Strain Gages 1

Strain Gages

For General Purpose

For Waterproof

For Concrete Applications

For Composite Materials, PCB & Plastics

For Ultra-small Strains, High Temperatures & Low Temperatures

For High Elongation Strains

For Non-magnetoresistive Applications

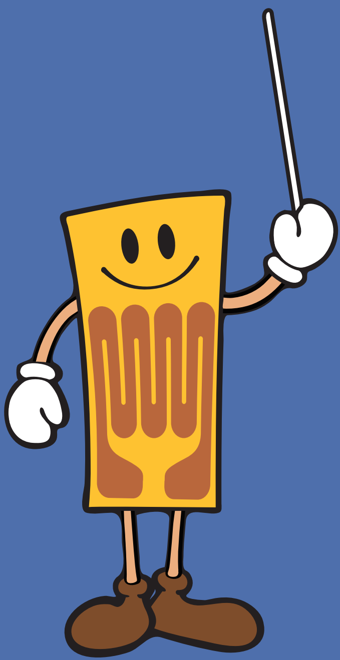
For Hydrogen Gas Environment & Bending Strains

Gages with a Protector & Embedded Gages

Crack Gages

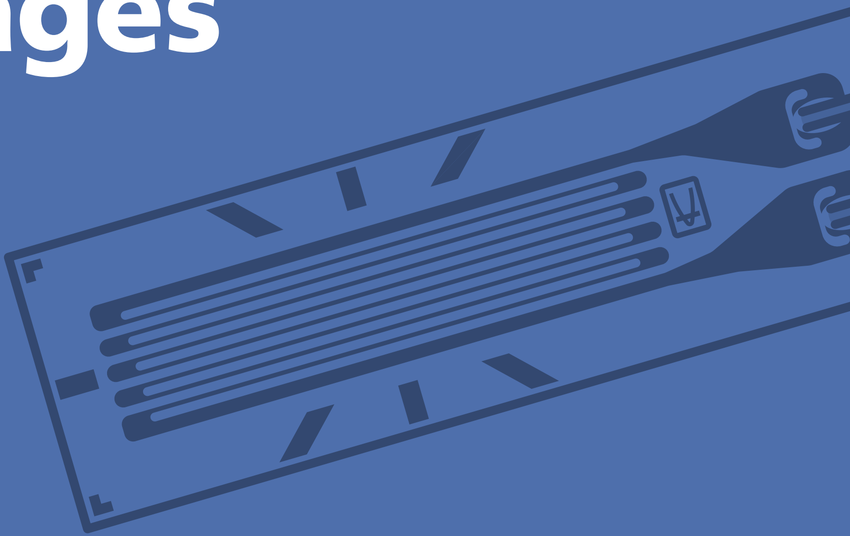
Adhesives & Coating Agents

Custom-designed Gages



*When using for special purposes, please contact us.
*For prices and delivery date, please contact us.
*For specific catalogues, please contact us.

Strain Gages

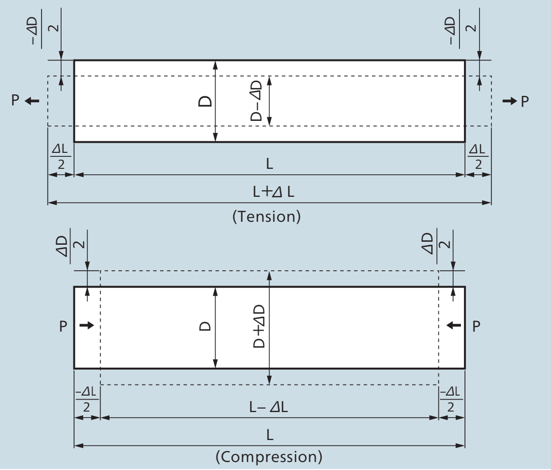


Strain Gages
Outline
Lead-wire cable
General
Waterproof
Concrete
Composite material
PCB
Plastics
Ultra-small strain
High temp.
Low temp.
High elongation
Non-magnetoresistive
Hydrogen gas
Bending
With protector
Embedded
Crack
Adhesive
Coating agent
Custom-designed

■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.) below.

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 tensile force makes 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 $\times 10^{-6}$ strain, $\mu\varepsilon$ or $\mu m/m$ 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

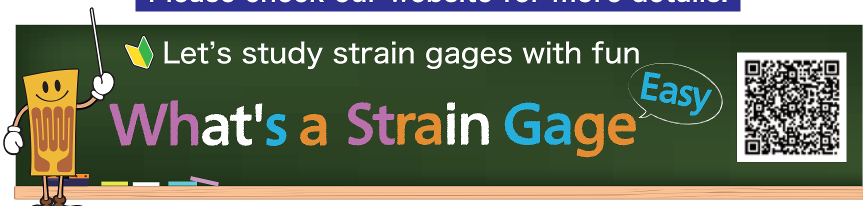
ε_1: Longitudinal strain $\frac{\Delta L}{L}$ or $-\frac{\Delta L}{L}$ (See Fig. 1)

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 page 9-1.

A strain gage detects a minute dimensional change (strain) as an electric signal. By measuring strain with the gage bonded to a material or structure, the strength or safety will be known. Thus, the strain gage is used in various industries including machinery, automobile, electric, civil engineering, medical, and food.
The strain gage is also adopted as a sensing element of force, pressure, acceleration, vibration, displacement, and torque transducers used for various purposes including measurement and control of production lines.
Kyowa produced the first Japanese-made strain gages in 1951, and based on the abundant experience and technology accumulated for these years, we manufacture a variety of high-performance, environmentally friendly strain gages.

Please check our website for more details.



www.kyowa-ei.com/eng/technical/strainbasic_course/index.html

■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.

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

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.

