages

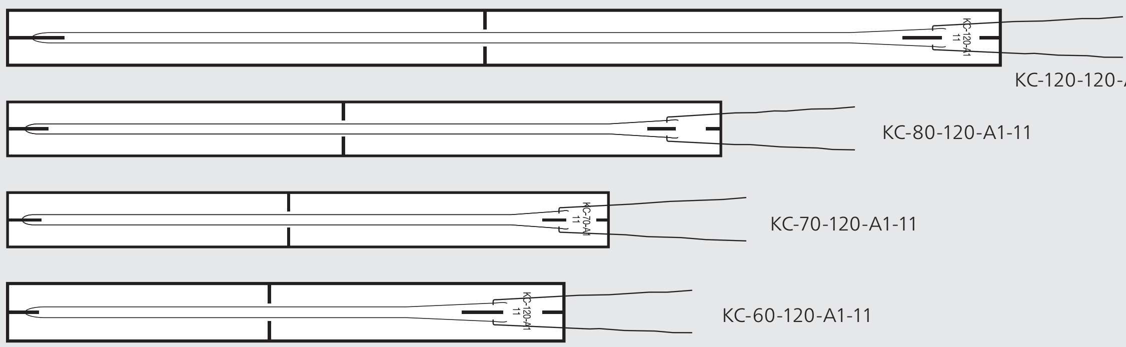
Featuring a longer gage length, the KC series gages are wire strain gages suitable for mean strain measurement of concrete under test. Usually, a model with a gage length over 3 times longer than the maximum diameter of the aggregate is selected for the purpose.

■Types, lengths and codes of lead-wire cables pre-attached to KC series gages

Type / Length	Vinyl-coated flat 2-wire cable	Vinyl-coated flat 3-wire cable
	A1	
15cm	L15C2R	L15C3R
30	L30C2R	L30C3R
1m	L1M2R	L1M3R
3	L3M2R	L3M3R
5	L5M2R	L5M3R
Operating temp.	–10 to 80°C	
Remarks	L-6 L-9 for ≥ 6 m	L-7 L-10 for ≥ 6 m

* For the other lead-wire cables, please contact us.

KC ●Uniaxial



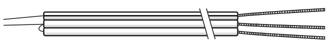
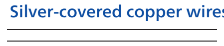
Models	KC-120-120-A1-11	KC-80-120-A1-11	KC-70-120-A1-11	KC-60-120-A1-11
Pattern	Uniaxial	Uniaxial	Uniaxial	Uniaxial
Base	132 × 6mm	95 × 8 mm	80 × 7.5 mm	74 × 8 mm
Grid	120 × 0.6 mm	84 × 0.6 mm	67 × 0.6 mm	60 × 0.6 mm
Resistance	120 Ω	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	10	10

When ordering, specify the model number as follows.

KC-□-120-A1-11 Lead-wire Cable Code

(e.g.)

KC-120-120-A1-11 L1M3R

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
Vinyl-coated flat 3-wire cable L-7 (L-10 for 6 m or longer) 	–10 to 80°C	1 m	L1M3R
		3 m	L3M3R
		5 m	L5M3R
Vinyl-coated flat 2-wire cable L-6 (L-9 for 6 m or longer) 	–10 to 80°C	1 m	L1M2R
		3 m	L3M2R
		5 m	L5M2R
Silver-covered copper wires 	–196 to 150°C	25 mm	

Strain Gages for Concrete KM

● Gage Factor	Approx. 1.8, 2.0
● Applicable Linear Expansion Coefficients (x10⁻⁶/°C)	11
● Self-temperature-compensation Range	0 to 50°C

Operating Temperature Ranges
–10 to 70°C

■Embedded Strain Gages

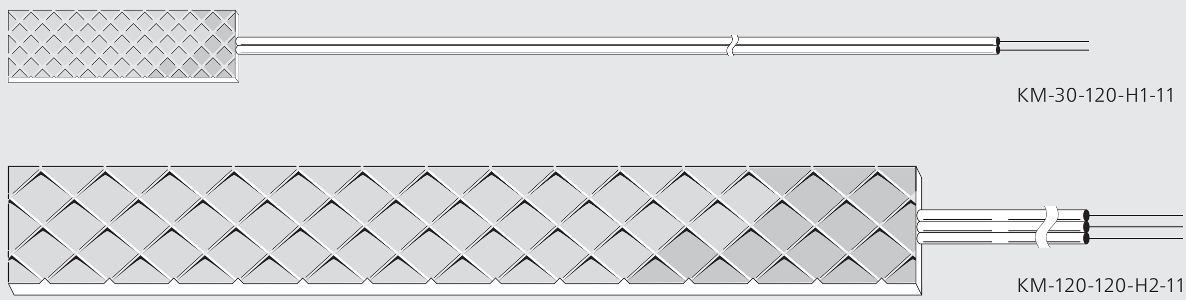
The KM series gages are designed to be embedded in mortar or concrete for the purpose of measuring internal stress.
To ensure better adhesion to mortar or the like, the KM series gages feature a specially treated surface. They also provide suitable waterproofness and elastic modulus for the intended purpose.

■Types, lengths and codes of lead-wire cables pre-attached to KM gages

Type / Length	KM-30 Vinyl-coated flat 2-wire cable	KM-120 Vinyl-coated flat 3-wire cable
	H1	H2
1m	Y1M2	W1M3
3	Y3M2	W3M3
5	Y5M2	W5M3
Operating temp.	–10 to 70°C	

* For the other lead-wire cables, please contact us.

KM ●Uniaxial



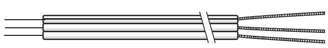
Models	KM-30-120-H1-11	KM-120-120-H2-11
Pattern	Uniaxial, foil strain gage with vinyl-coated flat 2-wire cable	Uniaxial, wire strain gage with vinyl-coated flat 3-wire cable
Gage Factor	Approx. 1.8	Approx. 2.0
Base	30 × 9 × 3 mm	120 × 15 × 5 mm
Grid	10 mm	70 mm
Resistance	120 Ω	120 Ω
Pieces per Pack	1	1

When ordering, specify the model number as follows.

KM-□-120-□-11 Lead-wire Cable Code

(e.g.)

KM-30-120-H1-11 Y1M2

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
Vinyl-coated flat 2-wire cable 	–10 to 70°C	1 m	Y1M2
		3 m	Y3M2
		5 m	Y5M2
Vinyl-coated flat 3-wire cable 	–10 to 70°C	1 m	W1M3
		3 m	W3M3
		5 m	W5M3

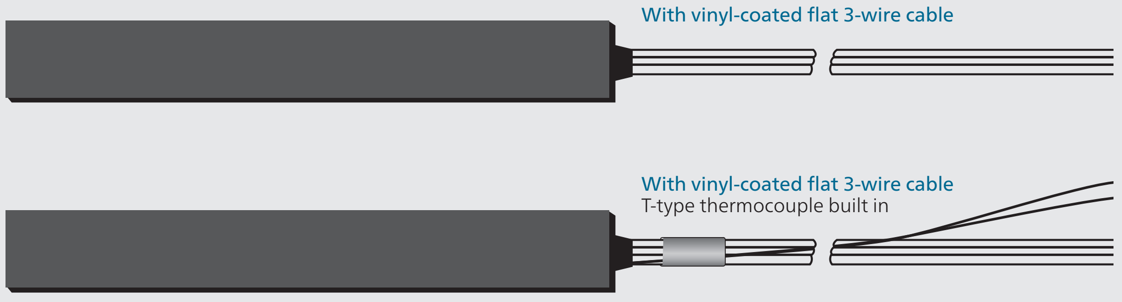
Strain Gages for Concrete KMC

Operating Temperature Ranges
Room temperature to 70°C

■Concrete-embedded Strain Gages

The KMC series gages are designed to measure self-shrinkage and self-stress of cemented materials. They enable measurement of high-strength and high-fluidity concrete immediately after placing. They are also used effectively to check for cracks of cemented materials.
Usually, a T-type thermocouple is installed near the gage, but the KMC series H4-type gages do not require such installation since they are equipped with a built-in thermocouple.

KMC ●Uniaxial



Models	KMC-70-120-H3	KMC-70-120-H4
Pattern	Uniaxial, wire strain gage with vinyl-coated flat 3-wire cable 3 m long	Uniaxial, wire strain gage with vinyl-coated flat 3-wire cable 3 m long
Base	80 × 10 × 2 mm	80 × 10 × 2 mm
Grid	67 mm	67 mm
Resistance	120 Ω	120 Ω
Built-in Thermocouple	—	T
Pieces per Pack	1	1

When ordering, specify the model number as follows.

KMC-70-120-H□ Lead-wire Cable Code

(e.g.)

KMC-70-120-H3

Strain Gages for Composite Materials and Plastics KFRP

● Gage Factor	Approx. 2.1
● Applicable Linear Expansion Coefficients (x10^{-6}/°C)	1, 3, 6, 9
● Self-temperature-compensation Range	0 to 150°C

Applicable Adhesives and Operating Temperature Ranges

CC-33A: –196 to 120°C
CC-35: –30 to 120°C
CC-36: –30 to 100°C
EP-34B: –55 to 200°C
EP-340: –55 to 150°C

■Foil Strain Gages for Composite Materials

CE

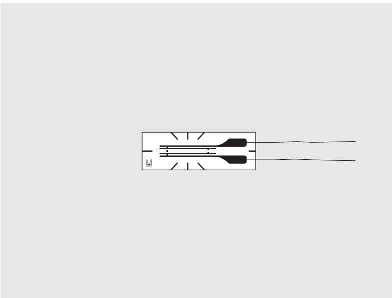
The KFRP series foil strain gages are self-temperature-compensation gages (SELCOM gages) suitable for strain measurement of composite materials such as CFRP and GFRP. The special gage pattern minimizes both the effect of self-heating due to gage current and the effect of reinforcement of low-elasticity materials.

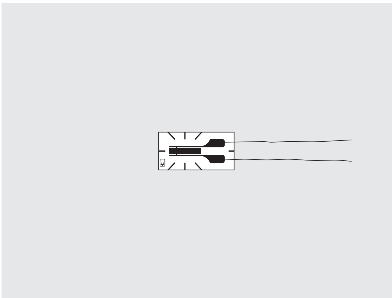
■Types, lengths and codes of lead-wire cables pre-attached to KFRP gages

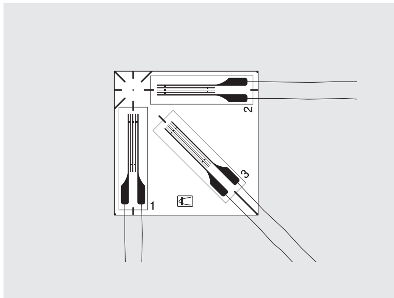
Type / Length	2 polyester-coated copper wires	3 polyester-coated copper wires	Vinyl-coated flat 2-wire cable		Vinyl-coated flat 3-wire cable		Mid-temperature 2-wire cable	Mid-temperature 3-wire cable	Fluoroplastic coated high/low-temp. 3-wire cable
	C1, D22	C1, D22	C1	D22	C1	D22	C1, D22	C1, D22	C1, D22
15cm	N15C2	N15C3	L15C2R	L15C2S	L15C3R	L15C3S	R15C2	R15C3	F15C3
30	N30C2	N30C3	L30C2R	L30C2S	L30C3R	L30C3S	R30C2	R30C3	F30C3
1m	N1M2	N1M3	L1M2R	L1M2S	L1M3R	L1M3S	R1M2	R1M3	F1M3
3			L3M2R	L3M2S	L3M3R	L3M3S	R3M2	R3M3	F3M3
5			L5M2R	L5M2S	L5M3R	L5M3S	R5M2	R5M3	F5M3
Operating temp.	–196 to 150°C		–10 to 80°C				–100 to 150°C		–196 to 200°C
Remarks	Twisted for≥50 cm		L-6 L-9 for ≥ 6 m		L-7 L-10 for ≥ 6 m		L-11	L-12	L-3

* For the other lead-wire cables, please contact us.を追記

KFRP ●Uniaxial, Triaxial

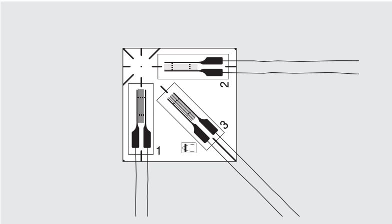
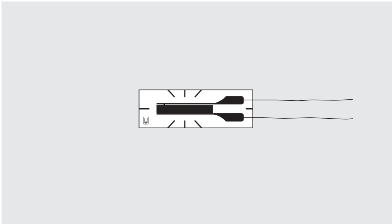
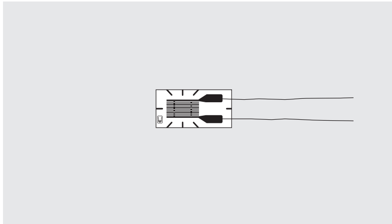


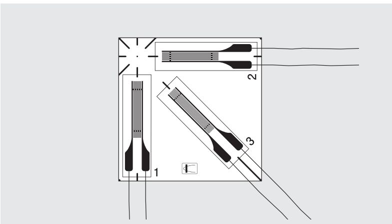
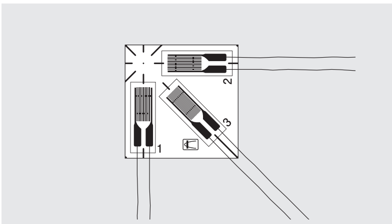




