TML

TML Pam E-101S

Precise & Flexible

Strain Gauges

- A asphalt
- M metal
- M mortar
- C concrete
- R rock
- G glass
- C ceramic
- W wood
- G gypsum
- P plastics
- C composite
- B bolt

TML Tokyo Sokki Kenkyujo Co., Ltd.

INTRODUCTION

This catalog presents the full range of TML standard strain gauges and associated products,
including bonding adhesives and coating materials,
manufactured by Tokyo Sokki Kenkyujo Co., Ltd.
It also describes how to find specific strain gauges, introduces typical applications,
and defines the most commonly used technical terms.

Prior to using the catalog, please check the information listed below.

CHANGES IN SPECIFICATIONS

In the interest of product improvement, the specifications in this catalog are subject to change without prior notice.

DIMENSIONS

Dimensions are mainly given in millimeters. Strain gauge patterns are shown in actual size, with enlargements of some miniature patterns.

PRICES

Prices are not listed in this catalog. For price information or orders, please contact TML or your local representatives.

HANDLING STRAIN GAUGES

1. The technical data supplied herein do not reflect the influence of the lead wire. The data must be corrected in accordance with the effect caused by the lead wire.
2. The service temperature of a strain gauge depends on the operating temperature of the adhesive, etc.
3. Insulation resistance should be checked at a voltage of less than 50 V.
4. Do not apply an excessive force to the gauge leads.
5. Apply adhesive to the back of the strain gauge and attach the gauge to the specimen.
6. The back of each strain gauge has been washed and degreased. Do not contaminate it by touching it directly.
7. After unpacking the strain gauge, store it in a dry place.

HANDLING BONDING ADHESIVES AND COATING MATERIALS

1. Read the operation manual carefully before using bonding adhesives and coating materials.
2. After using an adhesive, wipe all remaining adhesive off of the container and nozzle with a cloth, and replace the cap.
3. After using an adhesive, put the container back in the package and store it in a cool, dark place away from direct flames.
4. If an adhesive contacts skin or clothing, wash well with soap and water.

If you have any questions about this catalog, please contact TML or your local representatives.

Tokyo Sokki Kenkyujo Co., Ltd.
www.tml.jp/e

8-2, Minami-Ohi 6-Chome, Shinagawa-Ku, Tokyo 140-8560, Japan
Tel:Tokyo 03-3763-5611 Fax:Tokyo 03-3763-5713
E-mail: **sales@tml.jp**

Your local representatives:

TML STRAIN GAUGES

TML Strain Gauges are widely used for physical force measurements in mechanical, marine, aircraft and civil engineering as well as the fields of architecture, automobiles, and medical science.
Strain is measured to determine the degree and behaviour of forces such as stress or load.
Strain gauges are easy to use and offer a high degree of accuracy and stability.
They generally have a simple construction consisting of a fine electric resistance wire or photo-etched metallic resistance foil, together with an electrical insulation base and a set of gauge leads.
Weldable strain gauges are made by encapsulating the sensing element into a metal tube for use in harsh environments.
Backed by our long experience and advanced technology, TML products are the world's most widely used strain gauges for engineering applications.

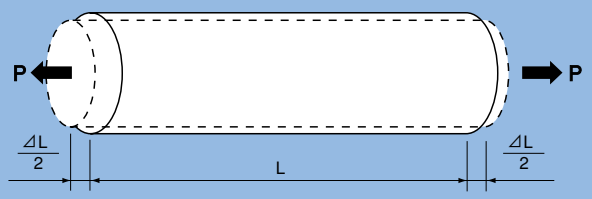
Table of contents

GENERAL DESCRIPTION

TML Strain Gauges are widely used for physical force measurement in mechanical, marine, aircraft and civil engineering as well as the fields of architecture, automobiles, and medical science.
Strain is measured; to determine a degree of deformation due to mechanical strain to determine forces such as stress or load and the degree of safety of a material or of a structural element that uses that material.
There are a number of ways of measuring strain mechanically and electrically, but the vast majority of stress measurement is carried out using strain gauges due to their superior measurement characteristics. Backed by our long experience and advanced technology, TML lines up a lot of strain gauges to meet with your needs.

What is STRAIN

When a material is streched (or compressed), the force used generates a corresponding stress inside. This stress in turn generates a proportional tensile strain (or compressive strain) which deforms the material by L+⊿L (or L−⊿L). Where L is the original length of the material. When this occurs, the ratio of ⊿L to L is called strain.



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

ε : strain
L : Original length of material
⊿L : Increment due to force P

Example) when a material of 100mm length deforms by 0.1mm length, it generates strain as follows.

$$\varepsilon = \frac{\Delta L}{L} = \frac{0.1}{100} = 0.001 = 1000 \times 10^{-6}$$

What is STRAIN GAUGE

External force applied to a ferritic material generates physical deformation and electrical resistance change of the material. In case that such material is sticked onto test specimen via electrical insulation, the material produces a change of electrical resistance corresponding to the deformation. Strain gauges consist of electrical resistance material and measure proportional strains to the resistance changes.

STRAIN GAUGE PRINCIPLES

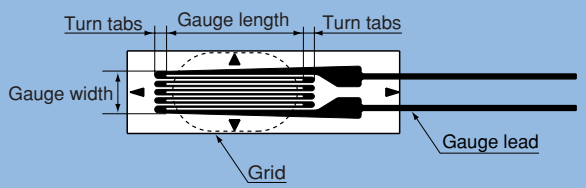
When strain is generated in a test specimen and a strain gauge is attached, the strain is relayed via the gauge base(electrical insulation) to the resistance wire or foil in the gauge. As a result, the fine wire or foil experiences a variation in electrical resistance. This variation is exactly proportional to the strain.

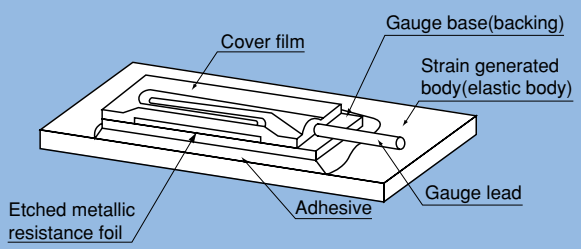
$$\varepsilon = \frac{\Delta L}{L} = \frac{\Delta R / R}{K}$$

ε : strain measured
R : Gauge resistance
⊿R : Resistance change due to strain
K : Gauge Factor as shown on package

STRAIN GAUGE CONFIGURATION

A strain gauge is constructed by bonding a fine electric resistance wire or photographically etched metallic resistance foil to an electrical insulation base using an appropriate bonding materials, and attaching gauge leads.





SELECTING STRAIN GAUGES

Strain gauges are provided with many convenient features, but they also have limitations. Each strain gauge has its limitations in terms of temperature, fatigue, the amount of strain, and the measurement environment. These limitations must be examined before a strain gauge is used.

●Strain Gauge Featuring

- Simple construction with a small mass and volume so as not to interfere with the stresses on the specimen.
- Short distance between measuring points for localized evaluation.
- Good frequency response for tracking rapid fluctuations in stress.
- Simultaneous measurement of multiple points and remote measurement.
- Electrical output for easy data processing.

TECHNICAL TERMS

GAUGE LENGTH

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

GAUGE RESISTANCE

Gauge resistance in ohms (Ω) expresses electrical resistance under free conditions at room temperature, unbonded as supplied.

GAUGE FACTOR

The amount shown in the following equation is called the gauge factor. In this equation, ε indicates the strain generated due to uniaxial stress in the direction of the strain gauge axis. ⊿R/R shows the ratio of resistance change due to strain ε. This is generally indicated by specifying the Poisson's ratio of the test specimen used.

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

, where K : Gauge Factor
ε : Mechanical strain
R : Gauge Resistance
⊿R : Resistance variation

TRANSVERSE SENSITIVITY (Kt)

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

$$K_t = \frac{\Delta R / R}{\varepsilon_t} \times 100$$

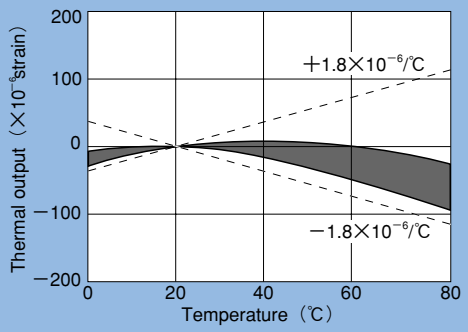
, where K_t : Transverse sensitivity
ε_t : uniaxial strain

TEMPERATURE COMPENSATION RANGE

This refers to a temperature range in which the thermal output of a self-temperature compensated gauge conforms to the requirement. Compensation is accurate within approximately ± 1.8×10⁻⁶ strain/℃. For greater accuracy, corrections can be made using the curves for apparent strain vs. temeprature which are supplied with each package of gauge.