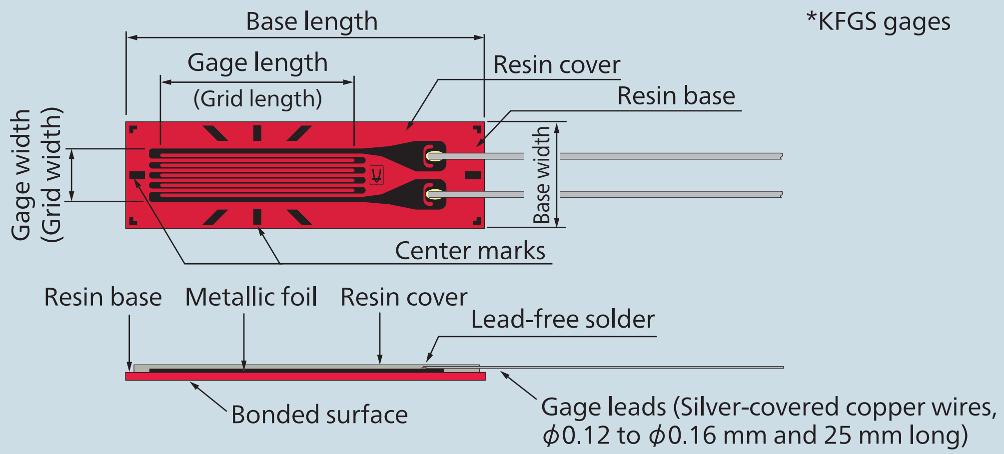
■Types of Strain Gages

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

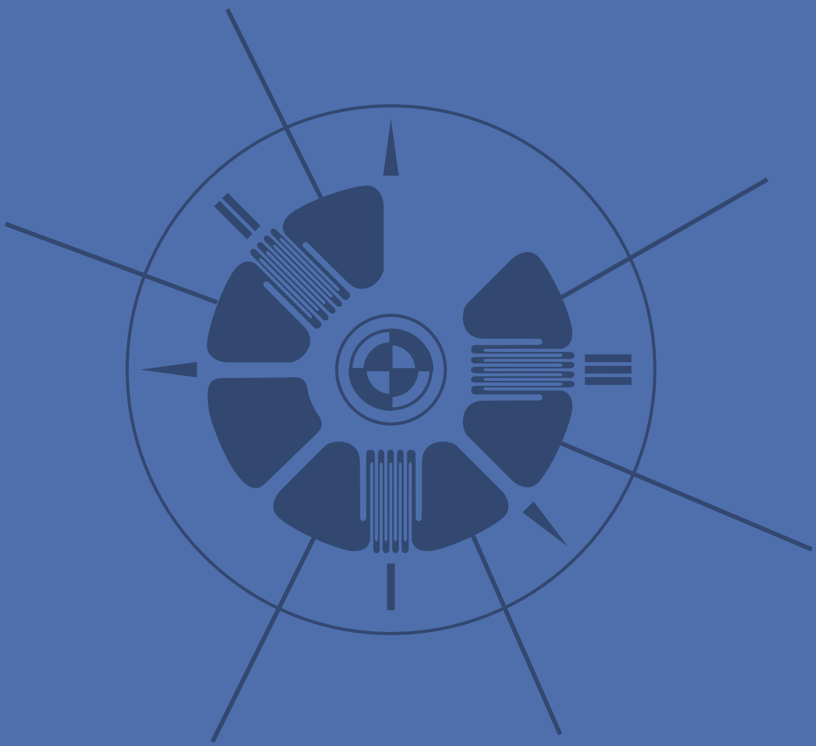
■Structure of a Strain Gage

The foil strain gage has metal foil on the electric insulator of the thin resin, and gage leads attached, as shown in Fig. 2 below.
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.

Fig. 2 Structure of a foil strain gage



*KFGS gages



■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 ΔR due to strain. Then, the output voltage is,

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

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

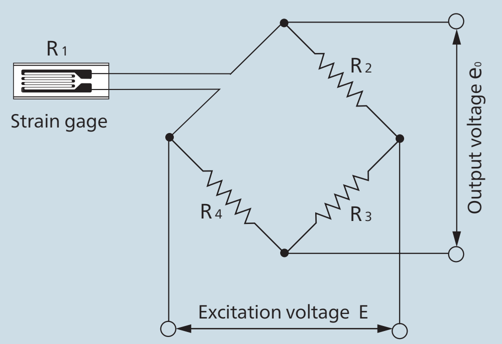
$$e_0 = \frac{R^2+R\Delta R - R^2}{(2R+\Delta R)\,2R} \cdot E$$

Since R may be regarded extremely larger than ΔR,

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

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 9-7 and 9-8.

●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" (See page 9-4).

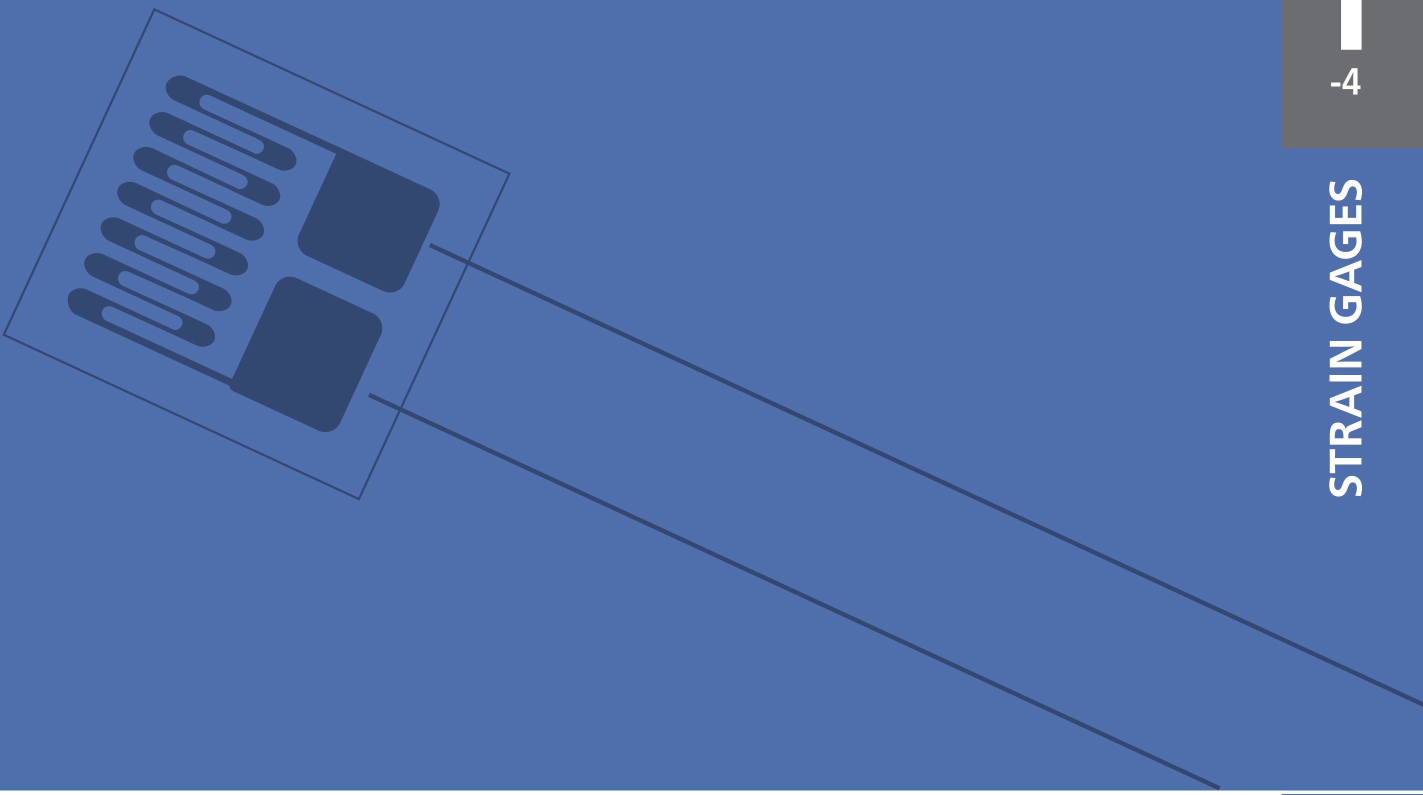


Fig. 4-1

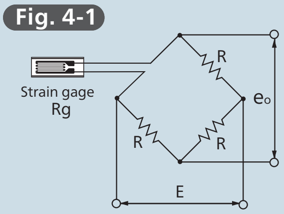


Fig. 4-2

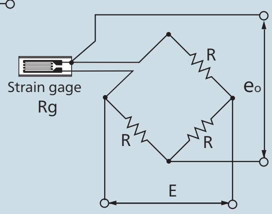
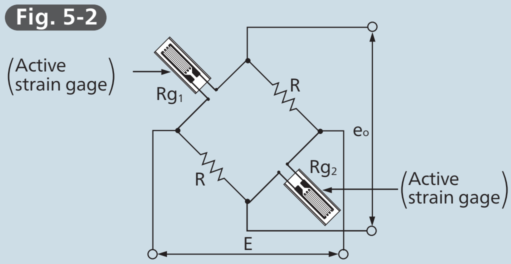


Fig. 5-2

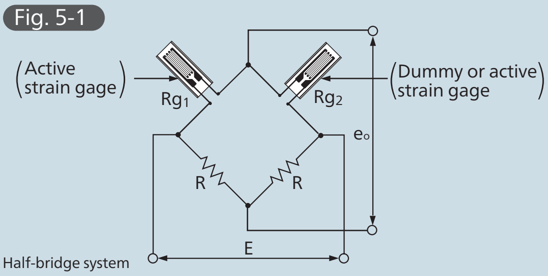


Active opposite-leg half-bridge system

●**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" (See pages 9-7 and 9-8).