Models	KFRP-5-120-C1- 1 3 6 9	KFRP-2-120-C1- 1 3 6 9	KFRP-5-120-D22- 1 3 6 9
Pattern	Uniaxial	Uniaxial	Triaxial, 0°/90°/45°
Base	15 × 5 mm	10 × 5 mm	19 × 19 mm
Grid	5 × 1.4 mm	2 × 1.2 mm	5 × 1.4 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	10

KFRP ●Uniaxial, Triaxial

			
Models	KFRP-2-120-D22- 1 3 6 9	KFRP-5-350-C1- 1 3 6 9	KFRP-2-350-C1- 1 3 6 9
Pattern	Triaxial, 0°/90°/45° plane arrangement	Uniaxial	Uniaxial
Base	15 × 15 mm	15 × 5 mm	10 × 5 mm
Grid	2 × 1.2 mm	5 × 1.5 mm	2 × 2.2 mm
Resistance	120 Ω	350 Ω	350 Ω
Pieces per Pack	10	10	10

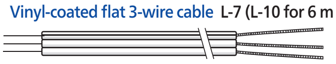
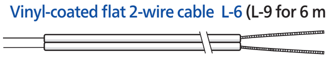
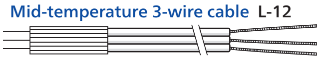
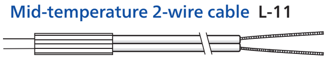
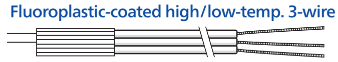
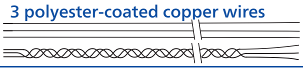
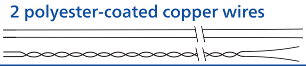
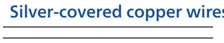
		
Models	KFRP-5-350-D22- 1 3 6 9	KFRP-2-350-D22- 1 3 6 9
Pattern	Triaxial, 0°/90°/45° plane arrangement	Triaxial, 0°/90°/45° plane arrangement
Base	19 × 19 mm	15 × 15 mm
Grid	5 × 1.5 mm	2 × 2.2 mm
Resistance	350 Ω	350 Ω
Pieces per Pack	10	10

When ordering,
specify the model number as follows.

KFRP-□-□-□-□ Lead-wire Cable Code

(e.g.)

KFRP-5-120-C1-1 L1M3R

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
Vinyl-coated flat 3-wire cable L-7 (L-10 for 6 m or longer) 	−10 to 80°C	1 m	L1M3R L1M3S
		3 m	L3M3R L3M3S
		5 m	L5M3R L5M3S
Vinyl-coated flat 2-wire cable L-6 (L-9 for 6 m or longer) 	−10 to 80°C	1 m	L1M2R L1M2S
		3 m	L3M2R L3M2S
		5 m	L5M2R L5M2S
Mid-temperature 3-wire cable L-12 	−100 to 150°C	1 m	R1M3
		3 m	R3M3
		5 m	R5M3
Mid-temperature 2-wire cable L-11 	−100 to 150°C	1 m	R1M2
		3 m	R3M2
		5 m	R5M2
Fluoroplastic-coated high/low-temp. 3-wire cable L-3 	−196 to 200°C	1 m	F1M3
		3 m	F3M3
		5 m	F5M3
3 polyester-coated copper wires  30 cm / 50 cm, 1 m	−196 to 150°C	30 cm	N30C3
		50 cm	N50C3
		1 m	N1M3
2 polyester-coated copper wires  30 cm / 50 cm, 1 m	−196 to 150°C	30 cm	N30C2
		50 cm	N50C2
		1 m	N1M2
Silver-covered copper wires 	−196 to 200°C	25 mm	

Strain Gages for Printed Boards KFRS

CE

● Gage Factor	Approx. 2.0
● Applicable Linear Expansion Coefficients (x10^{-6}/°C)	13
● Self-temperature-compensation Range	–30 to 120°C

Applicable Adhesives and Operating Temperature Ranges

CC-33A: –196 to 120°C
CC-36: –30 to 100°C
PC-600: –196 to 150°C

■Foil Strain Gages for Printed Boards

PCB are used for varieties of products including cellular phones, car navigation systems and digital cameras. To evaluate the mechanical and thermal characteristics of these PCB, the KFRS gages were developed by integrating the advantageous features of KFG and KFR gages.

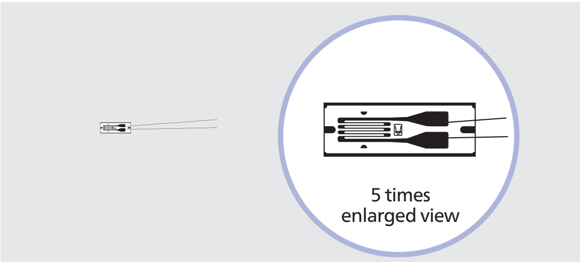
- ●Dimensions of gage base (bondable space to mounted components and narrow parts) 1.2 mm long by 1.1 mm wide (uniaxial), 2.5 mm long by 2.5 mm wide (biaxial or triaxial)
- ●Linear expansion coeffcient of 13 x 10^{-6}/°C, suitable for component-mounted boards
- ●Self-temperature-compensation range expanded to –30 to 120°C to satisfy thermal cyclic tests of PCB.

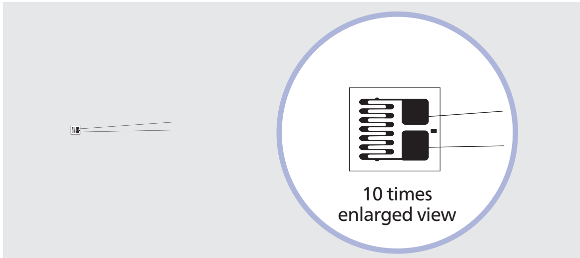
■Types, lengths and codes of lead-wire cables pre-attached to KFRS gages

Type / Length	2 polyester-coated copper wires	3 polyester-coated copper wires	Vinyl-coated flat 2-wire cable		Vinyl-coated flat 3-wire cable		Mid-temperature 2-wire cable	Mid-temperature 3-wire cable
	C1, D34, D35	C1, D34, D35	C1	D34, D35	C1	D34, D35	C1, D34, D35	C1, D34, D35
10cm	N10C2	N10C3						
30	N30C2	N30C3	L30C2R	L30C2S	L30C3R	L30C3S	L30C2	R30C3
1m	N1M2	N1M3	L1M2R	L1M2S	L1M3R	L1M3S	R1M2	R1M3
3			L3M2R	L3M2S	L3M3R	L3M3S	R3M2	R3M3
5			L5M2R	L5M2S	L5M3R	L5M3S	R5M2	R5M3
Operating temp.	–196 to 150°C		–10 to 80°C				–100 to 150°C	
Remarks	Twisted for ≥ 50 cm		L-6		L-7		L-11	L-12

* For the other lead-wire cables, please contact us.

KFRS ●Uniaxial





Models	KFRS-1-120-C1-13	KFRS-02-120-C1-13
Pattern	Uniaxial	Uniaxial
Base	4 × 1.4 mm	1.2 × 1.1 mm
Grid	1 × 0.65 mm	0.2 × 0.8 mm
Resistance	120 Ω	120 Ω
Pieces per Pack	10	10

When ordering, specify the model number as follows.

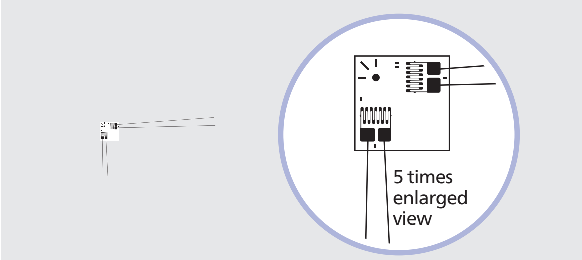
KFRS-□-120-C1-13□ Lead-wire Cable Code

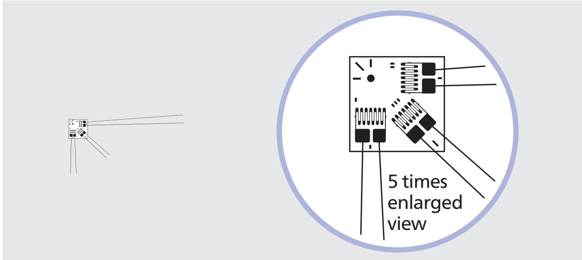
(e.g.)

KFRS-1-120-C1-13 L1M3R

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
Vinyl-coated flat 3-wire cable L-7 (L-10 for 6 m or longer)	–10 to 80℃	1 m	L1M3R¦L1M3S
		3 m	L3M3R¦L3M3S
		5 m	L5M3R¦L5M3S
Vinyl-coated flat 2-wire cable L-6 (L-9 for 6 m or longer)	–10 to 80℃	1 m	L1M2R¦L1M2S
		3 m	L3M2R¦L3M2S
		5 m	L5M2R¦L5M2S
Mid-temperature 3-wire cable L-12	–100 to 150℃	1 m	R1M3
		3 m	R3M3
		5 m	R5M3
Mid-temperature 2-wire cable L-11	–100 to 150℃	1 m	R1M2
		3 m	R3M2
		5 m	R5M2
3 polyester-coated copper wires	–196 to 150℃	10 cm	N10C3
		30 cm	N30C3
2 polyester-coated copper wires	–196 to 150℃	10 cm	N10C2
		30 cm	N30C2
Silver-covered copper wires	–196 to 150℃	25 mm	

KFRS ●Biaxial, Triaxial





Models	KFRS-02-120-D34-13	KFRS-02-120-D35-13
Pattern	Biaxial, 0°/90° plane arrangement	Triaxial, 0°/90°/45° plane arrangement
Base	2.5 × 2.5 mm	2.5 × 2.5 mm
Grid	0.2 × 0.8 mm	0.2 × 0.8 mm
Resistance	120 Ω	120 Ω
Pieces per Pack	5	5

When ordering, specify the model number as follows.

KFRS-02-120-□-13 Lead-wire Cable Code

(e.g.)

KFRS-02-120-D35-13 L1M3R

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
Vinyl-coated flat 3-wire cable L-7 (L-10 for 6 m or longer) 	−10 to 80°C	1 m	L1M3R / L1M3S
		3 m	L3M3R / L3M3S
		5 m	L5M3R / L5M3S
Vinyl-coated flat 2-wire cable L-6 (L-9 for 6 m or longer) 	−10 to 80°C	1 m	L1M2R / L1M2S
		3 m	L3M2R / L3M2S
		5 m	L5M2R / L5M2S
Mid-temperature 3-wire cable L-12 	−100 to 150°C	1 m	R1M3
		3 m	R3M3
		5 m	R5M3
Mid-temperature 2-wire cable L-11 	−100 to 150°C	1 m	R1M2
		3 m	R3M2
		5 m	R5M2
3 polyester-coated copper wires 	−196 to 200°C	10 cm	N10C3
		30 cm	N30C3
2 polyester-coated copper wires 	−196 to 200°C	10 cm	N10C2
		30 cm	N30C2

Strain Gages for Plastics

KFP

● Gage Factor	Approx. 2.1
● Applicable Linear Expansion Coefficients (x10^{-6}/°C)	65
● Self-temperature-compensation Range	10 to 80°C

Applicable Adhesives and Operating Temperature Ranges

CC-33A: –20 to 80°C
CC-35: –20 to 80°C
CC-36: –20 to 80°C
EP-34B: –20 to 80°C

■ Foil Strain Gages for Plastics

CE

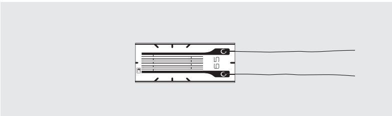
The KFP series foil strain gages provide an applicable linear expansion coeffcient of 65 x 10^{-6}/°C, which makes them suitable for strain measurement of plastics such as acrylic resin.

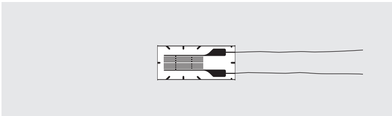
■ Types, lengths and codes of lead-wire cables pre-attached to KFP gages

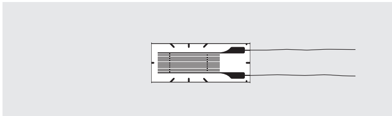
Type / Length	2 polyester-coated copper wires	3 polyester-coated copper wires	Vinyl-coated flat 2-wire cable	Vinyl-coated flat 3-wire cable
	C1			
15cm	N15C2	N15C3	L15C2R	L15C3R
30	N30C2	N30C3	L30C2R	L30C3R
1m	N1M2	N1M3	L1M2R	L1M3R
3			L3M2R	L3M3R
5			L5M2R	L5M3R
Operating temp.	–20 to 80°C		–10 to 80°C	
Remarks	Twisted for ≥ 50 cm		L-6 L-9 for ≥ 6 m	L-7 L-10 for ≥ 6 m

* For the other lead-wire cables, please contact us.