SELF-TEMPERATURE COMPENSATED GAUGES

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



OPERATIONAL TEMPERATURE RANGE

The temperature range listed in the Normal column of the selection is for stable static measurement. The Short-Term or Special column indicates the range for dynamic measurement, short term measurement or measurement without temperature change.

STRAIN LIMIT

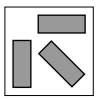
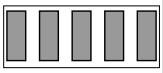
The strain limit or allowable elongation percent depends on the properties of the wire, foil material, backing, and adhesive used. In general, the strain limit for a gauge with a short gauge length is slightly lower than that for one with a longer gauge length in the same series.

FATIGUE LIFE

When strain is repeatedly applied to the gauge, it causes increased resistance under zero strain, peeling-off of the gauge, or disconnection, resulting in failure. The number of repeated cycles that the gauge can endure is called its fatigue life. It is generally indicated by the repetition number under the specified conditions of strain amount and repetition speed as apparent strain drifts to 100×10⁻⁶ strain from the beginning. The fatigue life of TML gauges depends mainlly on the properties of the backing material and adhesive used. This varies somewhat with the size and configuration of the grid. In general, larger gauges exhibit better fatigue performance. It is advisable to use foil gauges where maximum resistance to fatigue is required.

STRAIN GAUGE SHAPE

TML also supplies strain gauges in different patterns for a range of applications. Select the appropriate gauge patterns for your application.

Qty. of elements	1	2	2
Gauge pattern			
Nomenclature	Single element	2-element Cross	2-element Cross
Grid layout	——	Stacked type	Plane type
Qty. of elements	**3**	**3**	**5**
Gauge pattern			
Nomenclature	3-element Rosette	3-element Rosette	5-element Single-axis
Grid layout	Stacked type	Plane type	——

GAUGE LENGTH SELECTION

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

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

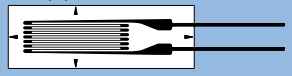
FREQUENCY RESPONSE

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

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

GAUGE WIDTH

Strain gauges with the same gauge length are also available in a narrower width (FLK-type). Select narrow strain gauges for thin specimens such as cylindrical pipes, etc.

F L A type 

F L K type 

STRAIN GAUGES ANALYSIS

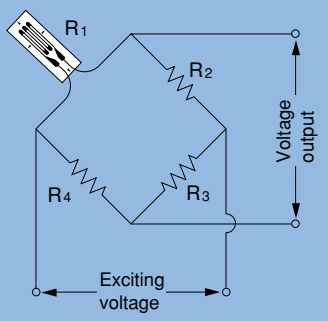
STRAIN GAUGE MEASUREMENT

When strain is generated in a test specimen and a strain gauge is attached, the strain is relayed via the gauge base(electrical insulation) to the resistance wire or foil in the gauge. As a result, the fine wire or foil experiences a variation in electrical resistance. This variation is exactly proportional to the strain.

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

ε : strain measured
R : Gauge resistance
ΔR : Resistance change due to strain
K : Gauge Factor as shown on package

Normally, this resistance change is very small and requires a Wheatstone bridge circuit to convert it to voltage output.



The voltage output of a bridge circuit is given as follows.

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

e : Voltage output
E : Exciting voltage
R_1 : Gauge resistance
$R_2 \sim R_4$: Fixed resistance

Assuming the value R such that $R=R_1=R_2=R_3=R_4$, the active gauge resistance varies to $R+\Delta R$ due to strain. Thus, the output voltage Δe(variation) due to the strain is given as follows.

$$\Delta e = \frac{\Delta R}{4R+2\Delta R} E$$

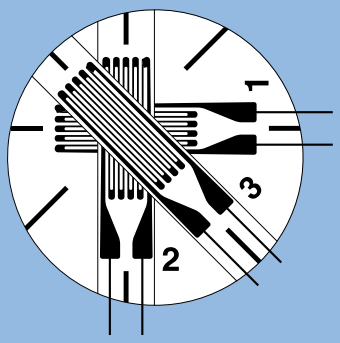
When $\Delta R \ll R$,

$$\Delta e = \frac{\Delta R}{4R} E = \frac{E}{4} K\varepsilon$$

The strain gauge is connected to a strainmeter, which provides the Wheatstone bridge circuit and exciting input voltage. The strain (ε) is measured on a digital or analog display.

CALCULATION FOR 3-ELEMENT ROSETTE ANALYSIS

The principal strain and its direction are calculated with a 45˚ /90˚ 3-element strain gauge, as described below.



1st axis : ε_1
2nd axis : ε_2 at 90˚ position
3rd axis : ε_3 at 45˚ position

Maximum principal strain

$$\varepsilon_{max} = \frac{1}{2}\left[\varepsilon_1 + \varepsilon_2 + \sqrt{2\{(\varepsilon_1-\varepsilon_3)^2+(\varepsilon_2-\varepsilon_3)^2\}}\right]$$

Minimum principal strain

$$\varepsilon_{min} = \frac{1}{2}\left[\varepsilon_1 + \varepsilon_2 - \sqrt{2\{(\varepsilon_1-\varepsilon_3)^2+(\varepsilon_2-\varepsilon_3)^2\}}\right]$$

Maximum shearing strain

$$\gamma_{max} = \sqrt{2\{(\varepsilon_1-\varepsilon_3)^2+(\varepsilon_2-\varepsilon_3)^2\}}$$

Angle from ε_1 gauge to direction of principal strain

$$\phi_P = \frac{1}{2}\tan^{-1}\left\{\frac{2\varepsilon_3-(\varepsilon_1+\varepsilon_2)}{\varepsilon_1-\varepsilon_2}\right\}$$

If $\varepsilon_1 > \varepsilon_2$, the angle to the maximum principal strain is rotated by ϕ_P clockwise from the 1st axis, and the minimum principal strain is located at ϕ_P+90°. If $\varepsilon_1 < \varepsilon_2$, the angle to the maximum principal strain is rotated by ϕ_P+90° clockwise from the 1st axis, and the minimum principal strain is located at ϕ_P.

Maximum principal stress

$$\sigma_{max} = \frac{E}{1-\nu^2}(\varepsilon_{max} + \nu\varepsilon_{min}) = \frac{E}{2}\left\{\frac{\varepsilon_1+\varepsilon_2}{1-\nu} + \frac{1}{1+\nu}\sqrt{2\{(\varepsilon_1-\varepsilon_3)^2+(\varepsilon_2-\varepsilon_3)^2\}}\right\}$$

Minimum principal stress

$$\sigma_{min} = \frac{E}{1-\nu^2}(\varepsilon_{min} + \nu\varepsilon_{max}) = \frac{E}{2}\left\{\frac{\varepsilon_1+\varepsilon_2}{1-\nu} - \frac{1}{1+\nu}\sqrt{2\{(\varepsilon_1-\varepsilon_3)^2+(\varepsilon_2-\varepsilon_3)^2\}}\right\}$$

Maximum shearing stress

$$\tau_{max} = \frac{E}{2(1+\nu)}\gamma_{max} = \frac{E}{2(1+\nu)}\sqrt{2\{(\varepsilon_1-\varepsilon_3)^2+(\varepsilon_2-\varepsilon_3)^2\}}$$