Fig. 5-1

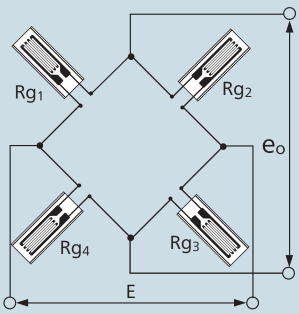


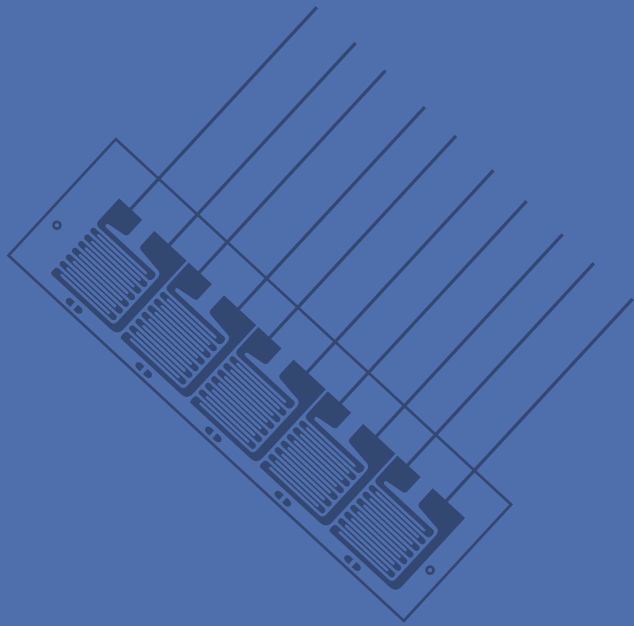
Half-bridge system

●**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" (See pages 9-7 and 9-8).

Fig. 6





■Self-temperature-compensation Gages (SELCOM Gages)

When receiving a temperature change, a strain gage bonded to a measuring object generates an apparent strain due to a difference in linear expansion coefficient between the measuring object and the resistive element of the strain gage, and a thermally-induced resistance change of the gage element. The SELCOM gage has a resistance temperature coefficient of the resistive element adjusted to match with the measuring object, thereby minimizing the apparent strain.
Kyowa's SELCOM gages have been adjusted so that, when they are bonded to suitable measured materials, the average value of the apparent strain in the self-temperature-compensation range is within ±1.8 μm/m per ˚C* (representative value).
As shown in Fig. 7, the thermally-induced apparent strain of KFGS gages is within ±1 μm/m per ˚C* in a temperature range of 20 to 40˚C in which they are most frequently used. For the principle of SELCOM gages, see page 9-4. For the models and suitable measured materials, see page 1-6.

* Representative value. For details, see the "Thermal Output" data attached with the products.

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

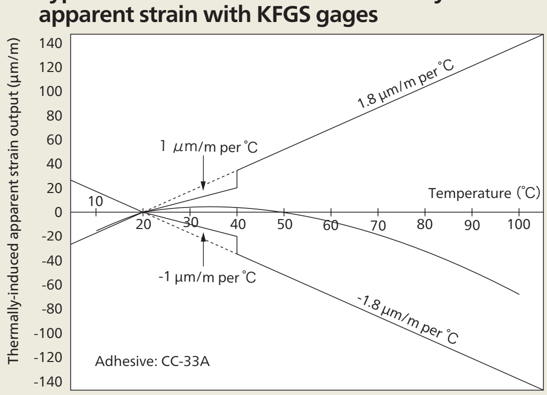


Fig. 7

■The following are described in Technical Memo. (See the chapter 9.)

- Mechanical properties of industrial materials
- Linear expansion coefficients of materials
- Examples of strain-gage measurement
- Tensile and compressive stress measurement
- Bending stress measurement
- Equation of strain on beams
- Torsional and shearing stress measurement of axis
- Temperature effect on lead wires with 2-wire system
- Influence of insulation resistance
- Resistance change of strain gages bonded to curved surfaces
- Compensation methods of different gage factors
- Misalignment effect of bonding strain gages
- Compensation methods of effect of lead wire extension
- Compensation methods of nonlinearity error of quarter-bridge system
- Methods of obtaining the magnitude and direction of principal stress (Rosette analysis)
- Generating calibration values based on the tip parallel resistance method

■Strain-gage Model Name Coding System

KFGS-2-120-C1-11 L1M3R

- Model: KFGS
- Gage Length (mm): 2 (Suffix N indicates base and gage (grid) widths are narrow.)
- Resistance (Ω): 120
- Gage Pattern: C1
- Applicable Linear Expansion Coefficient: 11
- Type and Length of Lead-wire Cable: L1M3R

Model

KFGS: General-purpose Foil Strain Gages
KFB: Strain Gages for Measuring Axial Tension of Bolts
KFGT: Foil Strain Gages with a Temperature Sensor
KFRB: 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
KFRPB: 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
KSPLB: 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
KFHB: High-temperature Foil Strain Gages
KFLB: Low-temperature Foil Strain Gages
KFEM: Ultrahigh-elongation Foil Strain Gages
KFEL: High-elongation Foil Strain Gages
KFNB: Non-inductive Foil Strain Gages
KFSB: 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

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 (KFNB 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 (KFB gage)
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° (KFNB 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 KFSB)

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 (23.4)
Brass (21.0)
Tin (23.0)
2024-T4 (23.2)

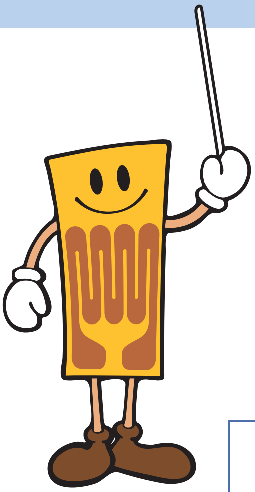
27: Magnesium alloy (27.0)

65: Acrylic resin (65.0)
Polycarbonate (66.6)

For choosing strain gages, see pages 1-7, 1-8.
For special custom-made gage patterns, see pages 1-52, 1-53.
Note: Combination of codes is limited and impossible to choose menu options at random.

Strain-gage Selection Chart

Please select strain-gage types matching to measurement purpose and environment.



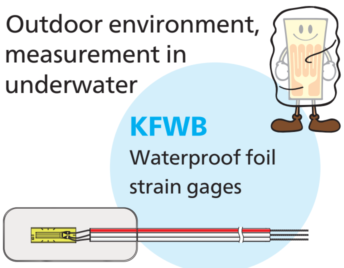
KFGS-2-120-

Model

Selecting strain-gage types matching the kind of material and the temperature of the environment.

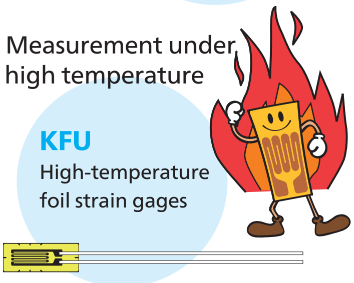
E.g.