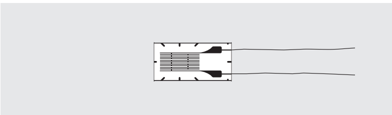
KFP ●Uniaxial







Models	KFP-5-120-C1-65	KFP-2-120-C1-65	KFP-5-350-C1-65
Pattern	Uniaxial	Uniaxial	Uniaxial
Base	13 × 5.2 mm	10 × 4.7 mm	13 × 5.2 mm
Grid	5 × 2.5 mm	2 × 2 mm	5 × 2.6 mm
Resistance	120 Ω	120 Ω	350 Ω
Pieces per Pack	10	10	10



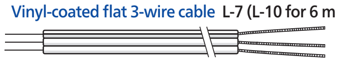
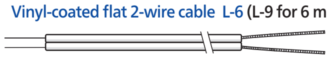
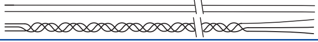
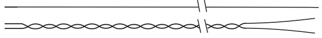
Models	KFP-2-350-C1-65
Pattern	Uniaxial
Base	10 × 5.2 mm
Grid	2 × 2.4 mm
Resistance	350 Ω
Pieces per Pack	10

When ordering, specify the model number as follows.

KFP-□-□-C1-65□ Lead-wire Cable Code

(e.g.)

KFP-5-120-C1-65 L1M3R

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
Vinyl-coated flat 3-wire cable L-7 (L-10 for 6 m or longer) 	–10 to 80°C	1 m	L1M3R
		3 m	L3M3R
		5 m	L5M3R
Vinyl-coated flat 2-wire cable L-6 (L-9 for 6 m or longer) 	–10 to 80°C	1 m	L1M2R
		3 m	L3M2R
		5 m	L5M2R
3 polyester-coated copper wires (30 cm; 50 cm, 1 m) 	–20 to 80°C	30 cm	N30C3
		50 cm	N50C3
		1 m	N1M3
2 polyester-coated copper wires (30 cm; 50 cm, 1 m) 	–20 to 80°C	30 cm	N30C2
		50 cm	N50C2
		1 m	N1M2
Silver-covered copper wires	–20 to 80°C	25 mm	

Strain Gages for Ultra-small Strain Measurements KSPB

● Gage Factor	Approx. 125, 160, 235
● Applicable Linear Expansion Coefficients (x10⁻⁶/°C)	11.7*
● Self-temperature-compensation Range	20 to 70°C*

*KSPB-3-120-F2-11only

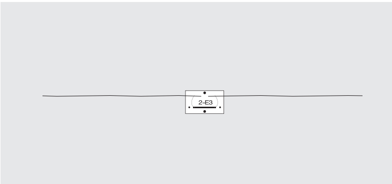
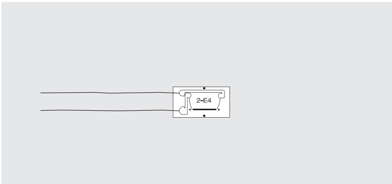
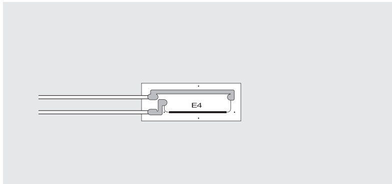
Applicable Adhesives and Operating Temperature Ranges
CC-33A: –50 to 120°C
EP-340: –50 to 150°C

■Semiconductor Strain Gages

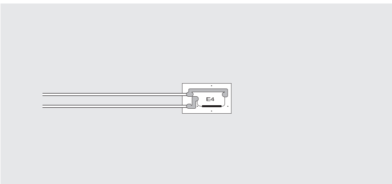
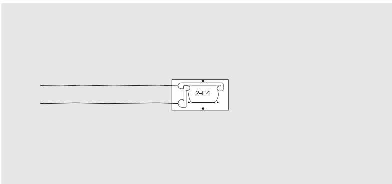
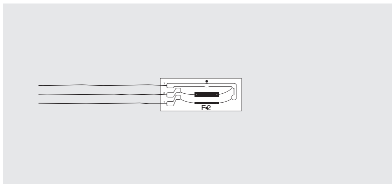
CE NEW

The KSPB series gages are stable-performance semiconductor strain gages usable for general stress measurement and transducers. The F2 type has a half-bridge formed with a 2-element structure (positive and negative) for self-temperature compensation and is suitable for strain measurement of steel products.

KSPB ●Uniaxial, Uniaxial 2-element

Models	KSPB-2-120-E3	KSPB-2-120-E4	KSPB-6-350-E4
Pattern	Uniaxial	Uniaxial	Uniaxial
Gage Factor	Approx. 125	Approx. 125	Approx. 125
Base	5 × 3 mm	7.7 × 4 mm	13 × 5 mm
Grid	2 × 0.25 mm	2 × 0.26 mm	6 × 0.27 mm
Resistance	120 Ω	120 Ω	350 Ω
Pieces per Pack	4	4	4

Models	KSPB-1-350-E4	KSPB-2-1K-E4	KSPB-3-120-F2-11
Pattern	Uniaxial	Uniaxial	Uniaxial 2-element
Gage Factor	Approx. 160	Approx. 170	Approx. 235
Applicable Linear Expansion Coefficients	—	—	11.7
Self-temperature-compensation Range	—	—	20 to 70℃
Base	6.6 × 4 mm	7.7 × 4 mm	10 × 4 mm
Grid	1 × 0.25 mm	2 × 0.2 mm	n: 3 × 0.83 mm p: 3 × 0.47 mm
Resistance	350 Ω	1000 Ω	120 Ω
Pieces per Pack	4	4	2

When ordering, specify the model number as follows.

KSPB-□-□-□-□

(e.g.) KSPB-2-120-E3

Lead-wire Cable Type and Shape	Oprg. Temp.	Length
Silver-covered copper wire	–50 to 150°C	25 mm
Silver-covered copper wires	–50 to 150°C	25 mm
Silver-covered copper wires	–50 to 150°C	25 mm

Strain Gages for Ultra-small Strain Measurements KSN

● Gage Factor	Approx. –100, –110
● Applicable Linear Expansion Coefficients (x10⁻⁶/°C)	11, 16
● Self-temperature-compensation Range	20 to 70°C

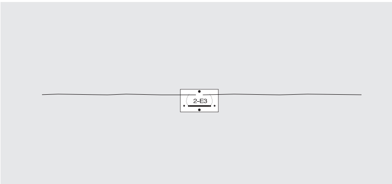
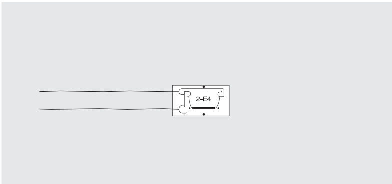
Applicable Adhesives and Operating Temperature Ranges

CC-33A: –50 to 120°C
CC-36: –30 to 100°C

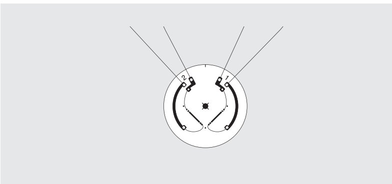
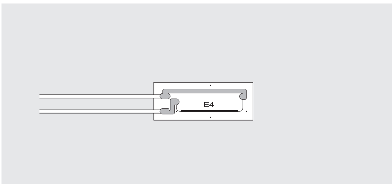
■Self-temperature-compensation Semiconductor Strain Gages

The KSN series gages use an n-type silicon as the resistive element to control the resistance temperature coefficient of the material according to the linear expansion coefficient of the measuring object. Thus, the change of thermally-induced resistance is minimized.

KSN ●Uniaxial, Biaxial

Models	KSN-2-120-E3- 11 16	KSN-2-120-E4- 11 16	KSN-2-120-E5- 11 16
Pattern	Uniaxial	Uniaxial	Uniaxial
Gage Factor	Approx. –100	Approx. –100	Approx. –110
Base	5 × 3 mm	7.7 × 4 mm	—
Grid	2 × 0.3 mm	2 × 0.3 mm	2 × 0.3 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	4	4	4

Models	KSN-2-120-F3- 11 16	KSN-6-350-E4- 11 16
Pattern	Biaxial, 0°/90°	Uniaxial
Gage Factor	Approx. –100	Approx. –100
Base	ϕ11	13 × 5 mm
Grid	2 × 0.3 mm	6 × 0.31 mm
Resistance	120 Ω	350 Ω
Pieces per Pack	2	4

When ordering, specify the model number as follows.

KSN-□-□-□-□

e.g. KSN-2-120-E3-11

Lead-wire Cable Type and Shape	Oprg. Temp.	Length
Silver-covered copper wire	–50 to 150°C	25 mm
Silver-covered copper wires	–50 to 150°C	25 mm
Oxygen-free tin-plated copper wires	–50 to 150°C	40 mm

Strain Gages for Ultra-small Strain Measurements KSPH

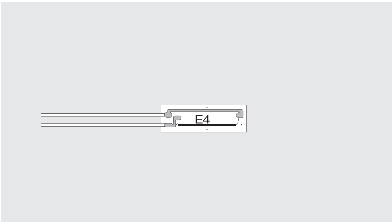
● Gage Factor	Approx. 170

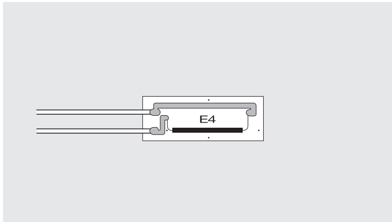
Applicable Adhesives and Operating Temperature Ranges
CC-33A: –50 to 120°C
CC-36: –30 to 100°C

■High-output Semiconductor Strain Gages

The KSPH series gages have high resistance, thereby making high excitation voltage applicable to obtain high output voltage.

KSPH ●Uniaxial





Models	KSPH-4-2K-E4	KSPH-9-10K-E4
Pattern	Uniaxial	Uniaxial
Base	11 × 4 mm	16 × 5 mm
Grid	4 × 0.73 mm	9 × 0.58 mm
Resistance	2000 Ω	10000 Ω
Pieces per Pack	4	4

When ordering, specify the model number as follows.

KSPH-□-□K-E4

(e.g.) KSPH-4-2K-E4

Lead-wire Cable Type and Shape	Oprg. Temp.	Length
Silver-covered copper wires	–50 to 150°C	25 mm

Strain Gages for Ultra-small Strain Measurements KSPL

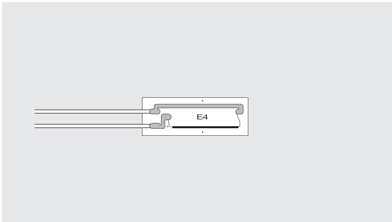
● Gage Factor	Approx. 90

Applicable Adhesives and Operating Temperature Ranges
CC-33A: –50 to 120°C
CC-36: –30 to 100°C

■Ultra Linear Semiconductor Strain Gage

The KSPL gage features a superior linearity of resistance change against strain in a comparatively wide range, thereby making it suitable as a sensing element of transducers.

KSPL ●Uniaxial



Models	KSPL-7-60-E4
Pattern	Uniaxial
Base	14 × 5 mm
Grid	7 × 0.28 mm
Resistance	60 Ω
Pieces per Pack	4

When ordering, specify the model number as follows.

KSPL-7-60-E4

Lead-wire Cable Type and Shape	Oprg. Temp.	Length
Silver-covered copper wires	–50 to 150°C	25 mm

High-temperature Gages KFU

● Gage Factor	Approx. 1.85 (350°C)
● Applicable Linear Expansion Coefficients (x10⁻⁶/°C)	11, 16, 23
● Self-temperature-compensation Range	10 to 300°C

Applicable Adhesives and Operating Temperature Ranges
PI-32: –30 to 350°C

■High-temperature Foil Strain Gages

The base is made of highly heat-resistant polyimide and the gage element is made of NiCr alloy foil, thereby letting the KFU gages exhibit superior characteristics over a wide temperature range.

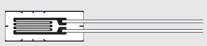
*Please use KFU for short period testing. E.g. 72 hours or less at 350°C, 360 hours or less at 300°C, adhesive PI-32 (It changes depending on the condition.)

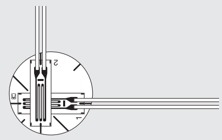
■Types, lengths and codes of lead-wire cables pre-attached to KFU gages

Type / Length	High/low-temp. 3-wire cable
	C1, D16, D17
15cm	H15C3
30	H30C3
1m	H1M3
3	H3M3
5	H5M3
Operating temp.	–30 to 350°C
Remarks	L-17

* For the other types of lead wire-cables, please contact us.

KFU ●Uniaxial, Biaxial





Models	KFU-5-120-C1- 11 / 16 / 23	KFU-2-120-C1- 11 / 16 / 23	KFU-5-120-D16- 11 / 16 / 23
Pattern	Uniaxial	Uniaxial	Biaxial, 0°/90° stacked rosette
Base	10 × 3.7 mm	6 × 3.7 mm	ϕ11
Grid	5 × 2.5 mm	2 × 2.5 mm	5 × 1.4 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	10

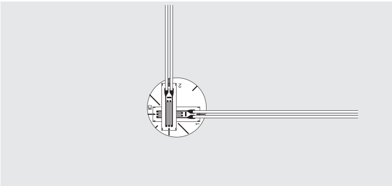
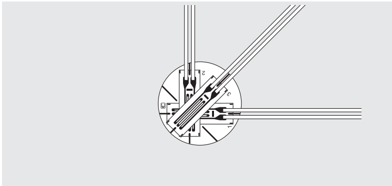
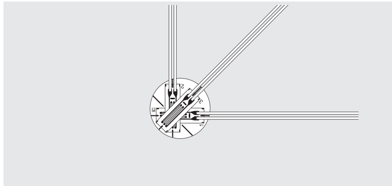
When ordering, specify the model number as follows.