,where E: Elastic modulus (Young's modulus)
ν : Poisson's ratio

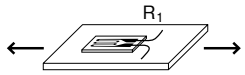
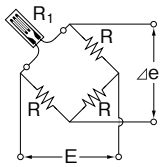
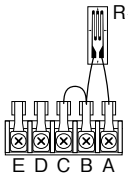
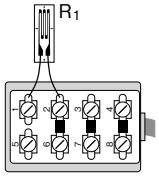
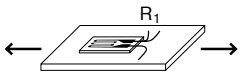
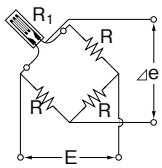
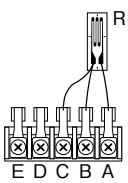
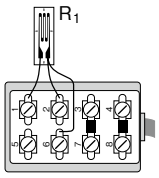
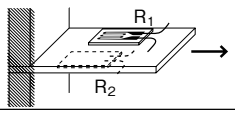
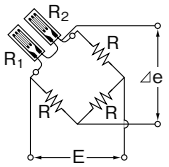
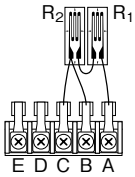
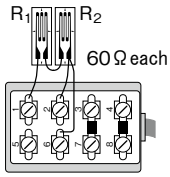
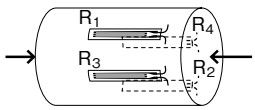
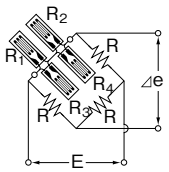
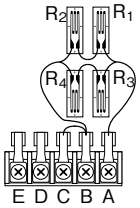
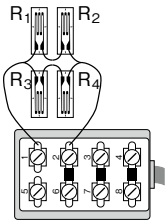
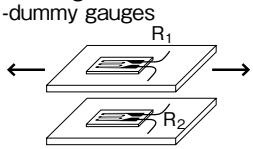
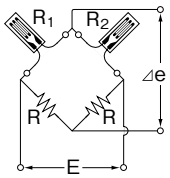
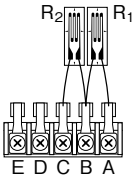
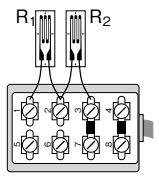
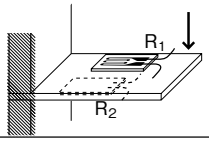
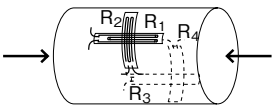
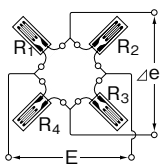
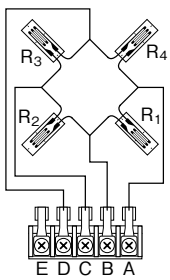
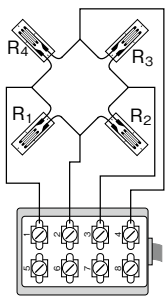
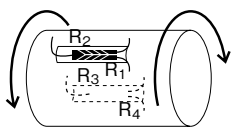
NOTE

The above rosette analysis equations are based on the 3-element strain gauge shown in the diagram. When the order of the axis numbers is different or when the gauge is not a 90˚ rosette gauge, different equations must be used. Check the axis numbers of the applicable strain gauge before performing rosette analysis calculations.

STRAIN GAUGE BRIDGE

Strain gauge connections and bridge circuits

Connection diagram varies according to strainmeter type.

Measuring mode	Bridge circuit	On switching box	On bridge box	Bridge output
Quarter bridge 				E :Exciting voltage e :Output voltage Δe :Output voltage due to strain e_0 :Output voltage before strain generation R_0 :Resistance before strain generation ΔR :Resistance change due to strain ε :Strain K :Gauge Factor $e = e_0 + \Delta e$ $R_1 = R_0 + \Delta R$ $R = R_0$ $\Delta e = \frac{E}{4} K\varepsilon$
Quarter bridge with 3-wire system 				
Quarter bridge with double gauge and 3-wire system eliminating bending strain 				$R_1 = R_0 + \Delta R$ $R_2 = R_0 + \Delta R$ $R = 2R_0$ $\Delta e = \frac{E}{4} K\varepsilon$
Quarter bridge with 4 gauges 				$R_1 = R_2 = R_3 = R_4 = R_0 + \Delta R$ $R = R_0$ $\Delta e = \frac{E}{4} K\varepsilon$
Half bridge with 1-active and 1-dummy gauges 				$R_1 = R_0 + \Delta R$ $R_2 = R_0 = R$ $\Delta e = \frac{E}{4} K\varepsilon$
Half bridge with 2-active gauges eliminating tensile strain 				$R_1 = R_0 + \Delta R$ $R_2 = R_0 - \Delta R$ $R = R_0$ $\Delta e = \frac{E}{2} K\varepsilon$
Full bridge 				$R_1 = R_3 = R_0 + \Delta R$ $R_2 = R_4 = R_0 - \nu \cdot \Delta R$ $\Delta e = \frac{E(1+\nu)}{2} K\varepsilon$ ν : Poisson's ratio
Full bridge 				$R_1 = R_3 = R_0 + \Delta R$ $R_2 = R_4 = R_0 - \Delta R$ $\Delta e = EK\varepsilon$

Output voltage due to strain is based on the condition that output voltage before strain generation(e_0) is zero.

TML ORIGINAL STRAIN MEASUREMENT

1-GAUGE 4-WIRE STRAIN MEASUREMENT METHOD

General

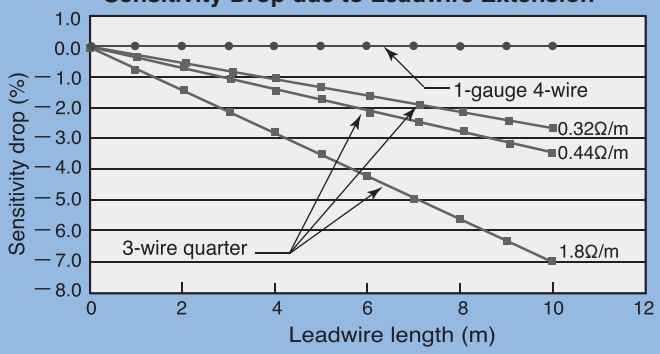
For strain gauge measurement, various bridge configurations are employed according to the number of strain gauges to be used and measuring purpose. In quarter bridge configuration, three wire method is widely used to remove the effect of temperature to gauge leadwire resistance. However, some measuring error occurs owing to gauge factor correction due to leadwire resistance and variation in the contact resistance of connection part. Our developed 1-gauge 4-wire strain measurement method serves not to induce any measurement error ascribable to the gauge factor correction and contact resistance. (Japanese Patent No.3546203)

FEATURES (Superiority to 3-wire quarter bridge method)

Leadwire Resistance

In conventional method, as bold and short leadwires as possible are recommended to keep the resistance of leadwires lower. On the contrary, as the 1-gauge 4-wire method is not influenced at all by the leadwire resistance, it is possible to connect a thin and long leadwires to strain gauges.

Sensitivity Drop due to Leadwire Extension

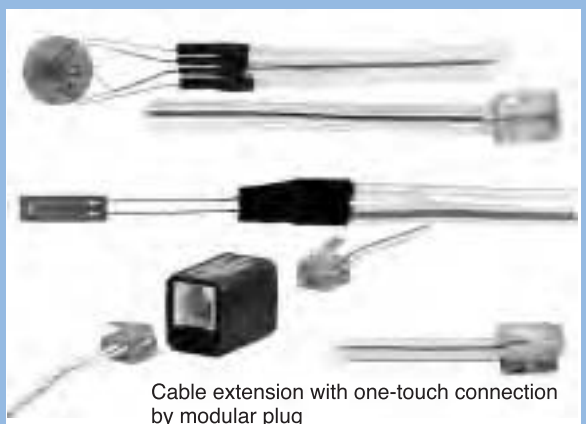


Contact resistance

In conventional method, leadwire extension and connection to a measuring instrument are done by soldering or the use of exclusive connector. As the 1-gauge 4-wire method is not affected at all by contact resistance, a modular plug can be used. Because the modular plug makes leadwire extension and connection to the instrument possible by merely plugging in, the efficiency of wiring work and prevention of wiring mistake are achieved and also RoHS-compliant lead free soldering is unnecessary.

Strain gauges with leadwires and modular plug

The strain gauges are used in our developed 1-gauge 4-wire strain measurement method (Patent No.3546203). Most of our strain gauges can be supplied with preattached leadwires and modular plug (RJ12). As a modular plug is attached to the end of the leadwires, soldering or screwing connection to a measuring instrument is unnecessary, but the instrument must be of TML make. The 4-wire leadwires are covered with polypropylene resin which does not generate noxious gas even if disposed by fire.