· Outdoor environment, measurement in underwater



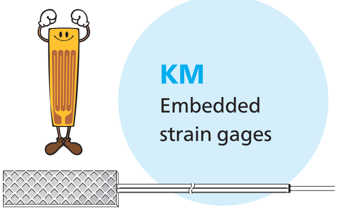
KFWB
Waterproof foil strain gages

· Measurement under high temperature



KFU
High-temperature foil strain gages

· Concrete internal strain measurement



KM
Embedded strain gages

Gage Length (mm)

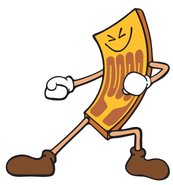
Selecting gage-length types matching the kind of materials and the environment of space.

Main Applications	Strain Gage Lengths (mm)
Strain measurement for mortar & concrete	30 to 120
Strain measurement for wood & glass	5 to 30
Strain measurement for common steel & acrylic	1 to 6
Concentrated stress measurement	0.15 to 2
Strain measurement in narrow space	0.2 to 1
Strain measurement in fast phenomena (Impact-shock, etc.)	0.2 to 1

Resistance (Ω)

Selecting strain-gage resistance matching the measurement application.

Applications	Resistance
Bending compensation	60 Ω
General-purpose strain measurement	120 Ω
For transducers	350 to 1000 Ω



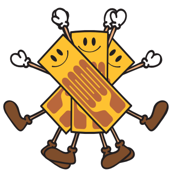
For special custom-made gage patterns, see pages 1-52, 1-53.
Note: Combination of codes is limited and impossible to choose menu options at random.

C1-11 L1M3R

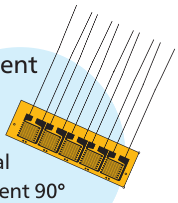
Gage Pattern

Selecting a pattern matching the measurement application.

E.g.

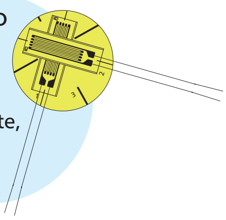


· Concentrated stress measurement



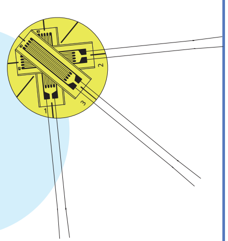
D9
Uniaxial
5-element 90°

· Measurement of Poisson ratio



D16
Biaxial 0, 90° stacked rosette, round base

· Stress analysis



D17
Triaxial 0, 90, and 45° stacked rosette, round base

Applicable Linear Expansion Coefficient

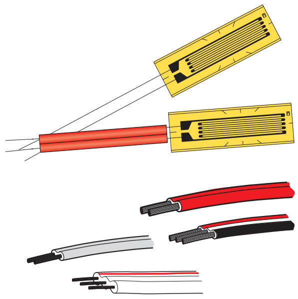
Selecting an applicable linear expansion coefficient matching the measurement application.

E.g.

- **5** Wood [lumber]
- **11** Common steel
- **16** Stainless steel
- **23** Aluminum alloy
- **27** Magnesium alloy
- **65** Plastics

Type and Length of Lead-wire Cable

Selecting a lead-wire cable matching the measurement under environments and temperature.

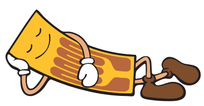


Stain gages with lead wires for labor saving

We supply these two types:

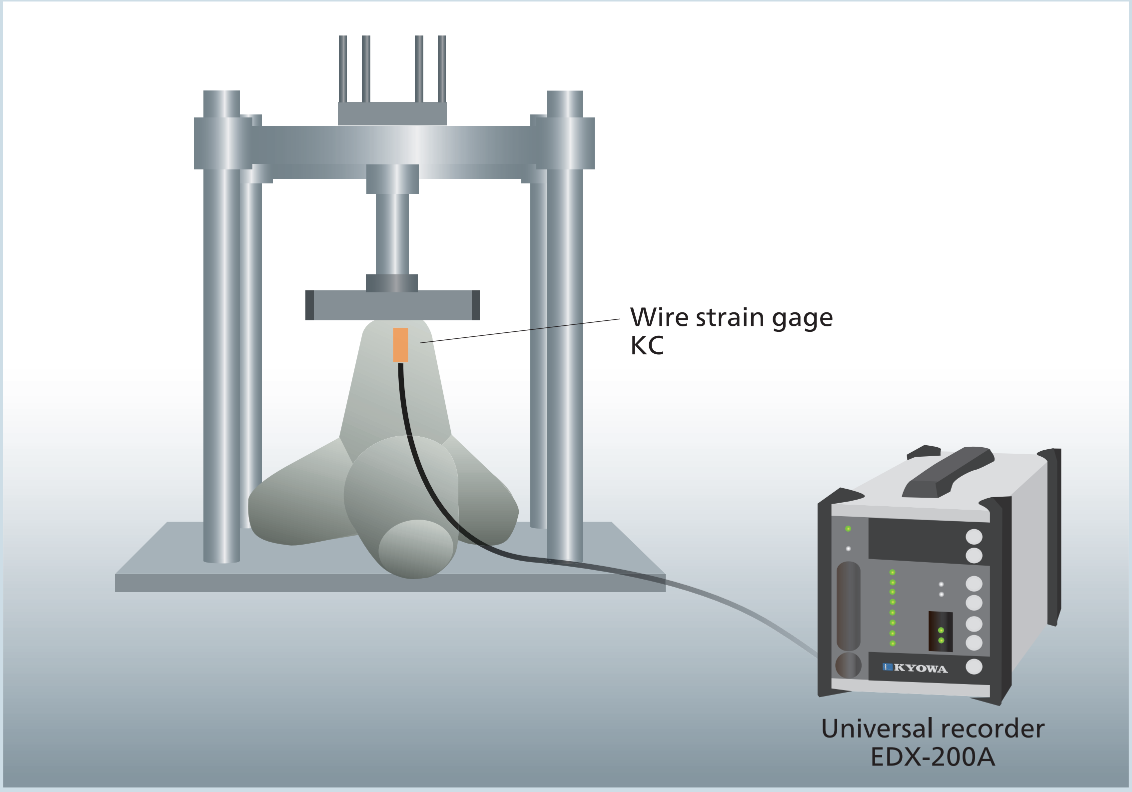
- Gages with leads only
- Gages connected with flat vinyl lead wires of required length

Gages connected with lead wires provide increases in speed and labor saving required for adhesion.
See the pages for each gage for combinations of gages and lead wires.