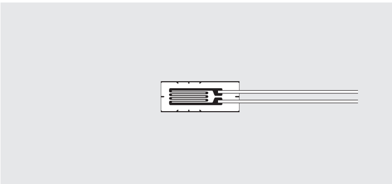
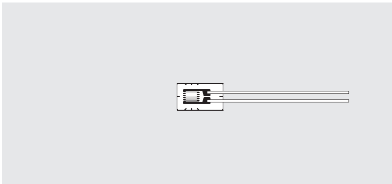
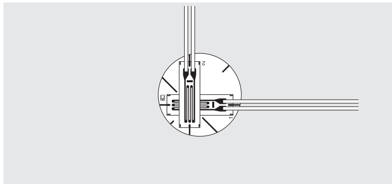
KFU-□-120-□-□ 

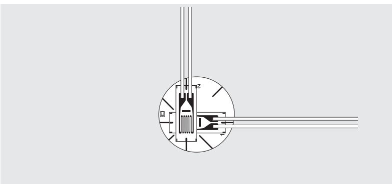
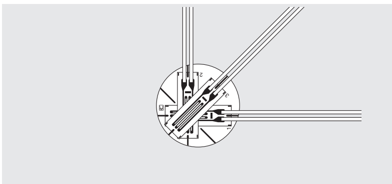
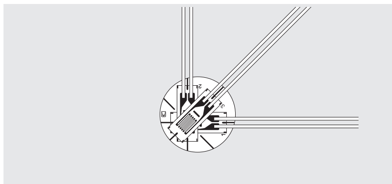
(e.g.)

KFU-5-120-C1-11 H1M3

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
High/low temp. 3-wire cable L-17 	–30 to 350°C	1 m	H1M3
		3 m	H3M3
		5 m	H5M3
Advanced ribbon cable	–30 to 350°C	25 mm	

			
Models	KFU-2-120-D16- 11 16 23	KFU-5-120-D17- 11 16 23	KFU-2-120-D17- 11 16 23
Pattern	Biaxial, 0°/90° stacked rosette	Triaxial, 0°/45°/90° stacked rosette	Triaxial, 0°/45°/90° stacked rosette
Base	ϕ8	ϕ11	ϕ8
Grid	2 × 1.2 mm	5 × 1.4 mm	2 × 1.2 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	10

			
Models	KFU-5-350-C1- 11 16 23	KFU-2-350-C1- 11 16 23	KFU-5-350-D16- 11 16 23
Pattern	Uniaxial	Uniaxial	Biaxial, 0°/90° stacked rosette
Base	10 × 3.7 mm	6 × 3.7 mm	ϕ11
Grid	5 × 2.4 mm	2 × 2.4 mm	5 × 2 mm
Resistance	350 Ω	350 Ω	350 Ω
Pieces per Pack	10	10	10

			
Models	KFU-2-350-D16- 11 16 23	KFU-5-350-D17- 11 16 23	KFU-2-350-D17- 11 16 23
Pattern	Biaxial, 0°/90° stacked rosette	Triaxial, 0°/45°/90° stacked rosette	Triaxial, 0°/45°/90° stacked rosette
Base	ϕ10	ϕ11	ϕ10
Grid	2 × 2 mm	5 × 2 mm	2 × 2 mm
Resistance	350 Ω	350 Ω	350 Ω
Pieces per Pack	10	10	10

When ordering, specify the model number as follows.

KFU-□-□-□-□ Lead-wire Cable Code

(e.g.)

KFU-5-350-C1-11 H1M3

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
High/low temp. 3-wire cable L-17 	−30 to 350°C	1 m	H1M3
		3 m	H3M3
		5 m	H5M3
Advanced ribbon cable	−30to 350°C	25 mm	

High-temperature Gages KH

● Gage Factor	Approx. 2.0 (350°C)
● Applicable Linear Expansion Coefficients (x10⁻⁶/°C)	11, 16
● Self-temperature-compensation Range	10 to 300°C

Applicable Adhesives and Operating Temperature Ranges
Spot welding: –50 to 350°C

■High-temperature Foil Strain Gages

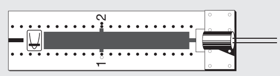
The G4 type KH gages are 350 Ω gages with a metal base which enables easy mounting with a compact spot welder.
*Operating time (Depends on usage conditions)
24 hours or less at 350°C
72 hours or less at 300°C

■Types, lengths and codes of lead-wire cables pre-attached to KH gages

Type / Length	Glass-coated cable of 3 Ni-clad copper wires
	G4
15cm	D15C3
30	D30C3
1m	D1M3
3	D3M3
5	D5M3
Operating temp.	–50 to 350°C

* For the other types of lead wire-cables, please contact us.

KH ●Uniaxial



Models	KH-5-350-G4- 11 / 16
Pattern	Uniaxial
Base	30 × 8 mm
Grid	5 × 1 mm
Resistance	350 Ω
Pieces per Pack	5

When ordering, specify the model number as follows.

KH-5-350-G4-□ Lead-wire Cable Code

(e.g.)

KH-5-350-G4-11 D1M3

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
Glass-coated cable of 3 Ni-clad copper wires 	–50 to 350°C	1 m	D1M3
		3 m	D3M3
		5 m	D5M3
Advanced ribbon cable	–50 to 350°C	25 mm	

High-temperature Gages

KFH

● Gage Factor	Approx. 1.9 (250°C)
● Applicable Linear Expansion Coefficients (x10^{-6}/°C)	11, 16, 23
● Self-temperature-compensation Range	10 to 250°C

Applicable Adhesives and Operating Temperature Ranges
(It changes depending on the condition.)
PC-600: –196 to 250°C up to 24 h at 250°C
EP-34B: –55 to 200°C up to 120 h at 200°C
PI-32: –196 to 250°C up to 24 h at 250°C

■High-temperature Foil Strain Gages

CE

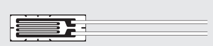
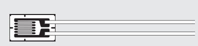
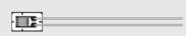
The base is made of highly heat-resistant polyimide and the gage element is made of NiCr alloy foil, thereby ensuring less thermal output and excellent temperature characteristics.

■Types, lengths and codes of lead-wire cables pre-attached to KFH gages

Type / Length	High/low-temp. 3-wire cable	Fluoroplastic-coated high/low-temp. 3-wire
	C1, D25	
15cm	H15C3	F15C3
30	H30C3	F30C3
1m	H1M3	F1M3
3	H3M3	F3M3
5	H5M3	F5M3
Operating temp.	–196 to 250˚C	–196 to 250˚C
Remarks	L-17	L-3

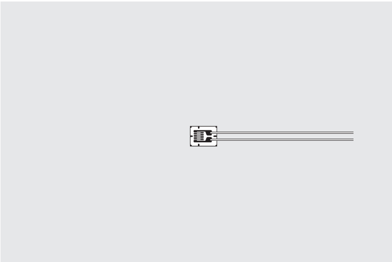
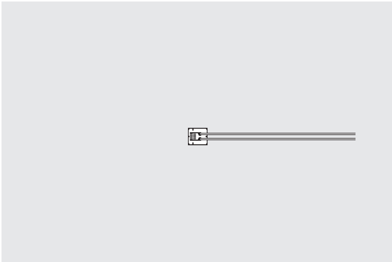
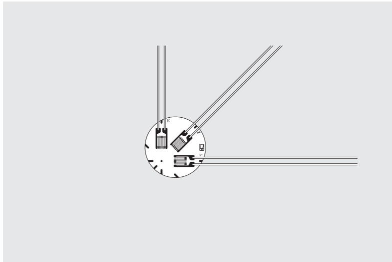
* For the other types of lead wire-cables, please contact us.

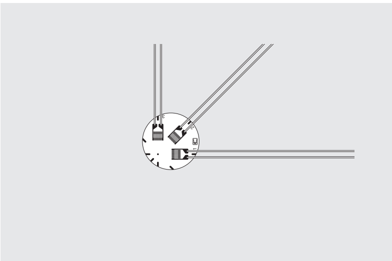
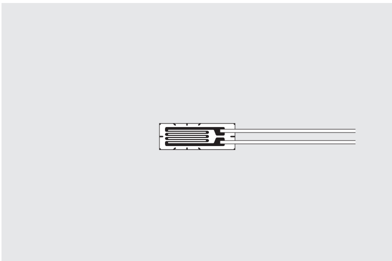
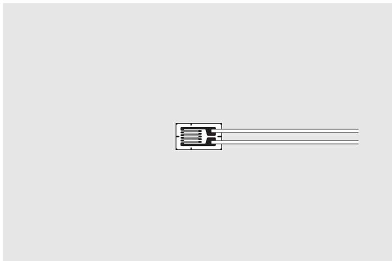
KFH ●Uniaxial

Models	KFH-5-120-C1- 11 / 16 / 23	KFH-2-120-C1- 11 / 16 / 23	KFH-1-120-C1- 11 / 16 / 23
Pattern	Uniaxial	Uniaxial	Uniaxial
Base	10 × 3.7 mm	6 × 3.7 mm	4 × 2.7 mm
Grid	5 × 2.5 mm	2 × 2.5 mm	1 × 1.5 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	10

KFH ●Uniaxial, Triaxial

			
Models	KFH-05-120-C1- 11 / 16 / 23	KFH-02-120-C1- 11 / 16 / 23	KFH-1-120-D25- 11 / 16 / 23
Pattern	Uniaxial	Uniaxial	Triaxial, 0°/90°/45°
Base	3.3 × 2.7 mm	2.5 × 2.2 mm	ϕ8
Grid	0.5 × 1.4 mm	0.2 × 1 mm	1 × 1.5 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	5

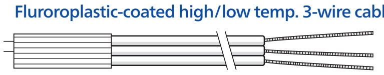
			
Models	KFH-05-120-D25- 11 / 16 / 23	KFH-5-350-C1- 11 / 16 / 23	KFH-2-350-C1- 11 / 16 / 23
Pattern	Triaxial, 0°/90°/45°	Uniaxial	Uniaxial
Base	ϕ7.5	10 × 3.7 mm	6 × 3.7 mm
Grid	0.5 × 1.4 mm	5 × 2.4 mm	2 × 2.4 mm
Resistance	120 Ω	350 Ω	350 Ω
Pieces per Pack	5	10	10

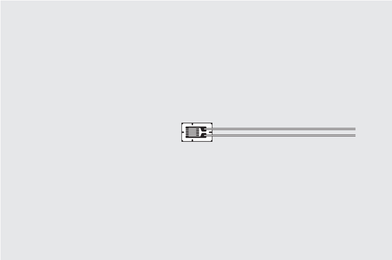
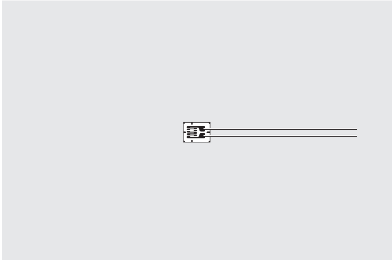
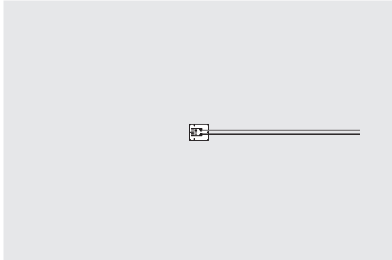
When ordering, specify the model number as follows.

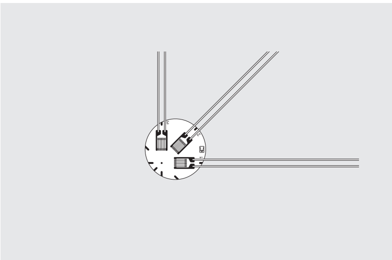
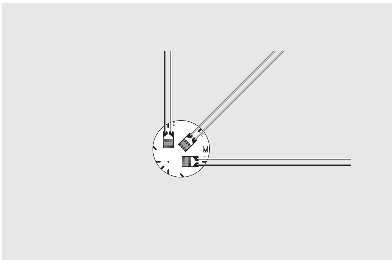
KFH-□-□-□-□ Lead-wire Cable Code

(e.g.)

KFH-5-120-C1-11 H1M3

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
High/low temp. 3-wire cable L-17 	−196 to 250°C	1 m	H1M3
		3 m	H3M3
		5 m	H5M3
Fluroroplastic-coated high/low temp. 3-wire cable L-3 	−196 to 250°C	1 m	F1M3
		3 m	F3M3
		5 m	F5M3
Advanced ribbon cable	−196 to 250°C	25 mm	

			
Models	KFH-1-350-C1- 11 / 16 / 23	KFH-05-350-C1- 11 / 16 / 23	KFH-02-350-C1- 11 / 16 / 23
Pattern	Uniaxial	Uniaxial	Uniaxial
Base	4 × 2.7 mm	3.5 × 2.7 mm	3.0 × 2.7 mm
Grid	1 × 1.5 mm	0.5 × 1.5 mm	0.2 × 1.5 mm
Resistance	350 Ω	350 Ω	350 Ω
Pieces per Pack	10	10	10

		
Models	KFH-1-350-D25- 11 / 16 / 23	KFH-05-350-D25- 11 / 16 / 23
Pattern	Triaxial, 0°/90°/45°	Triaxial, 0°/90°/45°
Base	ϕ8	ϕ7.5
Grid	1 × 1.5 mm	0.5 × 1.5 mm
Resistance	350 Ω	350 Ω
Pieces per Pack	5	5

When ordering, specify the model number as follows.