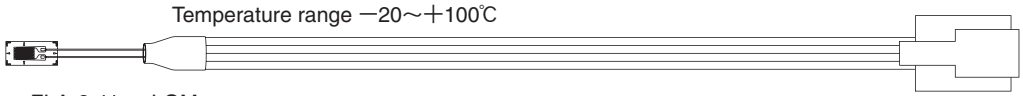
Cable extension with one-touch connection by modular plug

Single type

4-wire palleled leadwire attached

Applicable leadwire : 0.08mm^2 poly-propyrene with modular plug

Temperature range −20～+100℃



FLA-2-11- _ LQM

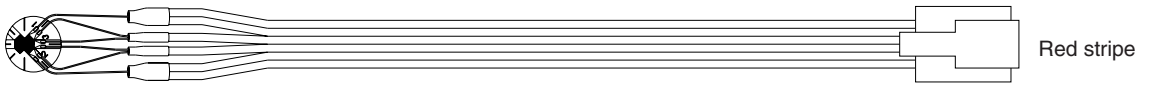
Rectangular 3-element type

Ordinarily, leadwires are needed for individual gauge elements, but in the 1-gauge 4-wire method, one piece only of 6-wire parallel leadwires is used, and with TML exclusive switching box SSW-13R, connection for 3 channels can be completed with one modular plug only.

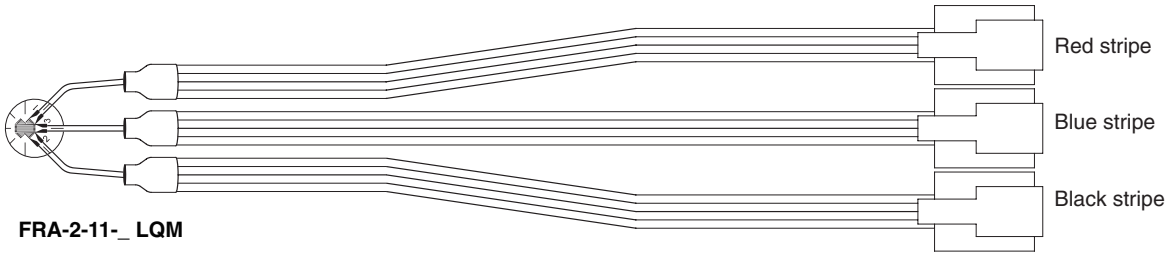
Rectangular 3-element, 45° stacked rosette gauge

Applicable leadwire : 0.08mm^2 poly-propyrene with modular plug

Temperature range −20～+100℃



FRA-2-11-_ LHM

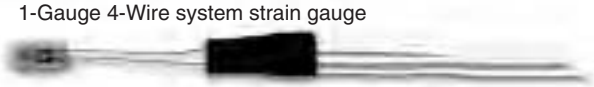


FRA-2-11-_ LQM

With TML data logger model TDS-530, 1-gauge 4-wire method is completed by merely connecting the modular plug to its built-in switching box and with TDS-602/TDS-303 data loggers to the exclusive external switching boxes. (Wiring-saved rosette gauges needs external switching box model SSW-13R regardless of the data loggers.) If TML high speed digital dynamic strainmeter model DRC-3410 is used, dynamic 1-gauge 4-wire strain measurement becomes possible.

■ 1-Gauge 4-Wire strain measurement system

1-Gauge 4-Wire system strain gauge



3-element rosette strain gauge
[3-Gauge 6-Wire system strain gauge]

Modular-plug integrated leadwires

Most of our strain gauges can be supplied with any lengths of leadwires with modular plug (RJ12). This makes wiring efficiently, prevents wiring mistake and reduces cost due to repeated use of the same leadwires.

No contact resistance

1-gauge 4-wire strain measurement need not take contact resistance into account. Using commercial interconnection adapter, leadwire extension can be easily done.

Static Strain Measurement

Data Logger

TDS-630
TDS-530
TDS-303

Switching Box

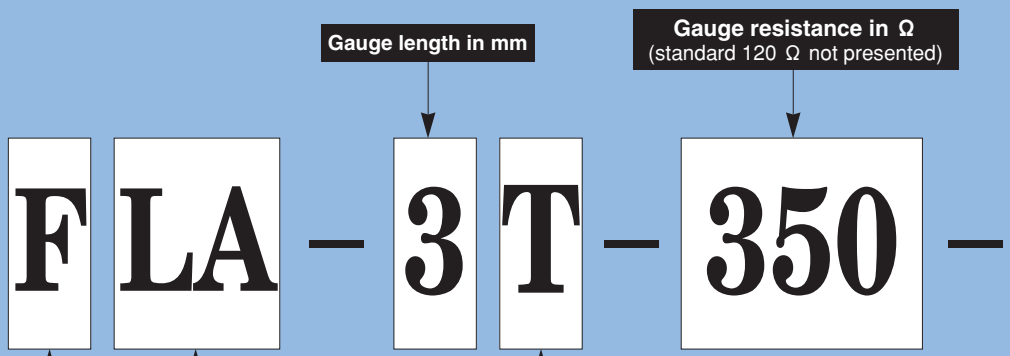
IHW-50G/ISW-50G
SSW-50G
SSW-10F/SSW-13R

For wiring-saved rosette gauges, confirm compatible model of switching box.

Dynamic Strain Measurement

High Speed Digital Strainmeter
DRC-3410

TML STRAIN GAUGE CODING SYSTEM



Gauge series	
F	General purpose Stress concentration use Chain gauge CCFXX, CCFYX
UF	General purpose
WF	Waterproof construction
PF	Polyester foil gauge
P	Polyester wire gauge
FLM / WFLM	Metal-backing strain gauge
MF	Magnetic field use
PM / PMF	Polyester mold strain gauge
YEF / YF / YUF	Post-yield foil gauge
PMFLS / SSM	For asphalt use
LF	Low elastic modulus
PFLW / PLW	For wood long term use
GF	For plastic material use
UBF / BF	For composite material use
CEF	Wide range temperature use
CF	Cryogenic temperature use
QF / ZF	High temperautre use
SFA	Stress measurement
AW	Weldable capsulated gauge
BTM	Bolt axial strain measurement
BTMP	Bolt axial force measurement
DD	One-side gauge
FAC	Crack detection
TF	Temperature measurement

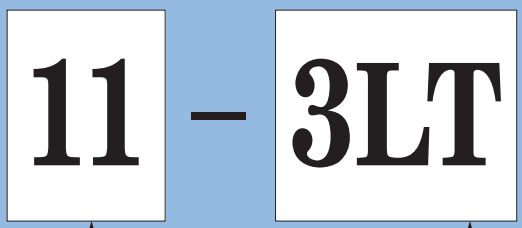
Pattern configuration(*1)	
L/LA/LK/LX/LG/BX/BY	Single
C/CA/LC/CS/CB	2-element
R/LR/RA/RAS/RS	3-element
XV/YV/BXV/BYV	5-element Single
CV	5-element Cross
CT	Torque
LT	45° Single

(*1) Not always coded

Cross : 90° 2-element
Rosette : 45° /90° 3-element

Functions(*2)		Applicabe gauge
A	Left 45° Right 45° for shearing strain measurement	QFLT QFLT
T	Thermocouple type	Temperature-integrated

(*2) Not indicated for general model



Compensation material ppm/℃ (*3)			
3 Composite material		17 Stainless steel/Copper alloy	
Ceramic (Si_3N_4)	2.6～3.3	SUS 304	16.2
CFRP	3 ～ 5	SUS 310	15.8
5 Composite material		SUS 316	16.0
Ceramic (SiC)	4.6	SUS 321	16.7
CFRP	3 ～ 5	Copper	16.7
8 Composite material		Beryllium copper	16.6
Glass	7.9	Brass	16.7
Titanium	8.9	Bronze	17.0
Titanium alloy(Ti-6Al-4V)	8.8	Constantan	14.9
11 Mild steel (ferritic)		23 Aluminium	
Mild steel (0.1-0.2C)	11.8	Aluminium	23.4
Hard steel (0.4-0.5C)	11.2	Aluminium 2024-T4	23.0
Cast iron	10.5	Lead and its alloy	29.0
Hastelloy-276	11.2	Gypsum	25.0
Inconel 600	13.3	Polyimide	20～30
Inconel 750	12.1	28 Magnesium alloy	27.0
Monel	13.5	50 Plastics	
SUS 630(17-4PH)	10.8	Epoxy	45～65
SUS 631(17-7PH)	10.6	70 Plastics	
Concrete	7～13	Acrylics	70
		ABS	74
		Polyacetal (POM)	80
		Polycarbonate (PC)	66～70
		Polystyrene (PS)	60～80

Lead wires pre-attached	
002LE	Paralleled polyimide lead wire of 2cm long
005LE	Paralleled polyimide lead wire of 5cm long
1L	Paralleled vinyl lead wire of 1m long
3L	Paralleled vinyl lead wire of 3m long
5L	Paralleled vinyl lead wire of 5m long
3LT	3-wire paralleled vinyl lead wire of 3m long
5LT	3-wire paralleled vinyl lead wire of 5m long

(*3) Indicated only for self-temperature compensated gauges
For other materials, contact TML or your local representatives.