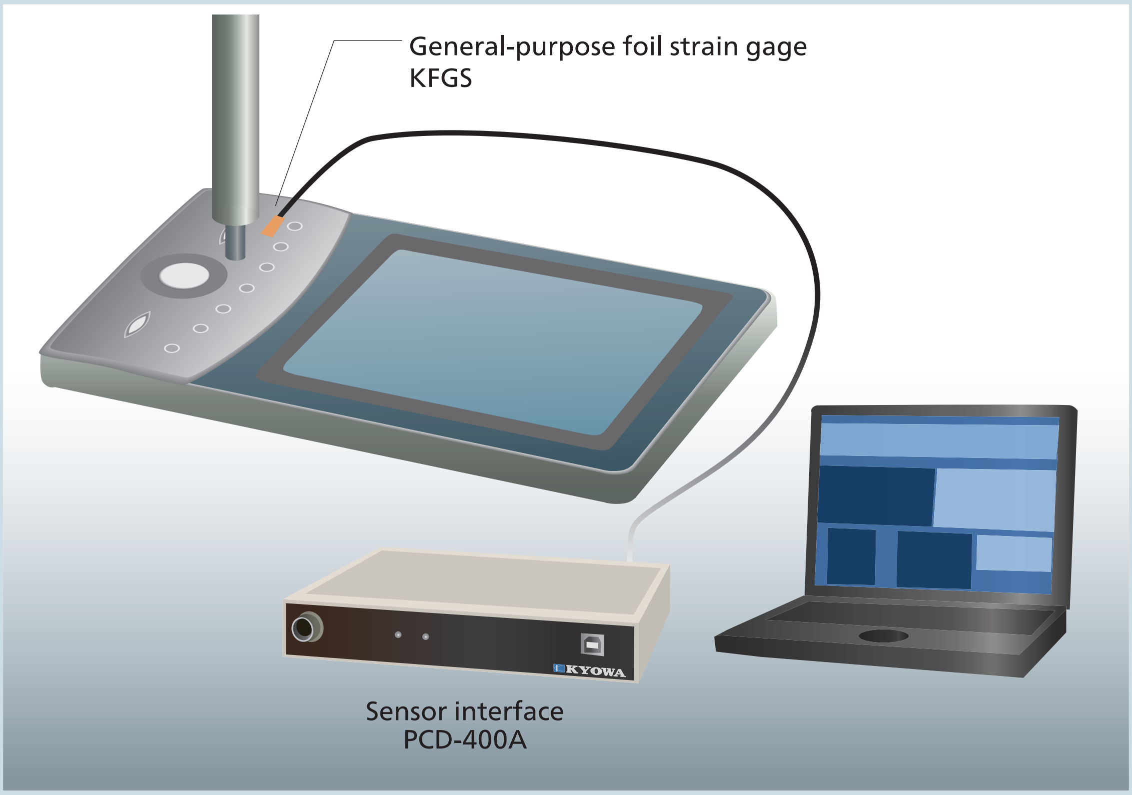


Strain-gage Measurement Examples

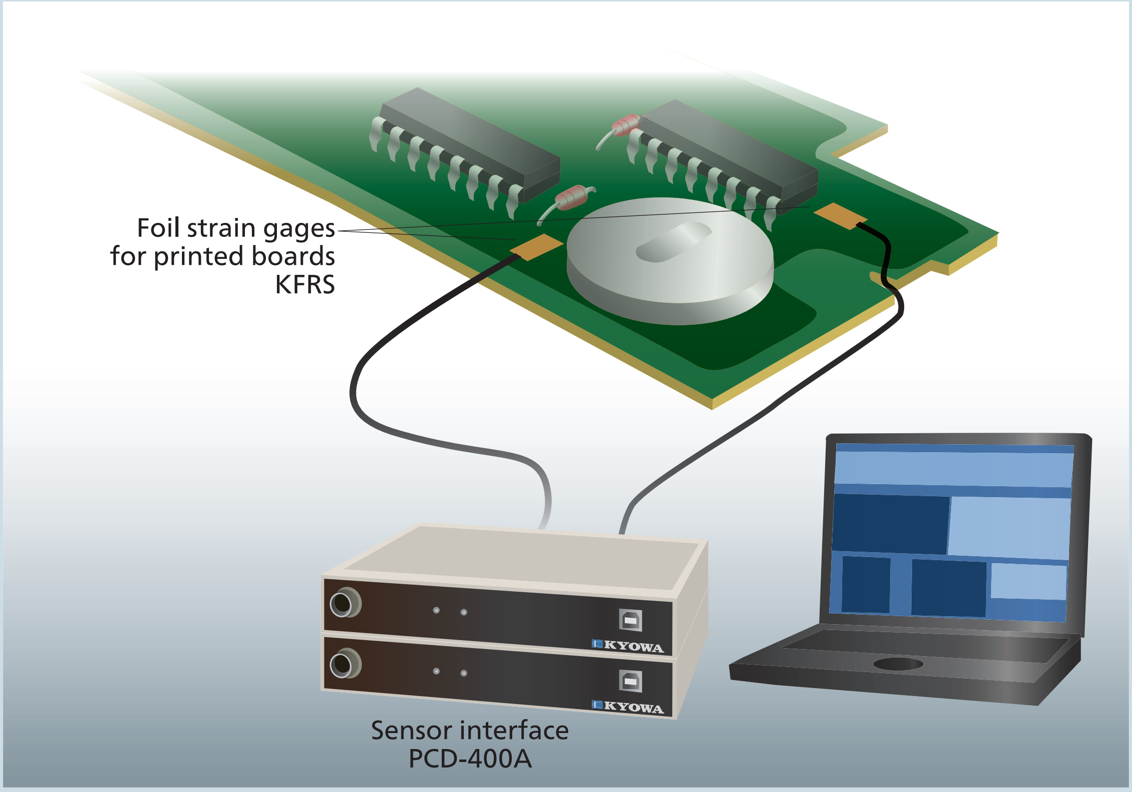
●Stress Measurement of precast concrete such as Tetrapods®



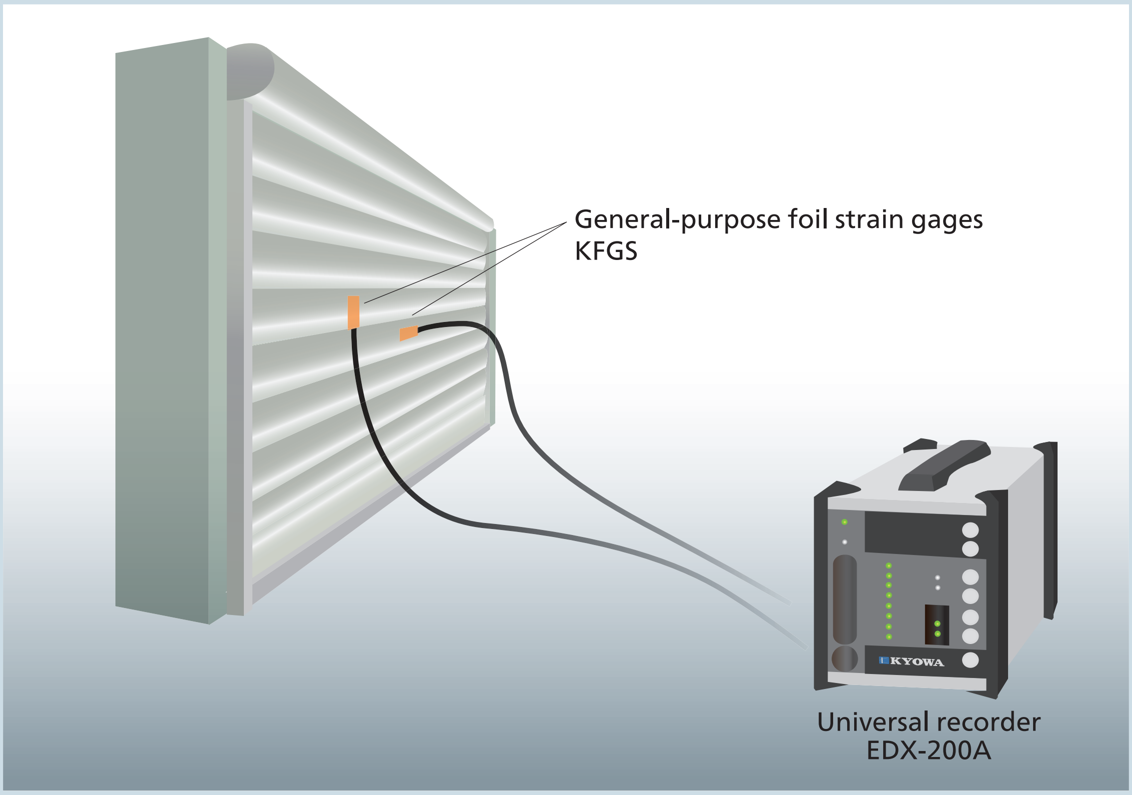
●Stress measurement of plastic parts



●Stress measurement when a PCB is mounted



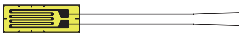
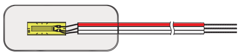
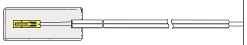
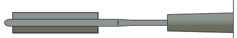
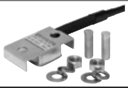
●Stress measurement during strength testing of a shutter