KFH-□-350-□-□ Lead-wire Cable Code

(e.g.)

KFH-1-350-C1-11 H1M3

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
High/low temp. 3-wire cable L-17 	−196 to 250°C	1 m	H1M3
		3 m	H3M3
		5 m	H5M3
Fluroroplastic-coated high/low temp. 3-wire cable L-3 	−196 to 250°C	1 m	F1M3
		3 m	F3M3
		5 m	F5M3
Advanced ribbon cable	−196 to 250°C	25 mm	

Low-temperature Gages KFL

● Gage Factor	Approx. 2.1
● Applicable Linear Expansion Coefficients (x10⁻⁶/°C)	5, 11, 16, 23
● Self-temperature-compensation Range	−196 to 50°C

Applicable Adhesives and Operating Temperature Ranges

PC-600: −269 to 150°C
CC-33A: −196 to 120°C
EP-270: −269 to 30°C

■Low-temperature Foil Strain Gages

CE

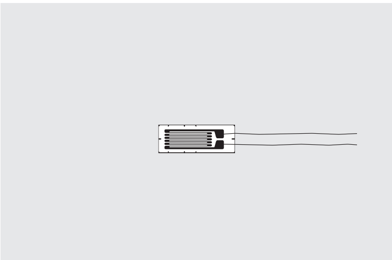
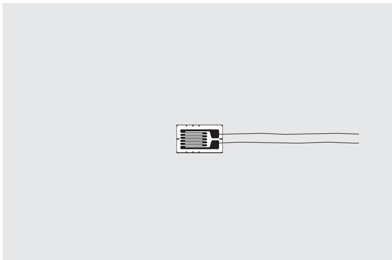
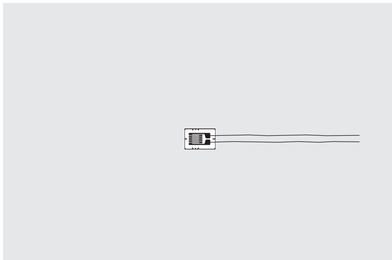
The gage element is made of NiCr alloy, which exhibits excellent characteristics under low-temperature environments and is sandwiched between polyimde films. Thus, the KFL series gages are suitable for strain measurement of tanks and vessels containing low-temperature liquids such as LNG and LPG.

■Types, lengths and codes of lead-wire cables pre-attached to KFL series gages

Type / Length	2 polyester-coated copper wires	3 polyester-coated copper wires	Mid-temperature. 2-wire cable	Mid-temperature. 3-wire cable	Fluoroplastic-coated high/low-temp. 3-wire cable
	C1, D25				
15cm	N15C2	N15C3	R15C2	R15C3	F15C3
30	N30C2	N30C3	R30C2	R30C3	F30C3
1m	N1M2	N1M3	R1M2	R1M3	F1M3
3			R3M2	R3M3	F3M3
5			R5M2	R5M3	F5M3
Operating temp.	−196 to 150°C		−100 to 150°C		−269 to 150°C
Remarks	Twisted for ≥ 50 cm		L-11	L-12	L-3

* For the other types of lead wire-cables, please contact us.

KFL ●Uniaxial

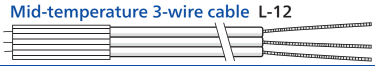
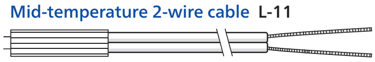
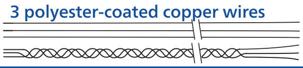
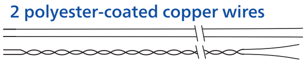
			
Models	KFL-5-120-C1- 11 / 16 / 23	KFL-2-120-C1- 11 / 16 / 23	KFL-1-120-C1- 11 / 16 / 23
Pattern	Uniaxial	Uniaxial	Uniaxial
Base	10 × 3.7 mm	6 × 3.7 mm	4 × 2.7 mm
Grid	5 × 2.5 mm	2 × 2.5 mm	1 × 1.5 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	10

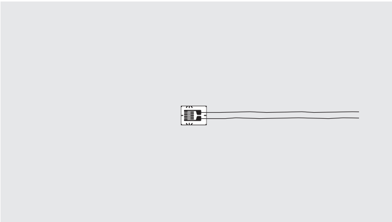
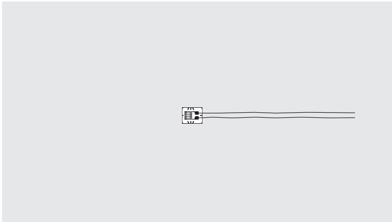
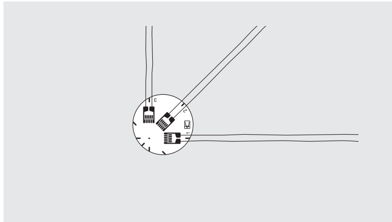
When ordering, specify the model number as follows.

KFL-□-120-C1-□ Lead-wire Cable Code

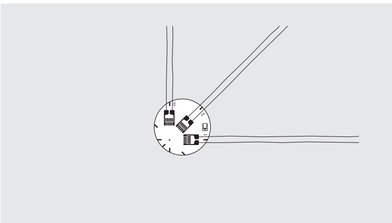
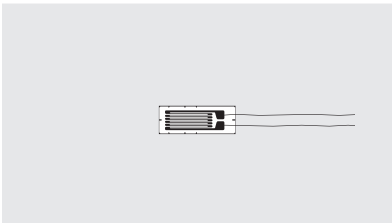
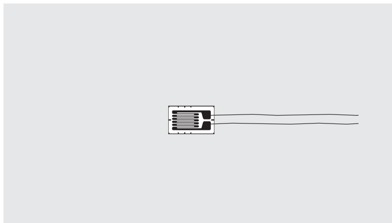
(e.g.)

KFL-5-120-C1-11 F1M3

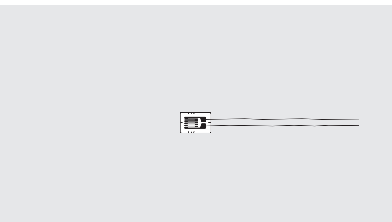
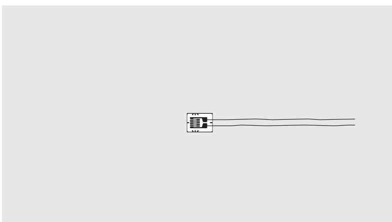
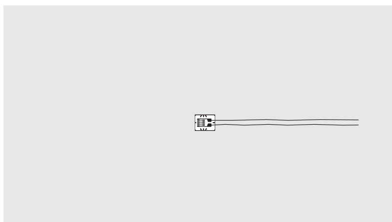
Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
Fluroroplastic-coated high/low temp. 3-wire cable L-3 	−269 to 150°C	1 m	F1M3
		3 m	F3M3
		5 m	F5M3
Mid-temperature 3-wire cable L-12 	−100 to 150°C	1 m	R1M3
		3 m	R3M3
		5 m	R5M3
Mid-temperature 2-wire cable L-11 	−100 to 150°C	1 m	R1M2
		3 m	R3M2
		5 m	R5M2
3 polyester-coated copper wires  30 cm / 50 cm, 1 m	−196 to 150°C	30 cm	N30C3
		50 cm	N50C3
		1 m	N1M3
2 polyester-coated copper wires  30 cm / 50 cm, 1 m	−196 to 150°C	30 cm	N30C2
		50 cm	N50C2
		1 m	N1M2
Silver-covered copper wires	−269 to 150°C	25 mm	

Models	KFL-05-120-C1- 11 16 23	KFL-02-120-C1- 11 16 23	KFL-1-120-D25- 11 16 23
Pattern	Uniaxial	Uniaxial	Triaxial, 0°/90°/45°
Base	3.3 × 2.7 mm	2.5 × 2.2 mm	ϕ8
Grid	0.5 × 1.4 mm	0.2 × 1 mm	1 × 1.5 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	5

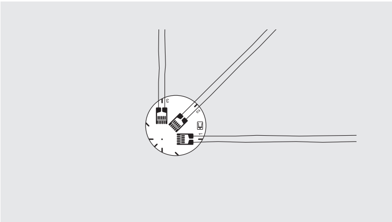
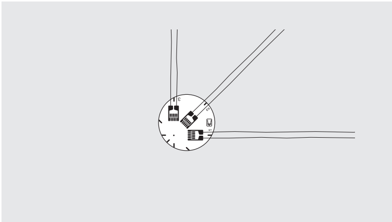




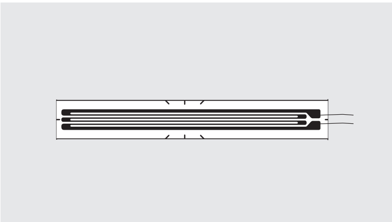
Models	KFL-05-120-D25- 11 16 23	KFL-5-350-C1- 11 16 23	KFL-2-350-C1- 11 16 23
Pattern	Triaxial, 0°/90°/45°	Uniaxial	Uniaxial
Base	ϕ7.5	10 × 3.7 mm	6 × 3.7 mm
Grid	0.5 × 1.4 mm	5 × 2.4 mm	2 × 2.4 mm
Resistance	120 Ω	350 Ω	350 Ω
Pieces per Pack	5	10	10

Models	KFL-1-350-C1- 11 16 23	KFL-05-350-C1- 11 16 23	KFL-02-350-C1- 11 16 23
Pattern	Uniaxial	Uniaxial	Uniaxial
Base	4 × 2.7 mm	3.5 × 2.7 mm	3 × 2.7 mm
Grid	1 × 1.5 mm	0.5 × 1.5 mm	0.2 × 1.5 mm
Resistance	350 Ω	350 Ω	350 Ω
Pieces per Pack	10	10	10

KFL ●Triaxial, Uniaxial for concrete and lumber

		
Models	KFL-1-350-D25- 11 / 16 / 23	KFL-05-350-D25- 11 / 16 / 23
Pattern	Triaxial, 0°/90°/45°	Triaxial, 0°/90°/45°
Base	ϕ8	ϕ7.5
Grid	1 × 1.5 mm	0.5 × 1.5 mm
Resistance	350 Ω	350 Ω
Pieces per Pack	5	5

	
Models	KFL-30-350-C1- 5 / 11
Pattern	Uniaxial (For concrete and lumber)
Base	36 × 5.2 mm
Grid	30 × 2.7 mm
Resistance	350 Ω
Applicable Linear Expansion Coefficients	5 (lumber) 11 (concrete)
Pieces per Pack	10

When ordering, specify the model number as follows.

KFL-□-350-□-□ Lead-wire Cable Code

(e.g.)

KFL-5-120-C1-11 F1M3

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
Fluroroplastic-coated high/low temp. 3-wire cable L-3	−269 to 150°C	1 m	F1M3
		3 m	F3M3
		5 m	F5M3
Mid-temperature 3-wire cable L-12	−100 to 150°C	1 m	R1M3
		3 m	R3M3
		5 m	R5M3
Mid-temperature 2-wire cable L-11	−100 to 150°C	1 m	R1M2
		3 m	R3M2
		5 m	R5M2
3 polyester-coated copper wires (30 cm / 50 cm, 1 m)	−196 to 150°C	30 cm	N30C3
		50 cm	N50C3
		1 m	N1M3
2 polyester-coated copper wires (30 cm / 50 cm, 1 m)	−196 to 150°C	30 cm	N30C2
		50 cm	N50C2
		1 m	N1M2
Silver-covered copper wires	−269 to 150°C	25 mm	

High-elongation Strain Gages KFEM

CE

- Resistance: 120 Ω
- Gage Factor: Approx. 2.0
- Operating Temperature Range: –20 to 80°C
- Strain Limit at Room Temperature: 20 to 30%
- Applicable Adhesive: CC-36

■Ultrahigh-elongation Foil Strain Gages

KFEM series ultrahigh-elongation foil gages allow strain to be measured on various regions of structures, from elastic to plastic, and are suitable for large strain measurement. They can measure 20 to 30% of material deformation.

*Strain limit of 20% to 30% is ensured for simple tension applied to the gage bonded on stainless steel (SUS 304) or aluminum alloy (A1050) at normal temperature.

*Strain limit will be decreased under the following conditions.
- In case of bonding to non-adhesive materials such as aluminum alloy (A7075) and plastics (Polypropylene)
- In case of the targets have discontinuous distortion, or any crack on its surface
- In case of measurement at high/low temperature.