Color code of gauge base for different test specimen

TML strain gauges are almost self-temperature compensated. Series F, UF and WF are self-temperature compensated for the most commonly found material mild steel, stainless steel/copper alloy and aluminium, and are identified with gauge base colors of red, brown and green respectively.

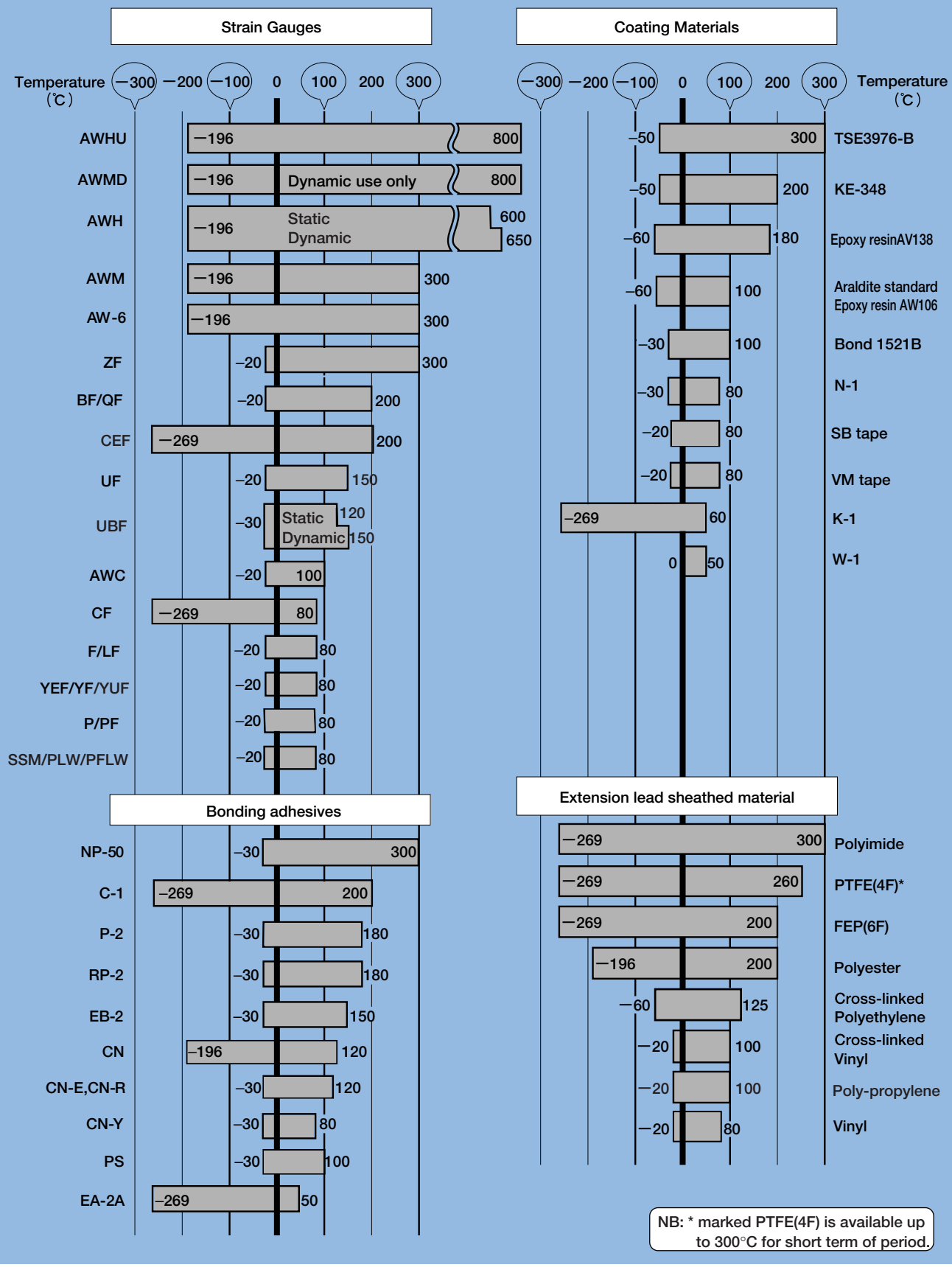
Material	Linear thermal expansion coefficient	Identified color of gauge base	Gauge type exampled
Mild steel	11ppm/℃	Red	FLA-3-11
Stainless steel Copper alloy	17ppm/℃	Brown	FLA-3-17
Aluminium	23ppm/℃	Green	FLA-3-23

TML STRAIN GAUGES SELECTION

1. Measuring purpose

Material	Purpose	Operating temperature	Gauge series	Bonding adhesive	Coating materials	Extension wire
Metal Mild steel (ferritic) Stainless steel Copper alloy Aluminium Other metals	General purpose	Room (−20～+80℃)	F/PF	CN/P-2/EB-2	W-1/N-1/SB tape	Vinyl/Enamel
		High temperature (−20～+150℃)	UF	CN/EB-2 NP-50	W-1/N-1/SB tape	Vinyl/FEP(6F)
		High temperature (−20～+200℃)	QF	C-1/NP-50	KE-348	FEP(6F)/PTFE(4F)
		High temperature (−20～+300℃)	ZF	C-1/NP-50	TSE3976-B	PTFE(4F)
		High temperature (−196～+300℃)	AW-6	Spot welding	Contact TML	PTFE(4F)
			AWM			MI cable
		Dynamic use only High temperature (−196～+800℃)	AWMD	Spot welding	Contact TML	MI cable
		High temperature (−196～+800℃)	AWHU	Spot welding	Contact TML	MI cable
		High temperature (−196～+650℃)	AWH	Spot welding	Contact TML	MI cable
		Cryogenic temperature (−269～+80℃)	CF	EA-2A/C-1	K-1	FEP(6F)/PTFE(4F)
		Wide range (−269～+200℃)	CEF	C-1	Contact TML	FEP(6F)/PTFE(4F)
	Long-term	Room (−20～+80℃)	ZF	CN/C-1/NP-50	Bond 1521B W-1/SB tape	Vinyl/Cross-linked-vinyl/PTFE(4F)
			AW-6	Spot welding		
	Stress concentration	Room (−20～+80℃)	FXV/FYV FBXV/FBYV CCFXX/CCFYX	CN/P-2/EB-2	W-1/SB tape	Vinyl
		High temperature (−20～+200℃)	QFXV/QFYV QFBXV/QFBYV	C-1/NP-50	KE-348	FEP (6F)
	Residual stress	Room (−20～+80℃)	FRS/FRAS	CN/P-2/EB-2	W-1/SB tape	Vinyl
	Torque	Room (−20～+80℃)	FCT	CN/P-2/EB-2	W-1/SB tape	Vinyl
		High temperature (−20～+200℃)	QFCT	NP-50/C-1	KE-348	FEP (6F)
	Shearing strain	High temperature (−20～+200℃)	QFLT	NP-50/C-1	KE-348	Vinyl
	Bending strain	Room (−10～+70℃)	DD	CN/P-2	＊＊＊＊	Vinyl
	Bolt axis	Room (−10～+80℃)	BTM	A-2	＊＊＊＊	Vinyl
		Room (0～+60℃)	BTMP-10A	＊＊＊＊	＊＊＊＊	＊＊＊＊
	Large strains (Elongation)	Room (−20～+80℃)	YEF/YF YUF	CN/CN-Y	SB tape	Vinyl
Metal Concrete	Magnetic field	Room (−20～+80℃)	MF	CN/CN-E/RP-2	W-1/SB tape	Twisted vinyl Shielded vinyl
Concrete Mortar	Surface strain	Room (−20～+80℃)	P/PF	CN-E/RP-2	W-1/SB tape	Vinyl
		Long-term use Room(−20～+80℃)	FLM/WFLM	PS		
	Inner strain	Room (−20～+60℃)	PM/PMF	Embedment	＊＊＊＊	Vinyl
Asphalt	Surface strain	Room (−20～+80℃)	SSM	RP-2/PS	＊＊＊＊	Vinyl
	Inner strain	Room (−20～+60℃)	PMFLS	Embedment	＊＊＊＊	Chloroprene
Plastics	General purpose	Room temperature (−20～+80℃)	GF	CN	W-1/N-1 SB tape	Vinyl
Composite	General purpose	High temperature (−20～+200℃)	BF	CN/NP-50	W-1/KE-348	Vinyl
Composite	General purpose	Static (−30～+120℃) Dynamic(−30～+150℃)	UBF	CN/NP-50	W-1/KE-348	Vinyl
Wood/Gypsum	General purpose	Room (−20～+80℃)	LF	CN-E	W-1	Vinyl
Wood	General purpose	Long-term use Room(−20～+80℃)	PFLW/PLW	PS	W-1/N-1 SB tape	Vinyl
General	Temperature	−20～+200℃	TF	CN/C-1/NP-50	W-1/SB tape	Vinyl