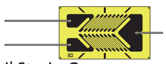
Strain-gage Selection Chart for Each Measurement Application

Metal

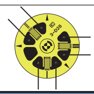
General Stress Measurement

Measurement Environment	Models	Pages
Under general environment	**KFGS**  General-purpose Foil Strain Gages	1-18
Max. elongation 5%	**KFGS**  General-purpose Foil Strain Gages	1-18
Usable at up to 150°C	**KFRB**  Foil Strain Gages	1-27
Simply waterproofed	**KFWB**  Waterproof Foil Strain Gages	1-29
Simply waterproofed	**KFWS**  Small-sized Waterproof Foil Strain Gages	1-30
Simply waterproofed, long-term stability	**KCW**  Weldable Waterproof Foil Strain Gages	1-30
Simply waterproofed, rugged	**KCH** Foil Strain Gages with a Protector 	1-45

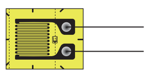
Applicable to Sensing Element of Transducers

Measurement Environment	Models	Pages
Uniaxial, high-resistance 350, 500, 1000 Ω	**KFGS**  General-purpose Foil Strain Gages	1-24
Uniaxial, for shearing strain	**KFGS-C15, C16**  General-purpose Foil Strain Gages	1-22
Biaxial, for torque measurement	**KFGS-D2, D31**  General-purpose Foil Strain Gages	1-20 1-21

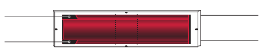
Residual Stress Measurement

Measurement Environment	Models	Pages
Installation by cutting method	**KFGS T-F7**  Foil Strain Gages with Gate Terminal	1-25
Installation by boring method	**KFGS-D28** Foil Strain Gages for Boring Method 	1-25

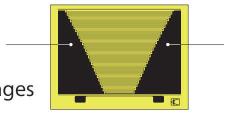
Measurement under Hydrogen Gas Environment

Measurement Environment	Models	Pages
Measurement under high-pressure hydrogen gas environment	**KFV**  Foil Strain Gage for Hydrogen Gas Environment	1-44

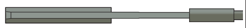
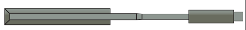
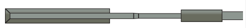
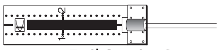
Internal Strain Measurement

Measurement Environment	Models	Pages
A box structure allowing no strain gage to be bonded on the inside of it.	**KFF**  Foil Strain Gages for Bending Strain Measurement	1-44

Crack Gages

Measurement Environment	Models	Pages
Measurement of the progress and propagation speed of crack	**KV** Crack Gages 	1-46

Measurement at High Temperature

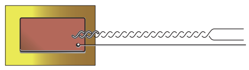
Measurement Environment	Models	Pages
Up to 950°C	**KHCX**  Encapsulated Gages	1-38
Up to 800°C	**KHCV**  Encapsulated Gages	1-38
Up to 750°C	**KHCR**  Encapsulated Gages	1-38
Up to 750°C	**KHCS**  Encapsulated Gages	1-38
Up to 650°C	**KHCM**  Encapsulated Gages	1-38
Up to 550°C	**KHC**  Encapsulated Gages	1-38
Up to 350°C	**KFU**  High-temperature Foil Strain Gages	1-39
Up to 350°C	**KH**  High-temperature Foil Strain Gages	1-39
Up to 250°C	**KFHB**  High-temperature Foil Strain Gages	1-40

Measurement at Low Temperature

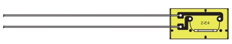
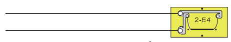
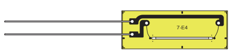
Measurement Environment	Models	Pages
Measurement at LHe temp.* (-269°C)	**KFLB**  Low-temperature Foil Strain Gages	1-41

* LHe temp.: Liquid Helium temperature

Measurement under High Electric Field

Measurement Environment	Models	Pages
Measurement under high electric field accompanying induction noise	**KFSB**  Shielded Foil Strain Gages	1-43

Applicable to Ultra-small Strain Measurement and Highly-sensitive Element of Transducers

Measurement Environment	Models	Pages
Measurement of <100μm/m under little temperature change environment	**KSPB**  Semiconductor Strain Gages	1-36
Measurement of <100μm/m under little temperature change environment	**KSN**  Self-temperature-compensation Semiconductor Strain Gages	1-36
Measurement of <100μm/m under little temperature change environment	**KSPLB**  Ultra Linear Semiconductor Strain Gages	1-37

Composite Materials, Printed Boards, and Plastics

General Stress Measurement

Measurement Environment	Models	Pages
Applicable linear expansion coefficient $1 \text{ to } 9\times10^{-6}$/°C	**KFRPB** Foil Strain Gages for Composite Materials	**1-33**
Applicable linear expansion coefficient 13×10^{-6}/°C	**KFRS** Foil Strain Gages for Printed Boards	**1-34**
Applicable linear expansion coefficient 65×10^{-6}/°C	**KFP** Foil Strain Gages for Plastics	**1-35**
For strain measurement inside resin	**KMP** Embedded Gage	**1-45**

Metal, Plastics, Lumber and Rubber

High-elongation Gages

Measurement Environment	Models	Pages
Max. elongation Approx. 20% to 30%	**KFEM** Ultrahigh-elongation Foil Strain Gages	**1-42**
Max. elongation Approx. 10 to 15%	**KFEL** High-elongation Foil Strain Gages	**1-42**

Wood [Lumber], Plaster, Paper, etc.

General Stress Measurement

Measurement Environment	Models	Pages
Lumber (Applicable linear expansion coefficient 5×10^{-6}/°C)	**KFGS** General-purpose Foil Strain Gages	**1-19**

Various Materials

General Stress Measurement

Measurement Environment	Models	Pages
Simultaneous measurement of strain and temperature	**KFGT** Foil Strain Gages with a Temperature Sensor	**1-26**

Metal Bolts

Measurement of Axial Tension of Bolts

Measurement Environment	Models	Pages
Tightening stress measurement of bolts	**KFB** Strain Gages for Measuring Axial Tension of Bolts	**1-26**

Impact Strain Measurement

Measurement Environment	Models	Pages
Measurement with no amplifier used	**KSPH** High-output Semiconductor Strain Gages	**1-37**

Custom-designed Gages

Measurement Environment	Models	Pages
For making transducers	**Diaphragm pattern**	**1-53**

Concentrated Stress Measurement

Measurement Environment	Models	Pages
Measurement of stress distribution at 8mm to 12mm intervals	**KFGS-D9, D19, D39** Pitch: 2 mm or 3 mm	**1-22**
Measurement of stress distribution at 2mm intervals	**KFRB-D9, D19** Pitch: 0.5 mm	**1-28**

Measurement under High Magnetic Field

Measurement Environment	Models	Pages
Measurement under DC magnetic field at low temperature	**KFLB** Low-temperature Foil Strain Gages	**1-41**
Measurement under DC magnetic field at mid temperature	**KFRB** Foil Strain Gages	**1-27**
Measurement under DC magnetic field at high temperature	**KFHB** High-temperature Foil Strain Gages	**1-40**
Measurement under DC/AC magnetic field	**KFNB** Non-inductive Foil Strain Gages	**1-43**

Concrete, Mortar, etc.