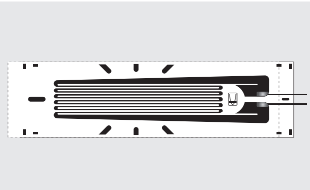
- Measurement of 20 to 30% material deformation possible
- Laminate protruding from the tip of gage base ensures improved adhesive property, making the gages hard to peel off.
- Foil material has an improved elongation property and is hard to

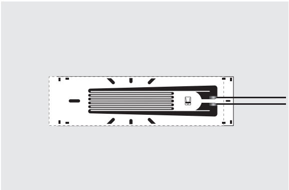
■Types, lengths and codes of lead-wire cables pre-attached to KFEM gages

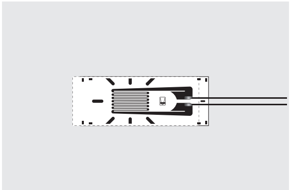
Type / Length	2 polyester-coated copper wires	Vinyl-coated flat 2-wire cable	Vinyl-coated flat 3-wire cable
	C1		
15cm	N15C2	L15C2R	L15C3R
30	N30C2	L30C2R	L30C3R
1m	N1M2	L1M2R	L1M3R
3		L3M2R	L3M3R
5		L5M2R	L5M3R
Operating temp.	–10 to 80°C		
Remarks	Twisted for ≥ 50 cm	L-6 L-9 for ≥ 6 m	L-7 L-10 for ≥ 6 m

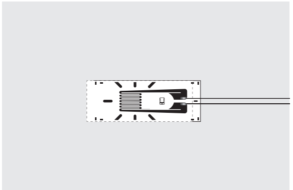
* For the other types of lead wire-cables, please contact us.

KFEM ●Uniaxial









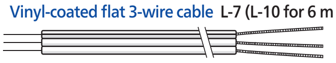
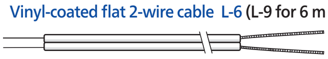
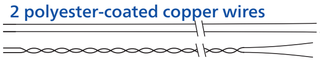
Models	KFEM-10-120-C1	KFEM-5-120-C1	KFEM-2-120-C1	KFEM-1-120-C1
Pattern	Uniaxial	Uniaxial	Uniaxial	Uniaxial
Base	17.5 × 4.5 mm	11.5 × 3 mm	8.5 × 3 mm	7.0 × 2.5 mm
Grid	10 × 2.5 mm	5 × 1.5 mm	2 × 1.5 mm	1 × 1.3 mm
Resistance	120 Ω	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	10	10

When ordering, specify the model number as follows.

KFEM-□-120-C1 Lead-wire Cable Code

(e.g.)

KFEM-2-120-C1

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
Vinyl-coated flat 3-wire cable L-7 (L-10 for 6 m or longer) 	–10 to 80°C	1 m	L1M3R
		3 m	L3M3R
		5 m	L5M3R
Vinyl-coated flat 2-wire cable L-6 (L-9 for 6 m or longer) 	–10 to 80°C	1 m	L1M2R
		3 m	L3M2R
		5 m	L5M2R
2 polyester-coated copper wires  30 cm / 50 cm, 1 m	–20 to 80°C	30 cm	N30C2
		50 cm	N50C2
		1 m	N1M2
Silver-covered copper wires	–20 to 80°C	25 mm	

Strain Gages

High-elongation Strain Gages KFEL

● Gage Factor	Approx. 2.1
● Resistance	120Ω
● Strain Limit at Room Temperature	10 to 15%

Applicable Adhesives and Operating Temperature Ranges
CC-36: –10 to 80°C

■High-elongation Foil Strain Gages

CE

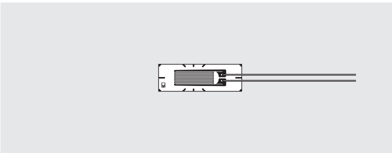
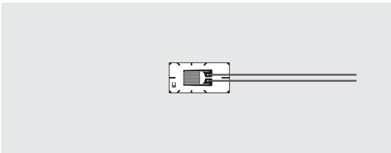
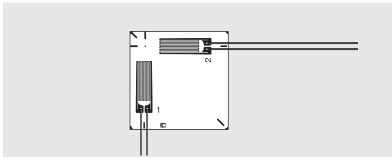
Developed to measure strain in elastic to plastic regions on structures, the KFEL gages can measure strain as large as 10 to 15% with simple tension strain. Thus, these gages are applicable for large strain measurement and destructive testing of metals (steel, stainless steel and aluminum) and plastics (polyethylene and polypropylene).

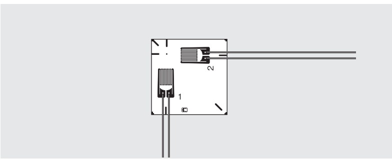
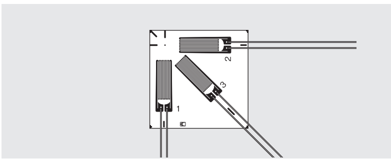
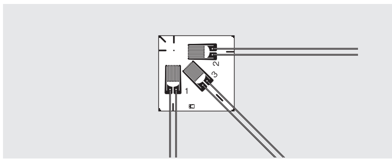
■Types, lengths and codes of lead-wire cables pre-attached to KFEL gages

Type / Length	2 polyester-coated copper wires	Vinyl-coated flat 2-wire cable		Vinyl-coated flat 3-wire cable	
	C1, D34, D35	C1	D34, D35	C1	D34, D35
15cm	N15C2	L15C2R	L15C2S	L15C3R	L15C3S
30	N30C2	L30C2R	L30C2S	L30C3R	L30C3S
1m	N1M2	L1M2R	L1M2S	L1M3R	L1M3S
3		L3M2R	L3M2S	L3M3R	L3M3S
5		L5M2R	L5M2S	L5M3R	L5M3S
Operating temp.	–10 to 80°C				
Remarks	Twisted for ≥ 50	L-6 L-9 for ≥ 6 m		L-7 L-10 for ≥ 6 m	

* For the other types of lead wire-cables, please contact us.

KFEL ●Uniaxial, Biaxial, Triaxial

			
Models	KFEL-5-120-C1	KFEL-2-120-C1	KFEL-5-120-D34
Pattern	Uniaxial	Uniaxial	Biaxial, 0°/90°
Base	11 × 3.5 mm	8 × 4 mm	13 × 13 mm
Grid	5 × 2.1 mm	2 × 2.1 mm	5 × 2.1 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	10

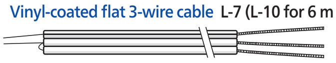
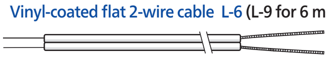
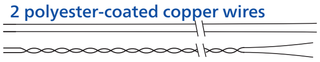
			
Models	KFEL-2-120-D34	KFEL-5-120-D35	KFEL-2-120-D35
Pattern	Biaxial, 0°/90°	Triaxial, 0°/90°/45°	Triaxial, 0°/90°/45°
Base	10 × 10 mm	13 × 13 mm	10 × 10 mm
Grid	2 × 2.1 mm	5 × 2.1 mm	2 × 2.1 mm
Resistance	120 Ω	120 Ω	120 Ω
Pieces per Pack	10	10	10

When ordering, specify the model number as follows.

KFEL-□-120-□ Lead-wire Cable Code

(e.g.)

KFEL-5-120-C1 L1M3R

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
Vinyl-coated flat 3-wire cable L-7 (L-10 for 6 m or longer) 	–10 to 80°C	1 m	L1M3R:L1M3S
		3 m	L3M3R:L3M3S
		5 m	L5M3R:L5M3S
Vinyl-coated flat 2-wire cable L-6 (L-9 for 6 m or longer) 	–10 to 80°C	1 m	L1M2R:L1M2S
		3 m	L3M2R:L3M2S
		5 m	L5M2R:L5M2S
2 polyester-coated copper wires  30 cm / 50 cm, 1 m	–10 to 80°C	30 cm	N30C2
		50 cm	N50C2
		1 m	N1M2
Silver-covered copper wires	–10 to 80°C	25 mm	

Non-magnetoresistive Gages KFN

● Gage Factor	Approx. 2.0
● Applicable Linear Expansion Coefficients (x10^{-6}/°C)	11, 16, 23
● Self-temperature-compensation Range	0 to 150°C

Applicable Adhesives and Operating Temperature Ranges
PC-600: −196 to 150°C
CC-33A: −196 to 120°C

■Non-inductive Foil Strain Gages

CE

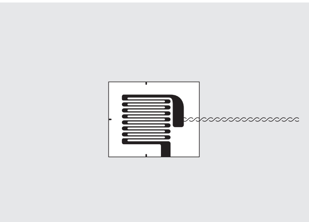
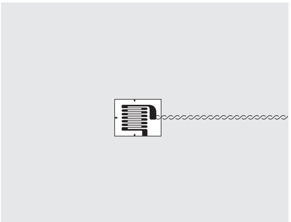
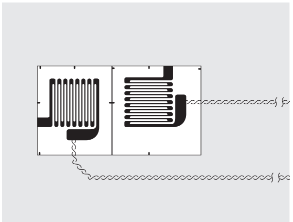
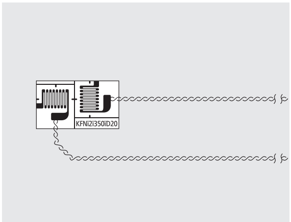
The gage element is made of a special alloy which provides less magnetoresistant effect; also, the shape is designed to eliminate induction.
Thus, the KFN series foil strain gages allow the strain to be measured accurately under AC magnetic environments.

■Types, lengths and codes of lead-wire cables pre-attached to KFN gages

Length \ Type	Vinyl-coated low-noise 3-wire cable
	C9, D20
15cm	J15C3
30	J30C3
1m	J1M3
3	J3M3
5	J5M3
Operating temp.	−10 to 80°C
Remarks	L-13

* For the other types of lead wire-cables, please contact us.

KFN ●Uniaxial, Biaxial

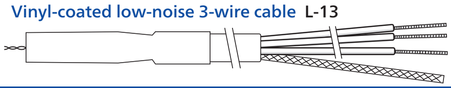
Models	KFN-5-350-C9- 11 / 16 / 23	KFN-2-350-C9- 11 / 16 / 23	KFN-5-350-D20-11 / 16 / 23	KFN-2-350-D20-11 / 16 / 23
Pattern	Uniaxial	Uniaxial	Biaxial, 0°/90° plane arrangement	Biaxial, 0°/90° plane arrangement
Base	12 × 10 mm	6 × 5 mm	22 × 12 mm	11 × 6 mm
Grid	5 × 6.6 mm	2 × 3.5 mm	5 × 6.6 mm	2 × 3.5 mm
Resistance	350 Ω	350 Ω	350 Ω	350 Ω
Pieces per Pack	10	10	5	5

When ordering, specify the model number as follows.

KFN-□-350-□-□ Lead-wire Cable Code

(e.g.)

KFN-5-350-C9-11 J1M3

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
Vinyl-coated low-noise 3-wire cable L-13 	−10 to 80°C	1 m	J1M3
		3 m	J3M3
		5 m	J5M3
2 polyester-coated copper wires 10 cm long 	−196 to 150°C	25 mm	

Strain Gages

Non-magnetoresistive Gages KFS

● Gage Factor	Approx. 2.0, 2.1
● Applicable Linear Expansion Coefficients (x10^{-6}/°C)	11, 16, 23
● Self-temperature-compensation Range	10 to 100°C

Applicable Adhesives and Operating Temperature Ranges

PC-600: –196 to 150°C
CC-33A: –196 to 120°C
EP-340: –55 to 150°C

■Shielded Foil Strain Gages

CE

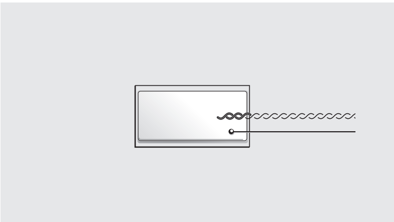
The KFS series foil strain gages are shielded by copper foil covering the whole body. Thus, if a large current flows to or around the gage bonding site, noise will be prevented from entering the measuring circuit.

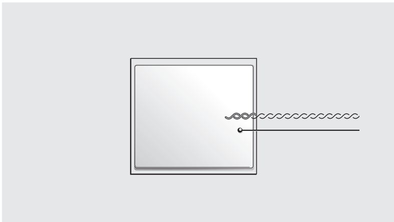
■Types, lengths and codes of lead-wire cables pre-attached to KFS gages

Type / Length	Vinyl-coated low-noise 3-wire cable
	J1
15cm	J15C3
30	J30C3
1m	J1M3
3	J3M3
5	J5M3
Operating temp.	–10 to 80°C
Remarks	L-13

* For the other types of lead wire-cables, please contact us.

KFS ●Uniaxial





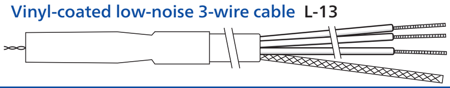
Models	KFS-5-120-J1-11 16 23	KFS-5-350-J1-11 16 23
Pattern	Uniaxial	Uniaxial
Gage Factor	Approx. 2.1	Approx. 2.0
Base	15 × 10 mm	17 × 16 mm
Grid	5 × 1.4 mm	5 × 6.6 mm
Resistance	120 Ω	350 Ω
Pieces per Pack	10	10

When ordering, specify the model number as follows.

KFS-5-□-J1-□ Lead-wire Cable Code

(e.g.)