2. OPERATIONAL TEMPERATURES



NB: * marked PTFE(4F) is available up to 300°C for short term of period.

TML STRAIN GAUGES SELECTION

3. Strain Gauge Characteristics

Gauge series		Applicable specimen	Applicable thermal expansion (ppm/℃)	Operational temperature (℃)		Bonding adhesive	Materials		Strain limit (×10⁻⁶ strain)
				Normal	Compensation		Backing	Element	
F Leadwire-integrated F		Metal, Glass, Ceramic	8, 11, 17,23	−20～+80	+10～+80	CN/P-2/ EB-2	Epoxy	Cu-Ni	5% (50000)
WF		Metal, Glass, Ceramics	11, 17, 23	0～+80	+10～+80	CN/P-2	Epoxy	Cu-Ni	3% (30000)
Temperature-integrated **FLA-T**		Metal, Glass, Ceramics	11, 17, 23	+30～+80	+10～+80	CN/P-2	Epoxy Polyimide	Cu-Ni Ni-Cr	3%(30000) 1%(10000)
UF Leadwire-integrated **UF**		Metal	11, 17, 23	−20～+150	+10～+100	CN NP-50 EB-2	Polyimide-Amide	Cu-Ni	5% (50000)
QF (High temperature)		Metal, Ceramics	11	−20～+200	+10～+100	CN/NP-50 C-1	Polyimide	Cu-Ni	3% (30000)
ZF (High temperature)		Metal, Ceramics	11	−20～+300	+10～+100	CN/NP-50 C-1	Polyimide	Ni-Cr	1% (10000)
CF (Cryogenic temperature)		Metal, Ceramics	11, 17, 23	−269～+80	−196～+80	CN/EA-2A C-1	Epoxy	Special alloy	1% (10000)
CEF (Wide range temperature)		Metal, Ceramics	11, 17, 23	−269～+200	−269～+80	C-1	Polyimide	Special alloy	1% (10000)
AW	**AWM**	Metal	11, 12.7, 23	−196～+300	Room～+300	Spot-welding	SUS304 Inconel	Special alloy	1% (10000)
	AWMD	Metal	＊＊＊＊	−196～+800	＊＊＊＊	Spot-welding	Inconel	Special alloy	1% (10000)
	AWH	Metal	Adjustable	−196～+650 −196～+600	Room～+600	Spot-welding	SUS321 Inconel	Special alloy	0.6% (6000)
	AWHU	Metal	10.9, 12.7	−196～+800	Room～+800	Spot-welding	Inconel	Special alloy	1% (10000)
	AW-6	Metal	11	−196～+300	+10～+300	Spot-welding	SUS304	Special alloy	0.5% (5000)
	AWC	Metal	11	−20～+100	+10～+300	Spot-welding	SUS304	Special alloy	0.5% (5000)
P Leadwire-integrated P		Concrete, Mortar	11	−20～+80	+10～+80	CN-E RP-2	Polyester	Cu-Ni Wire	2% (20000)
PF Leadwire-integrated PF		Metal, Mortar	11	−20～+80	+10～+80	CN RP-2	Polyester	Cu-Ni	2% (20000)
FLM/WFLM Metal-backing		Concrete, Mortar	11	−20～+80	+10～+80	PS	SUS 304	Ni -Cr	0.5% (5000)
PM/PMF Mold gauge		Concrete, Mortar	＊＊＊＊	−20～+60	＊＊＊＊	Embed	Acrylic, Special plastics	Cu-Ni Wire/Foil	＊＊＊＊
PMFLS Mold gauge		Asphalt	＊＊＊＊	−20～+60	＊＊＊＊	Embed	Special plastics	Cu-Ni	＊＊＊＊
SSM Pavement surface		Concrete, Asphalt	＊＊＊＊	−20～+80	＊＊＊＊	RP-2/PS	Special plastics	Cu-Ni	＊＊＊＊
GF Low-elastics		Plastics	50, 70	−20～+80	+10～+80	CN	Epoxy	Cu-Ni	3% (30000)
UBF/BF Composite		Composite	3, 5, 8, etc.	−20～+200	+10～+80	CN/EB-2 NP-50	Polyimide-amide	Cu-Ni	3% (30000)
LF Low-elastics		Wood, Gypsum	11	−20～+80	+10～+80	CN-E	Epoxy	Cu-Ni	3% (30000)
PFLW/PLW		Wood	11	−20～+80	+10～+80	PS	Polyester	Cu-Ni Wire/Foil	2% (20000)
MF Magnetic field		Metal, Concrete	＊＊＊＊	−20～+80	＊＊＊＊	CN/CN-E RP-2	Epoxy	Ni-Cr	1% (10000)
YUF **YF** Large strain **YEF**		Metal elongation	＊＊＊＊	−20～+80	＊＊＊＊	CN/CN-Y	Special plastics	Cu-Ni	20～30% 15～20% 10～15%
BTM Bolt-embed		Bolt axial force	＊＊＊＊	−10～+80	＊＊＊＊	A-2	Special plastics	Cu-Ni	0.5% (5000)
BTMP-10A		Bolt axial force	＊＊＊＊	−10～+80	＊＊＊＊	＊＊＊＊	＊＊＊＊	Cu-Ni	＊＊＊＊
DD		Metal	＊＊＊＊	−10～+70	＊＊＊＊	CN/P-2	Acrylic	Cu-Ni	0.15% (1500)
FAC Crack gauge		Metal, Concrete	＊＊＊＊	−20～+80	＊＊＊＊	CN/RP-2	Epoxy	Cu-Ni	＊＊＊＊
SF Stress gauge		Metal	11, 17, 23	−20～+200	+10～+100	CN/NP-50 C-1	Polyimide-amide	Cu-Ni	＊＊＊＊
Transducer-specific		General	＊＊＊＊	−20～+200	＊＊＊＊	CN/NP-50 C-1	Epoxy, Polyimide-amide	Cu-N, Ni-Cr	＊＊＊＊
TF Temperature gauge		Metal	11, 17, 23	−20～+200	+10～+80	C-1	Polyimide-amide	Ni-alloy	＊＊＊＊

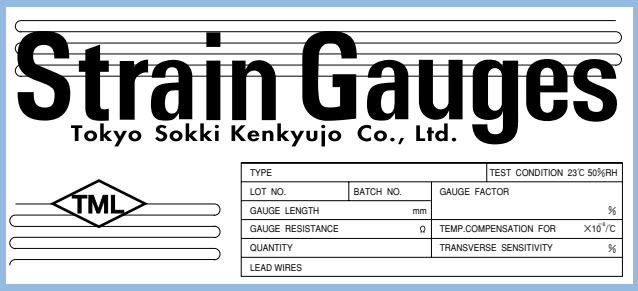
N.B. Fatigue life is measured at room temperature. Strain level : ±1500×10⁻⁶ strain 15Hz ◎: ±1000×10⁻⁶ strain 15Hz