General Stress Measurement

Measurement Environment	Models	Pages
Simply waterproofed	**KFWB** Waterproof Foil Strain Gages	**1-29**
Simply waterproofed	**KFWS** Small-sized Waterproof Foil Strain Gages	**1-30**
Surface strain meas. (Small aggregate)	**KFGS** General-purpose Foil Strain Gages Length: 10 to 30 mm	**1-31**
Surface strain meas. (Large aggregate)	**KC** Wire Strain Gages Length: 60 to 120 mm	**1-31**
Internal strain measurement	**KM** Embedded Strain Gages	**1-32**
Self-shrinkage strain measurement	**KMC** Concrete-embedded Strain Gages	**1-32**

Major Properties of Kyowa Strain Gages

Application	Models/series designation		Materials: Resistive elements	Materials: Bases	Operating temperature in combination with major adhesives after curing (℃) *1	Self-temperature-compensation (℃)	Applicable linear expansion coefficients (x10⁻⁶/℃)	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%	1.2×10⁷	1-18
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%	1.2×10⁷	1-20
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%	1.2×10⁷	1-31
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	—	—	1-22
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	—	—	1-25
For general stress measurement	Strain Gages for Measuring Axial Tension of Bolts KFB		CuNi alloy foil	Polyimide	EP-370 Normal temp. to 50	—	—	—	—	1-26
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%	1×10⁶	1-26
For general stress measurement	Foil Strain Gages KFRB	Strain measurement at mid temperature, for transducers	NiCr alloy foil	Polyimide	PC-600 -196 to 150 CC-33A -196 to 120 EP-340 -55 to 150	0 to 150	11, 16, 23	2.2%	1×10⁶	1-27
For general stress measurement	Foil Strain Gages KFRB	Concentrated stress measurement	NiCr alloy foil	Polyimide	PC-600 -196 to 150 CC-33A -196 to 120 EP-340 -55 to 150	0 to 150	11, 16, 23	—	—	1-28
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%	3×10⁴	1-29
For general stress measurement	Small-sized Waterproof Foil Strain Gages KFWS		CuNi alloy foil	Polyimide	CC-33A -10 to 80 EP-340 -10 to 80	10 to 80	11, 16, 23	5.0%	3×10⁴	1-30
For general stress measurement	Weldable Waterproof Foil Strain Gages KCW		NiCr alloy foil	Stainless steel	(Spot welding) -20 to 100	10 to 90	11	—	—	1-30
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%	1.5×10⁵	1-31
For general stress measurement	Embedded Strain Gages KM		CuNi alloy	Acrylate	(Embedment) -10 to 70	0 to 50	11	0.2%	—	1-32
For general stress measurement	Concrete-embedded Strain Gages KMC		CuNi alloy wire	Silicone	(Embedment) Normal temp. to 70	—	—	0.3%	—	1-32
For composite materials, plastics and rubber	Foil Strain Gages for Composite Materials KFRPB		NiCr alloy foil	Polyimide	EP-34B -55 to 200 CC-33A -196 to 120	0 to 150	1, 3, 6, 9	2.2%	1×10⁶	1-33
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%	2×10⁶	1-34
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%	1×10⁶	1-35
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 2×10⁶	1-36
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 2×10⁶	1-36
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 2×10⁶	1-36
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 2×10⁶	1-37
For ultra-small strain measurement	Ultra Linear Semiconductor Strain Gages KSPLB		P type Si	Polyimide	CC-33A -50 to 120 EP-340 -50 to 150	—	—	0.15%	*A 2×10⁶	1-37

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

	Models/ series designation	Materials: Resistive elements	Materials: Bases	Operating temperature in combination with major adhesives after curing (℃) *1	Self-temperature-compensation (℃)	Applicable linear expansion coefficients ($x10^{-6}$/℃)	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	—	—	1-38
	Encapsulated Gages KHCV	Heat-resistant special alloy wire	Heat-resistant metal	(Spot welding) 25 to 800	—	— (Dynamic measurement)	—	—	1-38
	Encapsulated Gages KHCR	Heat-resistant special alloy wire	Heat-resistant metal	(Spot welding) 25 to 750	25 to 750	11, 13, 16	—	—	1-38
	Encapsulated Gages KHCS	Heat-resistant special alloy wire	Heat-resistant metal	(Spot welding) -196 to 750	25 to 750	11, 13, 16	—	—	1-38
	Encapsulated Gages KHCM	Heat-resistant special alloy wire	Heat-resistant metal	(Spot welding) -196 to 650	25 to 650	11, 13, 16	—	—	1-38
	Encapsulated Gages KHC	NiCr alloy wire	Heat-resistant metal	(Spot welding) -196 to 550	Normal temp. to 500	11, 13, 16	—	—	1-38
	High-temperature Foil Strain Gages KFU	NiCr alloy foil	Polyimide	PI-32 -30 to 350	10 to 300	11, 16, 23	1.9%	*A 1.5×10^5 (300℃)	1-39
	High-temperature Foil Strain Gages KH	NiCr alloy foil	Stainless steel	(Spot welding) -50 to 350	10 to 300	11, 16	0.5%	*B 1×10^7	1-39
	High-temperature Foil Strain Gages KFHB	NiCr alloy foil	Polyimide	PC-600 -196 to 250 EP-34B -55 to 200 PI-32 -196 to 250	10 to 250	11, 16, 23	2.1%	—	1-40
For low temp.	Low-temperature Foil Strain Gages KFLB	NiCr alloy foil	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	1-41
For large strain measurement	Ultrahigh-elongation Foil Strain Gages KFEM	CuNi alloy foil	Polyimide	CC-36 -20 to 80	—	—	20% to 30%	—	1-42
	High-elongation Foil Strain Gages KFEL	CuNi alloy foil	Polyimide	CC-36 -10 to 80	—	—	15%	1×10^6	1-42
For antimagnetic applications	Non-inductive Foil Strain Gages KFNB	NiCr alloy foil	Polyimide	PC-600 -196 to 150 CC-33A -196 to 120	0 to 150	11, 16, 23	1%	1×10^4	1-43
	Shielded Foil Strain Gages KFSB	CuNi alloy foil (120 Ω) NiCr alloy foil (350 Ω)	Polyimide	CC-33A -196 to 120 EP-340 -55 to 120	10 to 100	11, 16, 23	0.5%	1×10^4	1-43
For hydrogen gas environments	Foil Strain Gage for Hydrogen Gas Environment KFV	Special alloy foil	Polyimide	PC-600 -30 to 80	—	—	—	—	1-44
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	1-44
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	1-45
Embedded	Embedded Gage KMP		Aluminum	—	20 to 120	—	—	—	1-45
Crack	Crack Gages KV	CuNi alloy foil	Paper base+ phenol-epoxy	CC-33A CC-36 PC-600	—	—	—	—	1-46

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.

Strain Gages
Outline
Lead-wire cable
General
Waterproof
Concrete
Composite material PCB Plastics
Ultra-small strain High temp. Low temp.
High elongation
Non-magnetoresistive
Hydrogen gas Bending
With protector Embedded
Crack
Adhesive Coating agent
Custom-designed

Strain Gages with Pre-attached Lead-wire Cables

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.