KFS-5-120-J1-11 J1M3

Lead-wire Cable Type and Shape	Oprg. Temp.	Length	Code
Vinyl-coated low-noise 3-wire cable L-13 	–10 to 80°C	1 m	J1M3
		3 m	J3M3
		5 m	J5M3
2 polyester-coated copper wires 	–196 to 150°C	25 mm	

Gages for Hydrogen Gas Emvironment KFV

CE

● Gage Factor Approx. 2.5

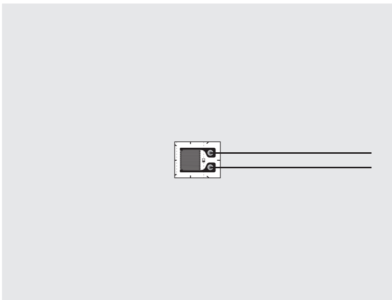
Applicable Adhesives and Operating Temperature Ranges
PC-600: –30 to 80°C

■Foil Strain Gage for Hydrogen Gas Environment

KFV is a foil strain gage that enables stable strain measurement under high-pressure hydrogen gas environments.

To Ensure Safe Usage
Before using KFV strain gages, request the leaflet and read thoroughly the Safety Precautions described there.

KFV ●Uniaxial



Models	KFV-2-350-C1
Pattern	Uniaxial
Gage Factor	Approx. 2.5
Base	6 × 5 mm
Grid	2 × 3.2 mm
Resistance	350 Ω
Pieces per Pack	2

When ordering, specify the model number as follows.

KFV-2-350-C1

Lead-wire Cable Type and Shape	Oprg. Temp.	Length
2 polyester-coated copper wires 	–30 to 80°C	15 mm

Strain Gages

Bending Strain Measuring Gages KFF

● Gage Factor	Approx. 2.1
● Applicable Linear Expansion Coefficients (x10^{-6}/°C)	11, 16, 23
● Self-temperature-compensation Range	20 to 60°C

Applicable Adhesives and Operating Temperature Ranges

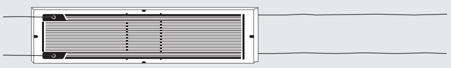
CC-33A: –50 to 80°C
EP-340: –50 to 80°C

CE

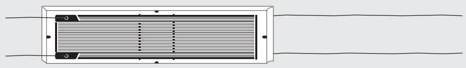
■Foil Strain Gages for Bending Strain Measurement

If measuring stress in box structures such as bridge girders, or in high-pressure vessels that do not allow gages to be bonded directly to the inside of the measuring object, the KFF series gages can be bonded to the outside surface to obtain strain on the inside.

KFF ●Uniaxial



1 mm thick



2 mm thick

Models	KFF-30-350-C11- 11 / 16 / 23	KFF-30-350-C12- 11 / 16 / 23
Pattern	Uniaxial 2-element	Uniaxial 2-element
Base	30 × 7 × 1 mm	30 × 7 × 2 mm
Resistance	350 Ω	350 Ω
Pieces per Pack	5	5

When ordering, specify the model number as follows.

KFF-30-350-□-□

(e.g.)

KFF-30-350-C11-11

Lead-wire Cable Type and Shape	Oprg. Temp.	Length
Silver-covered copper wires	–10 to 80°C	25 mm

Gages with a Protector

KCH

● Gage Factor Approx. 2.1

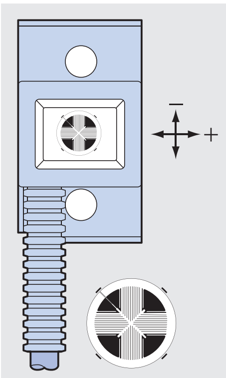
Applicable Adhesives and
Operating Temperature Ranges

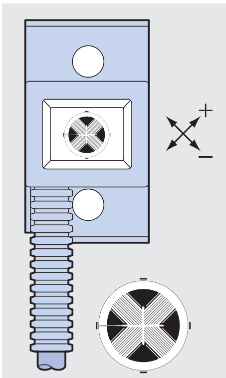
EP-340: –40 to 100°C
CC-33A: –40 to 100°C

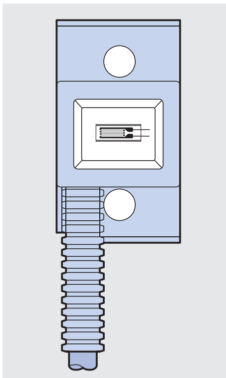
■Foil Strain Gages with a Protector

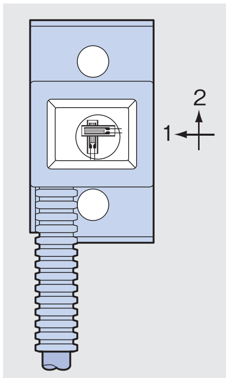
The unique design simplifies gage bonding, wiring and moisture-proofing work in the field.
In addition, the metal case protects the strain gage and significantly improves reliability compared with conventional gages.
Using stud bolts and adhesive, allows the gages to be mounted to the bottom or side plate of a tank for strain measurement, to a hopper or tank for weight measurement, to the shaft of a truck for tare weight measurement or any other similar applications where the gages need to be protected against moisture, water or small stones.

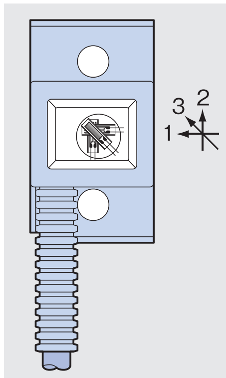
KCH ●Uniaxial, Biaxial, Triaxial











Models	KCH-5A-B KCH-5A-BJ	KCH-5A-S KCH-5A-SJ	KCH-5A-1	KCH-5A-2	KCH-5A-3
Pattern	Full bridge	Full bridge (For shearing strain)	Uniaxial	Biaxial, 0°/90° stacked rosette	Triaxial, 0°/90°/45° stacked rosette
Grid	2 mm	2 mm	5 mm	5 mm	5 mm
Resistance	350 Ω	350 Ω	350 Ω	350 Ω	350 Ω
Pieces per Pack	Full bridge	Full bridge	3-wire	3-wire	2-wire
Cable	KCH-5A-B and S come with special flexible vinyl-shielded 4-conductor (0.3 mm²) cable, 6.8 mm diameter by 10 m long, bared at the tip. KCH-5A-BJ and SJ come with flexible vinyl-shielded 4-conductor (0.3 mm²) cable, 2 m long (cable cover 1.75 m long) by 6.3 mm diameter (10.2 mm including cable cover) and terminated with waterproof connector plug (R04-P6-M6.8). Relay cables (TN-29 to 33) are optional accessories.	KCH-5A-B and S come with special flexible vinyl-shielded 4-conductor (0.3 mm²) cable, 6.8 mm diameter by 10 m long, bared at the tip. KCH-5A-BJ and SJ come with flexible vinyl-shielded 4-conductor (0.3 mm²) cable, 2 m long (cable cover 1.75 m long) by 6.3 mm diameter (10.2 mm including cable cover) and terminated with waterproof connector plug (R04-P6-M6.8). Relay cables (TN-29 to 33) are optional accessories.	Special flexible vinyl-shielded 4-conductor (0.3 mm²) cable, 6.8 mm diameter by 10 m long, bared at the tip.	Special flexible vinyl-shielded 6-conductor (0.3 mm²) cable, 6.8 mm diameter by 10 m long, bared at the tip.	Special flexible vinyl-shielded 6-conductor (0.3 mm²) cable, 6.8 mm diameter by 10 m long, bared at the tip.

When ordering, specify the model number as follows.

KCH-5A-□

e.g. KCH-5A-B

●Relay Cables (for KCH-5A-BJ/SJ) (Optional Accessories)

Model	TN-29	TN-30	TN-31	TN-32	TN-33
Cable length	2 m	3 m	7 m	10 m	12 m
Cable cover length	1.5 m	2.5 m	6.5 m	9.5 m	11.5 m
Remarks	With waterproof connector jack (R04-J6-F6.8) Bared at the tip				

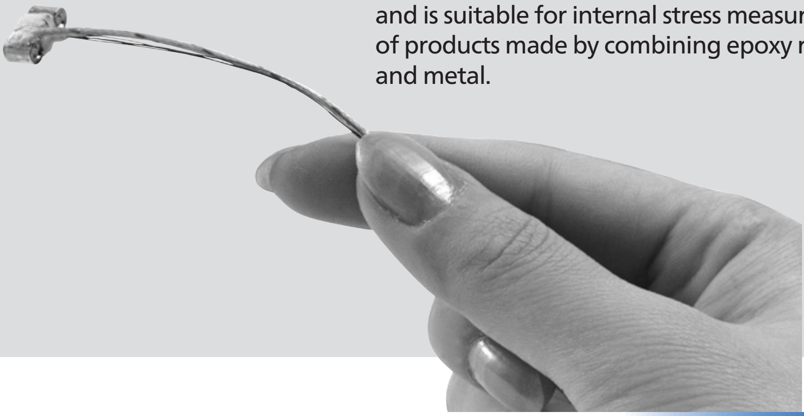
Embedded Gages

KMP

● Gage Factor　Approx. 2.0

Operating Temperature Ranges
20 to 150°C

Compensated Temperature Ranges
20 to 120°C



Embedded Gage

Embedded in resin, the KMP gage measures cure-shrinkage and internal strain. The compact design enables embedment in shaped resins and is suitable for internal stress measurement of products made by combining epoxy resin and metal.

KMP Developed by Mitsubishi Electric Corp.
Commercialized by Kyowa Electronic Instruments Co., Ltd.

Resistance	120 Ω
Gage Factor	Approx. 2.0
Length of Sensing Element	1 mm
Apparent Young's Modulus	Approx.70 GPa
Built-in Thermocouple	K (ϕ0.1)

**When ordering,
specify the model number as follows.**

KMP-8-H3-L100

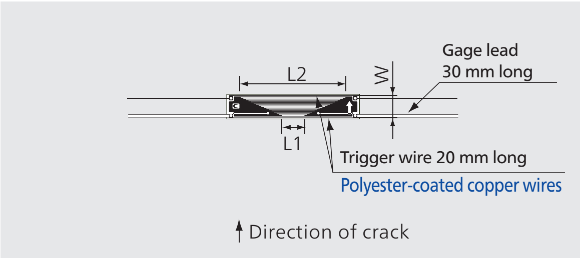
Crack Gages

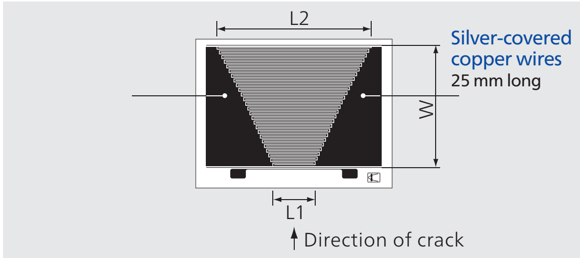
Bonded to the cracked part of a structure or material (or a part of such material where a crack is predicted to develop), the KV series gages measure the developing length and velocity of the crack.
Different from usual strain gages, the grids of the KV series gages are cut along with crack development, resulting in resistance change.

Applicable Adhesives
- CC-33A
- CC-36
- PC-600

- Progress and propagation velocity of the crack are electrically obtained.
- High response speed
- Applicable to both flat and curved surfaces
- Resistance change versus crack length is virtually linear.
- Dedicated adapter enables use of a conventional strain amplifier.
- Extremely simple and convenient compared with the conventional optical method.
- 2 trigger wires each in front of and behind the grid (KV-5C) can be used for automation of measurement.

KV ●Uniaxial



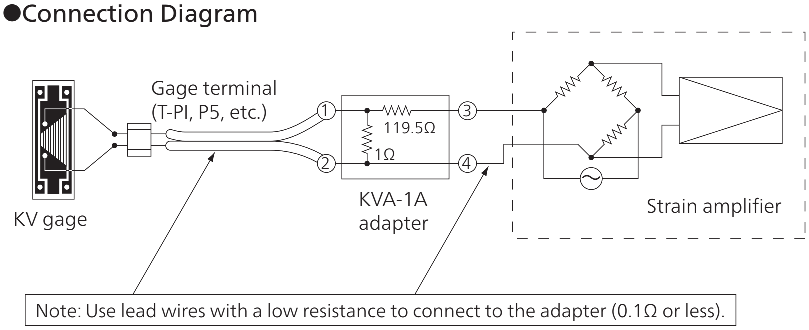


Models	KV-5C	KV-25B
Pattern	Uniaxial	Uniaxial
Base	30 × 5 mm	42 × 32 mm
Grid	L1 = 5.4 mm L2 = 25.2 mm W = 4.6 mm Pitch = 0.1 mm	L1 = 9 mm L2 = 33.6 mm W = 25.2 mm Pitch = 1 mm
Number of Grids	46	26
Resistance	Approx. 1.0 Ω	Approx. 1.0 Ω
Pieces per Pack	5	5

●Adapter KVA-1A (Optional Accessory)

Dimensions: 35×20×15mm

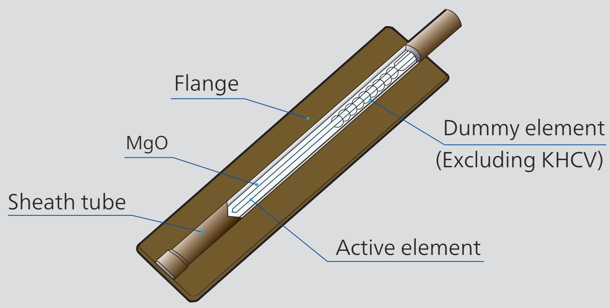
●Connection Diagram



When ordering, specify the model number as follows.