	Fatigue life at room temperature	Applications	Page
	1×10⁶	The F series employs specially controlled alloy foils which are 0.003 to 0.007mm thick. The grid is precision etched by the most advanced processes available, and employs an extremely thin epoxy backing. Leadwire integrated F series has a pre-attached vinyl leadwire to F series. 2 wire and 3 wire parallel are available.	25
	1×10⁶	This gauge eliminates the need for a moistureproof coating, which is sometimes troublesome in field test. The gauge has a vinyl leadwire and the entire gauge and leadwire junction have been fully overcoated with a transparent and flexible epoxy resin. Perfect waterproofing can be achieved by merely bonding the gauge with CN or P-2 bonding adhesive.	34
	1×10⁶	This gauge includes temperature sensor to measure both strain and temperature simultaneously. The FLA-T identical to the F series has T thermocouple.	35
	1×10⁶	The operational temperature range of this general-purpose gauge series extends to 150℃. The gauges are temperature compensated for mild steel, strainless steel and aluminium. The gauge backing is colour-coded according to the temperature compensated material type in the same method as for the F. The gauge with a pre-attached vinyl leadwire is available.	36
	1×10⁶	The QF series have a polyimide carrier backing for excellent performance at high temperature of 200℃. It offers a small gauge length of 0.2 or 0.4mm, for use as a stress concentration measurement gauge or shear stress measurement gauge.	39
	1×10⁶	The ZF series have a polyimide carrier backing for excellent performance at high temperature of 300℃. Owing to the use of Ni-Cr alloy and special grid design for the strain sensing element, creep characteristics in high temperature have been much improved.	41
	1×10⁶	This epoxy-backed foil gauge is designed for measuring under cryogenic conditions and offers single element, rectangular 2-element, and rectangular 3-element with 350Ω. The specially heat treated sensing foil shows very small zero shift under cryogenic temperature.	42
	◎1×10⁶	The CEF series have a polyimide-amide carrier backing for wide use in temperature range from cryogenic condition up to 200℃ and configuration of single element.	42
	◎1×10⁶	The AWM is a spot-weldable strain gauge with Quarter bridge with 3-wire system. As the element is hermetically sealed, the gauge withstand upto 300℃ and in harsh environment for strain measurement.	44
	◎1×10⁶	The AWMD is a spot-weldable strain gauge withstand upto 800℃ for only dynamic strain measurement. It has a standard high-pass filter with full bridge configuration to eliminate unexpected low frequency influence.	44
	◎1×10⁶	The AWH is a spot-weldable strain gauge withstand upto 600℃ for static measurement or upto 650℃ for dynamic measurement. The backing material is available in Inconel 600 or SUS321 which should be selected according to the test specimen.	45
	◎1×10⁶	The AWHU is a spot-weldable strain gauge withstand upto 800℃ for both static and dynamic measurement. Although it has a half bridge configuration, the measurement is made by full bridge using the supplied temperature compensation circuit board.	45
	◎1×10⁶	The AW-6 with quarter bridge with 3-wire system is suited for strain measurement in high temperature upto 300℃ for measurement of specimen to which adhesive is not applicable or for long term measurement.	46
	◎1×10⁶	The AWC-8B is fully encapsulated in a stainelss steel tube with quarter bridge with 3-wire system. It enables a long term strain measurement in harsh environment.	46
	◎1×10⁵	This gauge is a standard wire strain gauge with a transparent plastic backing impregnated with a polyester resin. It offers several remarkable features such as excellent electrical insulation, easy and accurate installation, and quick setting for concrete specimen.	47
	1×10⁶	This is a foil strain gauge with the same transparent plastic backing as that of the P series gauges. Electrical insulation is excellent, and installation is very easy. It is especially recommended for mortar measurement.	48
	◎1×10⁵	This gauge is designed for strain measurement on concrete surfaces. It has a thin stainless steel backing which prevents the penetration of moisture from the reverse side. The WFLM gauge has moisutreproofing overcoating in addition to stainless steel backing.	49
	＊＊＊＊	This gauge has been specially designed for measuring interior strain in concrete, mortar under a loading test. The PM is sealed, and PMF employs super engineering plastics capable of superior wateproofing. For long term use, the Strain Transducer KM is preferable.	50
	＊＊＊＊	The PMFLS series have a super engineering plastics carrier backing featuring high temperature resistive and waterproofing, making embedment possible into pavement of asphalt with heating (200℃), while operating temperature is available during −20 to+60℃.	51
	＊＊＊＊	The SSM series are specially designed to measure pavement surface strain with multi strain gauge system as the vehicle driving is carried out. The system is arranged with 16 sensing elements in X direction or Y direction respectively.	51
	1×10⁶	This gauge is specially designed for materials having a low elastic modulus, such as plastics, and is specially configured to minimize the effect of gauge tightening. Self-temperature compensation is available for materials with thermal expansion of 50 and 70 ppm/℃.	53
	1×10⁶	This gauge is designed for strain measurement on composite materials. Developing soft carrier backing, UBF series feature advanced characteristics of thermal cycle examination and gauge creep, and BF series feature special element to minimize gauge tightening.	52
	1×10⁶	This gauge is specially designed for materials having a low elastic modulus such as wood or gypsum. It consists of a foil-etched gauge with an epoxy carrier backing and it is self-temperature compensated with 11ppm/℃.	54
	◎1×10⁶	This gauge has a thin metal backing for a long term measurement on woods, not affected by moisture contained in wood. The gauge is bonded with PS adhesive.	54
	1×10⁶	Consisting two identical grids, this gauge is designed to cancel noise voltage for strain measurement in a magnetic environment. By using a specially configured element pattern, the gauge circuit minimizes electromagentic effects.	55
	YUF/YF : ＊＊＊＊ YEF: 5×10⁵	These gauges feature a special plastic carrier base capable of withstanding extreme elongation without creeping or cracking. The YUF series measure 20～30% elongation, the YF 15～20%, and the YEF 10～15% Cycle measurement under elastic strain (approx. ±1500x10⁻⁶) is available with the YEF series same as general strain gauge, while the other 2 series not available.	57
	＊＊＊＊	The BTM is designed to measure the tensile force of bolts. To install, simply insert the gauge together with A-2 bonding adhesive into a pre-drilled hole in the bolt head with syringe (optional). This method ensures that the gauge will not be damaged.	58
	＊＊＊＊	This unique wrench is designed for measurement of bolt axial force with special terminal bonded on hexagonal bolt head. No wiring on bolt-tightening is required, and greatly save complex works.	59
	◎1×10⁵	The DD is specially designed to separately measure bending and tensile stress by simply bonding the gauge to one side of a plate or beam. It works on the assumption that strain distribution in the section of the specimen which is subjected to both stress is linear.	60
	＊＊＊＊	The FAC-20 is designed to measure the progress (length) of a crack and its rate of growth to a pre-determined location on a test specimen for which metal fatigue monitoring is required. Adaptor CGA-120A is required between the gauge and the strainmeter.	60
	1×10⁶	The SF is a foil strain gauge with a polyimide backing and measures stress in the optioinal direction in a plane stress field. It detects stress in the gauge axial direction regarding the shearing strain.	60
	1×10⁶	This range of strain gauges is lined up for strain gauge-type transducers such as force transducers, pressure transducers, torque transducers, etc.	61
	＊＊＊＊	The TF is a series of resistance type temperature sensors(resistance thermometers) and is a bonded type like strain gauges.	63

PACKAGE DESIGNATION

TML strain gauges are delivered together with TML Strain Gauge Test Data (example shown below). The evaluation methods conform to the National Aerospace Standard NAS942 (Modified). For installation, handling and bonding procedures, please see the data sheet.

GAUGE PACKAGE



Batch No.

Production code for procedure and history

Environment

Temperature in degrees centigrade and relative humidity in % at which the test data are obtained.

GAUGE PACKAGE

Gauge type

Lot No.

Production number of element ingot

TYPE	FLA-3-11			TEST CONDITION 23℃ 50%RH	
LOT NO.	A502515	BATCH NO. UK32K		GAUGE FACTOR	
GAUGE LENGTH	3	mm		2.14	±1%
GAUGE RESISTANCE	120±0.3	Ω		TEMP.COMPENSATION FOR	11	×10⁻⁶/℃
QUANTITY	10			TRANSVERSE SENSITIVITY	0.0	%

Quantity

Number of gauges contained in a package

Gauge resistance

Electrical resistance of the strain gauge under free conditions at room temperature, unbonded as supplied. Various range (60, 120, 350, or 1000 Ω) are available.