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

	Model of strain gage		Code of lead-wire cable
E.g.	KFGS-2-120-C1-11	(space)	L1M3R

Models of Strain Gage		KFGS,KFRB, KFRPB,KFRS,KFP, KFLB,KFEL,KFEM	KFGS,KFRB, KFRPB,KFRS, KFP,KFLB	KFGS,KFRB,KFWB,KFWS,KC, KFRPB,KFRS,KFP,KFEL,KFEM			
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 cm	N30C2	N30C3	L30C2R	L30C2S	L30C3R	L30C3S
	1 m	N1M2	N1M3	L1M2R	L1M2S	L1M3R	L1M3S
	3 m	―	―	L3M2R	L3M2S	L3M3R	L3M3S
	5 m	―	―	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				Red, Red		Red stripe (Independent), White, White	

Models of Strain Gage		KFGS,KFRB,KFRPB, KFRS,KFLB		KFNB,KFSB	KFRPB,KFHB, KFLB	KFU,KFHB
Type of lead-wire cables		Mid-temperature 2-wire cable -100 to 150°C	Mid-temperature 3-wire cable -100 to 150°C	Vinyl-coated normal-temperature low-noise 3-wire cable -10 to 80°C	Fluoroplastic-coated high/low-temp. 3-wire cable -269 to 250°C	High/low-temperature 3-wire cable -269 to 350°C
Lengths of lead-wire cable (*)	15 cm	R15C2	R15C3	J15C3	F15C3	H15C3
	30 cm	R30C2	R30C3	J30C3	F30C3	H30C3
	1 m	R1M2	R1M3	J1M3	F1M3	H1M3
	3 m	R3M2	R3M3	J3M3	F3M3	H3M3
	5 m	R5M2	R5M3	J5M3	F5M3	H5M3
Models, etc.		L-11	L-12	L-13	L-3	L-17
Coating color		Grey, Grey	Red (Independent), White, Black	Red (Independent), White, Black	Red (Independent), Blue, Blue	Black (Independent), Yellow, Green

＊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 KFHB: The advance ribbon wire section is covered with the 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.

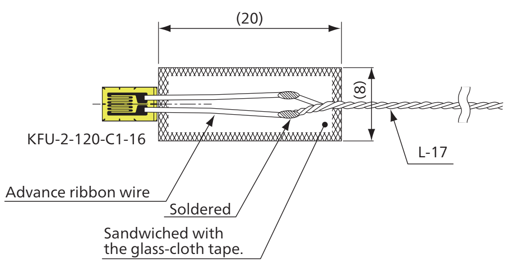


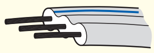
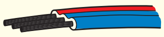
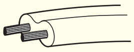
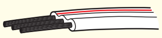
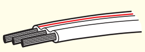
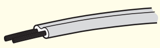
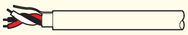
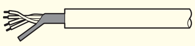
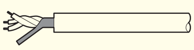
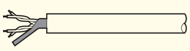
Figure: Example of lead-wire cable of a KFU gage

See page 1-30 for KCW, page 1-32 for KM.
See page 1-39 for KH.

For selecting other lead-wire cables, see page 1-16.

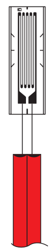
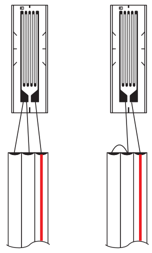
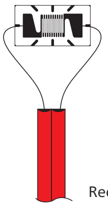
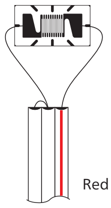
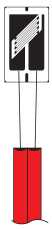
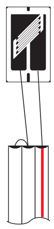
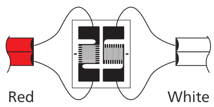
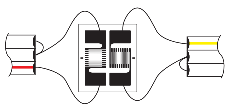
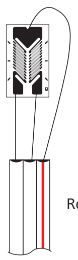
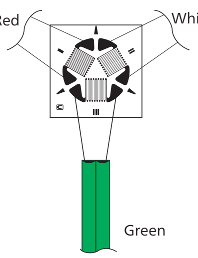
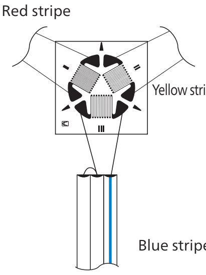
Lead-wire Cables

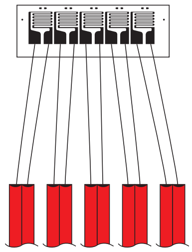
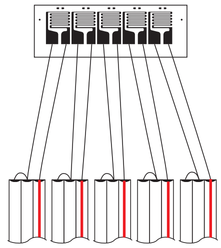
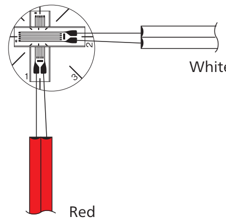
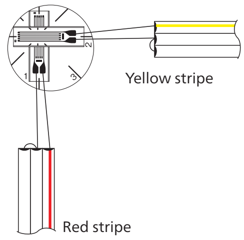
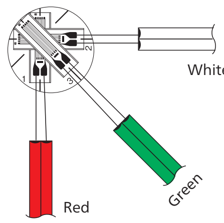
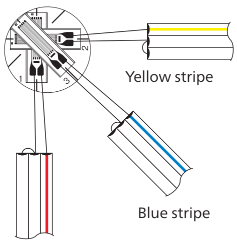
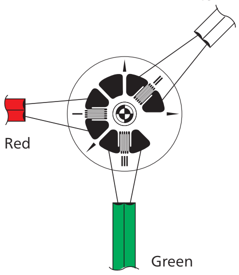
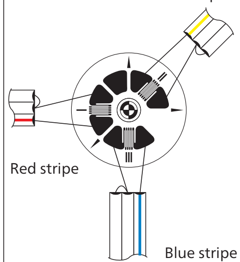
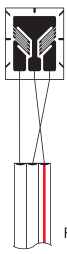
●L-type lead-wire cables

Operating Temperature	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°C	L-1	High-temperature lead wire 	CuNi alloy	0.07	1／ϕ0.30	14.20	ϕ0.50	50
−10 to 80°C	L-2	Vinyl-coated flat 3-wire cable 	Copper	0.30	12／ϕ0.18	0.12	ϕ2.30	100
−269 to 250°C	L-3	Fluoroplastic-coated high/low-temp. 3-wire cable 	Tin-plated copper	0.14	7／ϕ0.16	0.28	ϕ0.98	50
−10 to 80°C	L-5	Vinyl-coated flat 2-wire cable 	Copper	0.50	20／ϕ0.18	0.07	ϕ2.50	
−10 to 80°C	L-6 (*1)	Vinyl-coated flat 2-wire cable 	Copper	0.08	7／ϕ0.12	0.44	ϕ1.00	
−10 to 80°C	L-7 (*2)	Vinyl-coated flat 3-wire cable 	Copper	0.08	7／ϕ0.12	0.44	ϕ1.00	
−10 to 80°C	L-9 (*1)	Vinyl-coated flat 2-wire cable 	Copper	0.11	10／ϕ0.12	0.32	ϕ1.00	
−10 to 80°C	L-10 (*2)	Vinyl-coated flat 3-wire cable 	Copper	0.11	10／ϕ0.12	0.32	ϕ1.00	100
−100 to 150°C	L-11	Mid-temperature 2-wire cable 	Tin-plated copper	0.08	7／ϕ0.12	0.44	ϕ0.86	
−100 to 150°C	L-12	Mid-temperature 3-wire cable 	Tin-plated copper	0.08	7／ϕ0.12	0.44	ϕ0.86	
−10 to 80°C	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°C	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°C	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°C	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°C	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

Examples of vinyl-coated flat wire to connect gages

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 or C3	 Red	 Red stripe
C15 or 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 or D19 or D39	 Red	 Red stripes
D16	 White Red	 Yellow stripe Red stripe
D17	 White Red Green	 Yellow stripe Blue stripe Red stripe
D28	 White Red Green	 Yellow stripe Red stripe Blue stripe
D31		 Red stripe