KV-5C
KV-25B

Encapsulated Gages



■Encapsulated Gages

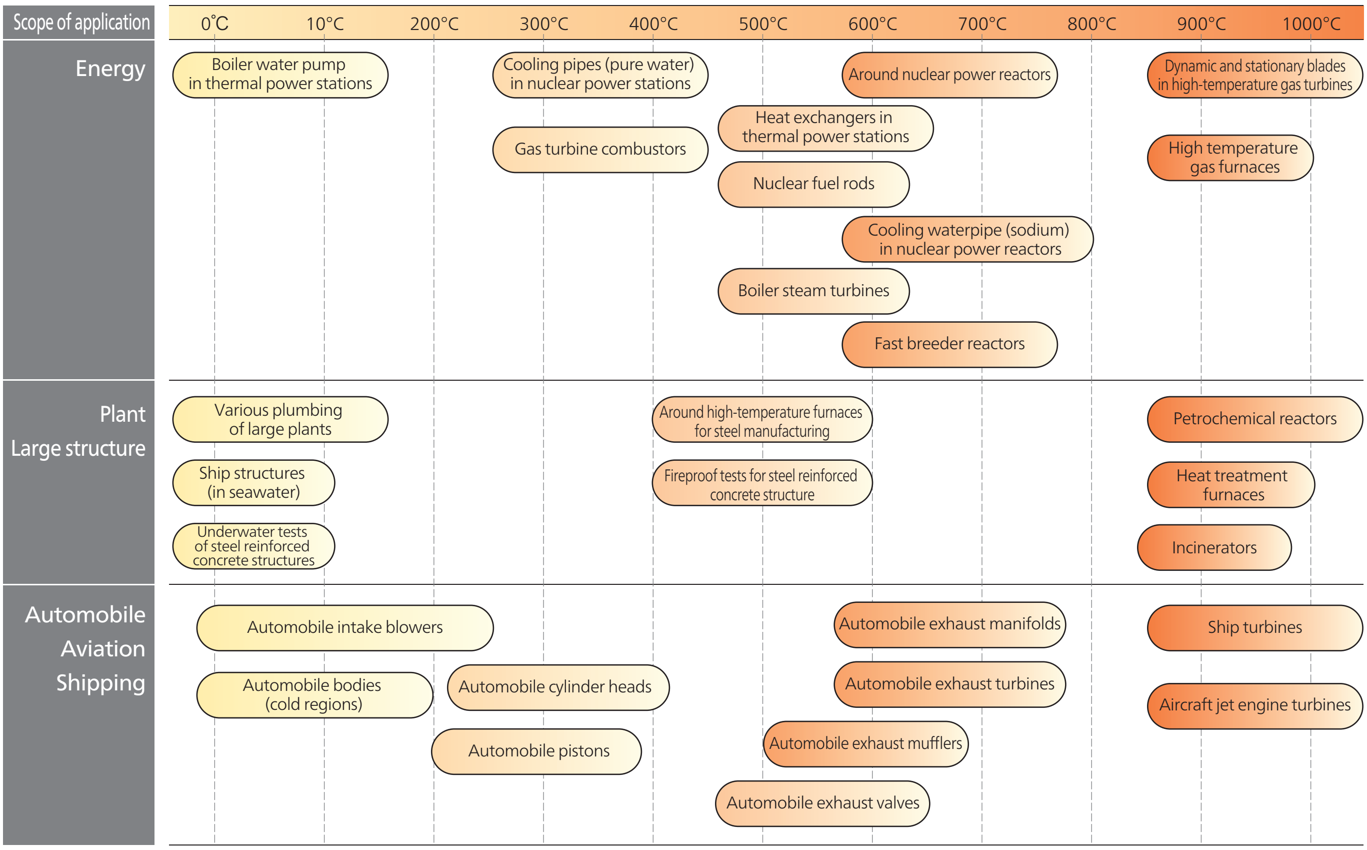
Encapsulated Gages are welded-type strain gages with a completely airtight structure. The product consists of a sensing part and a cable for signal output. The sensing part is comprised of a flange and an environmentally resistant metallic tube with encapsulated gage and insulator. The sensing part can be fixed to the measurement material by spot welding.
Using the high-temperature model, strain measurement can be conducted even in harsh environments involving high temperature, high pressure, and high humidity, such as nuclear-power generation, automobiles, and planes.
The specifications are for reference purpose only. Actual values may vary depending on operating conditions including temperatures.

- Gages and lead-wire cables (MI cables) are covered and integrated with metals (such as Inconel 600) with excellent environmental properties including heat or corrosion resistance, and can be used in high temperature and high pressure environments, seawater, and pure water.
- Provides high-precision measurement with minimal thermally-induced apparent strain (KHCX, KHCR, KHCS, KHCM, KHC).
- Detailed test data sheet allows strain measurement to be conducted with high precision.

■Types and typical applications

Type	Normal Temp.	High Temp.					
Model	KCW	KHC	KHCM	KHCS	KHCR	KHCV	KHCX
Measuring strain	Static/Dynamic					Dynamic	Static/Dynamic
Max. oprg. temp.*1	100°C	500/550°C	650°C	750°C	750°C	800°C	950°C
Temp. comp.*2	Yes					No	Yes

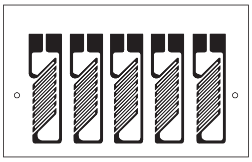
*1 Max. oprg. temp.: Max. operating temperature
*2 Temp. comp.: Temperature compensation



Custom-designed Gages

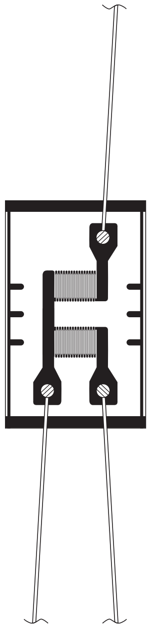
Various custom-designed gage patterns and lengths are available to meet the needs of your measurement.
For details, please contact us. Below are some illustrated examples of custom-designed strain gages.

5-element pattern
for shearing strain

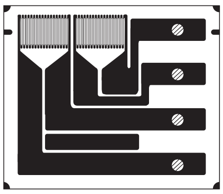


Small uniaxial pattern
with lead wires
from both ends

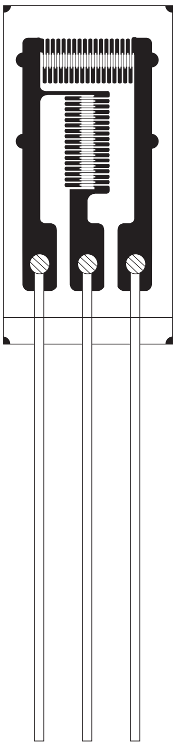
Uniaxial 2-element
half-bridge pattern



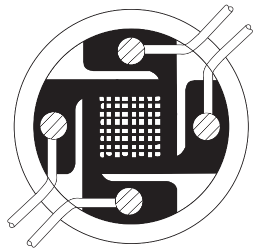
Uniaxial 2-element pattern



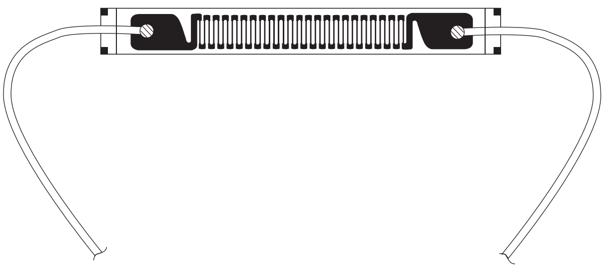
Biaxial orthogonal
half-bridge pattern



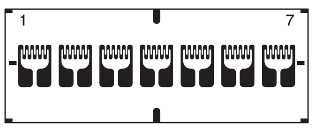
Ultra-small biaxial
0°/90° crossed pattern



Small uniaxial pattern with lead wires
from both ends



Multi-element pattern



Strain Gages for Transducers

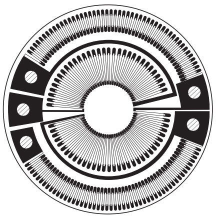
Being excellent in nonlinearity & repeatability, strain gages can be used not only to test strain, but to make transducers as well.
We use our own strain gages to produce our strain gage transducers, so naturally the transducers are of high reliability.

We provide various strain gages for our customers to make their own transducers to test load, force, pressure, torque, etc.
The following patterns are some examples.
For details, please contact us.

Diaphragm pattern

Applicable transducers

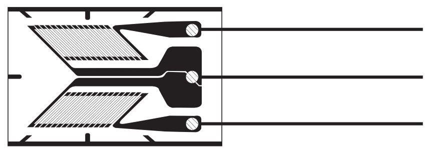
Pressure transducers



Biaxial shearing pattern

Applicable transducers

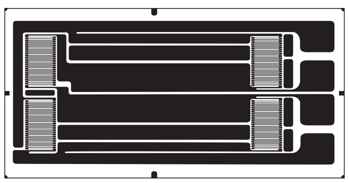
Torque transducers



Full-bridge pattern

Applicable transducers

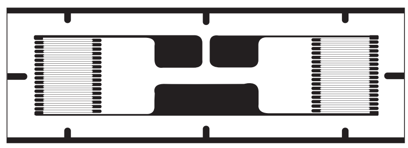
Load cells and displacement transducers



Uniaxial 2-element half-bridge pattern

Applicable transducers

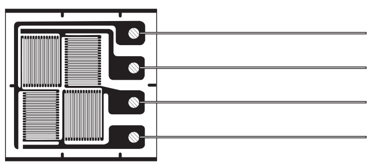
Load cells and pressure transducers



Full-bridge pattern

Applicable transducers

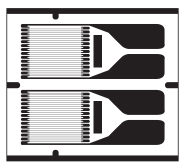
Load cells



Uniaxial 2-element pattern

Applicable transducers

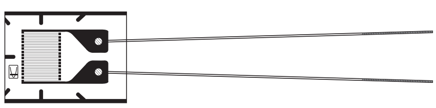
Load cells and displacement transducers



Uniaxial

Applicable transducers

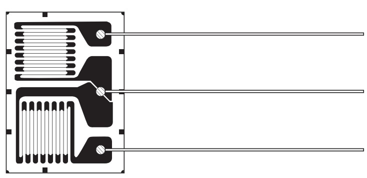
Load cells, pressure transducers,
displacement transducers,
and acceleration transducers



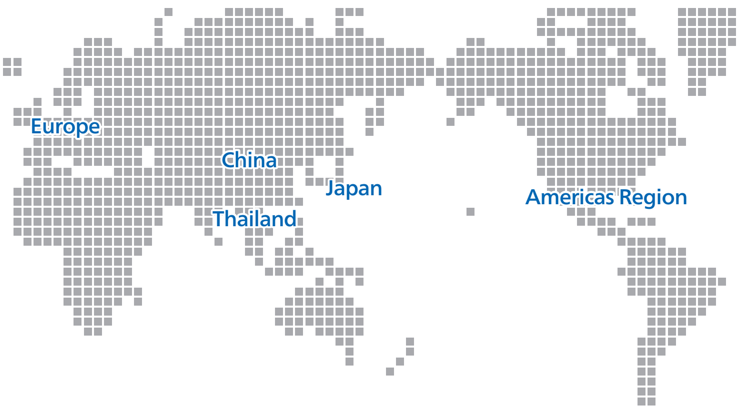
Biaxial half-bridge pattern

Applicable transducers

Load cells and pressure transducers



Sales Network



Americas Region
KYOWA AMERICAS, Inc.
TEL: +1-248-348-0348
E-mail: sales@kyowa-americas.com
Website: http://www.kyowa-ei.us/

China
KYOWA ELECTRONIC(SHANGHAI)TRADING CO.,LTD.
TEL: +86-21-64477770
E-mail: support-cn@d1.kyowa-ei.co.jp
Website: http://www.kyowa-ei.cn/

Thailand
KYOWA DENGYO(THAILAND) CO.,LTD.
TEL: +66-2-117-3760
E-mail:sales-thailand@kyowa-ei.co.th
Website:http://www.kyowa-ei.co.th/

Other Countries or Regions
Please visit below URL.
Website: http://www.kyowa-ei.com/

Kyowa Electronic Instruments Co.,Ltd.

Overseas Department:
3-5-1, Chofugaoka, Chofu, Tokyo 182-8520 Japan
TEL; +81-42-489-7220 FAX: +81-42-488-1122
E-mail: kyowaoverseas.hp@d1.kyowa-ei.co.jp
Website: http://www.kyowa-ei.com/

Safety Precautions

Be sure to observe the safety precautions given in the instruction manual, in order to ensure correct and safe operation.

• Specifications are subject to change without notice for improvement.

ISO 9001
ISO 14001
JQA-0821
JQA-EM4824

Manufacturer's Representative

KVALITEST
INDUSTRIAL

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