Gauge length

This represents the actual grid length in the sensitive direction. Within this length, the measured strain is averaged.

Ratio of transverse sensitivity

The sensitivity in the direction perpendicular to the axial direction is given in percent.

Applicable temperature compensation

Various temperature compensation values are available(3, 5, 8, 11, 17, 23, 50, 70 ppm/℃) (Blank is not for temperature compensation.)

Gauge factor with tolerance

This factor is a ratio of the resistance variation to the strain generated due to the uniaxial stress in the direction of the gauge axis.

COLOR CODING FOR TEST SPECIMEN

Colors of package label differ from test specimen.

Test specimen	Linear thermal expansion coefficient	Coloring	Gauge type exampled
Mild steel (ferritic)	11ppm /℃	Red	FLA-3-11-5LT
Stainless steel Copper alloy	17ppm /℃	Brown	FLA-3-17-5LT
Aluminium	23ppm/℃	Green	FLA-3-23-5LT
Others	—	Grey	GFLA-3-70-5LT

LEADWIRE-INTEGRATED STRAIN GAUGE PACKAGE

TYPE	FLA-3-11-5LT		
LOT NO.	A510511	GAUGE LENGTH	3 mm
GAUGE FACTOR	2.14		±1%
GAUGE RESISTANCE	119.5±0.5 Ω	QUANTITY	10
TEMP.COMPENSATION FOR	11 $\times 10^{-6}$/℃	TEST CONDITION	23℃ 50%RH
TRANSVERSE SENSITIVITY	0.0 %	BATCH NO.	ZF28T
LEAD WIRES	10/0.12 3W 5m		

LEAD WIRES

Core number/diameter(or cross section area) Wiring procedure Length of leadwire
Above in column examples 10-core 0.12mm diameter, 3-wire leadwire of 5-meter long.

TML STRAIN GAUGE TEST DATA

Test specimen used in thermal output test

Gauge type

Lot number

Gauge Factor

Bonding adhesive applied

Allowable tolerance of temperature compensation

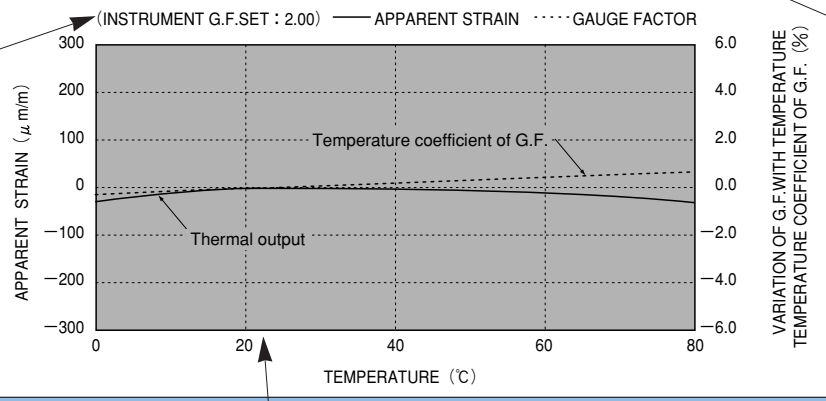
Gauge Factor set on strainmeter

GAUGE TYPE	:	FLA-3-11		TESTED ON	:	SS 400
LOT NO.	:	A502515		COEFFICIENT OF THERMAL EXPANSION	:	11.8 $\times 10^{-6}$/℃
GAUGE FACTOR	:	2.14	±1%	TEMPERATURE COEFFICIENT OF G. F.	:	+0.1±0.05 %/10℃
ADHESIVE	:	P-2		DATA NO.	:	A0312

THERMAL OUTPUT (ε app : APPARENT STRAIN)

$\varepsilon\ app = -2.94\times10^{1}+2.32\times T^{1}-4.60\times10^{-2}\times T^{2}+1.67\times10^{-4}\times T^{3}+5.00\times10^{-7}\times T^{4}$ (μm/m)

TOLERANCE : ±0.85 [(μm/m) /℃] , T : TEMPERATURE



Example of curved data on thermal output.

A linear thermal expansion coefficient of specimen materials in thermal test

Temperature coefficient of Gauge Factor with tolerance per 10℃

Quadratic equation of thermal output (apparent strain with temperature)

GAUGE FACTOR OF LEADWIRE-INTEGRATED STRAIN GAUGES

Gauge factor of leadwire-integrated given in the supplied TML STRAIN GAUGE TEST DATA is the strain gauge itself, but not corrected with attached leadwire. Refer to the data sheet in which Gauge Factor Correction due to Lead Wire attachment is given.

PRIMARY INSTALLATIONS

When bonding the strain gauges, the most suitable adhesive should be selected for each application. A typical installation procedure is described below using the fast-curing adhesive CN.

1. Preparation

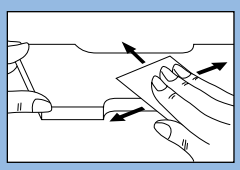
The following items are required for bonding and lead wire connection:Strain gauges, bonding adhesive, connecting terminals, test specimen, solvent, cleaning tissue for industrial use, soldering iron, solder, abrasive paper (120 - 320 grit), marking pencil, scale, tweezers, extension lead wire, polyethylene sheet, nippers.

2. Positioning

Roughly determine the location on the test specimen where the strain gauge is to be bonded.

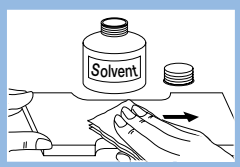
3. Surface preparation

Before bonding, remove all grease, rust, paint, etc., from the bonding area. Sand an area somewhat larger than the bonding area uniformly and finely with abrasive paper. Finish the surface with #120 to 180 abrasive paper for steel, or #240 to 320 for aluminium.



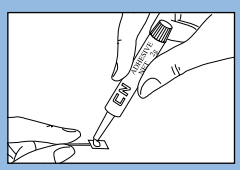
4. Fine cleaning

Clean the bonding area with industrial tissue paper or cloth soaked in a small quantity of chemical solvent such as acetone. Continue cleaning until a new tissue or cloth comes away completely free of contamination. Following the surface preparation, be sure to attach the gauge before the surface becomes covered with an oxidizing membrane or becomes newly contaminated.



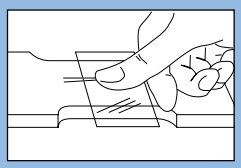
5. Applying bonding adhesive

Drop the proper amount of adhesive onto the back of the gauge base. Usually one drop of adhesive will suffice, but you may increase the number of drops according to the size of the gauge. Use the adhesive nozzle to spread the adhesive over the back surface thinly and uniformly.



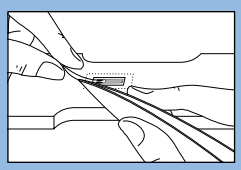
6. Curing and pressing

Place the gauge on the guide mark, place a polyethylene sheet onto it and press down on the gauge constantly using your thumb or a gauge pressing device. This should be done quickly as the curing process is completed very fast. The curing time varies depending on the gauge, test specimen, temperature, humidity and pressing force. The curing time under normal conditions is 20 - 60 seconds.



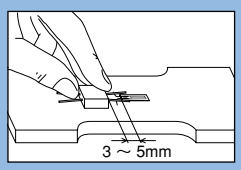
7. Raising the gauge leads

After curing completely, remove the polyethylene sheet, and raise the gauge leads with a pair of tweezers.



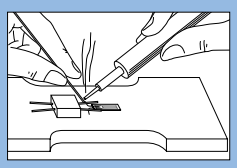
8. Bonding connecting terminals

Position the proper size connecting terminals adjacent to the bonded gauge. A distance of 3 - 5mm generally allows for easier wiring later.



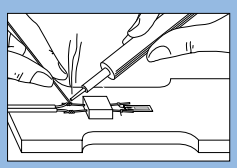
9. Soldering the gauge leads

Wrap the gauge leads around the connecting terminal wires. Solder the junction area with a little slack in the gauge leads, taking care to prevent excessive tension during measurement.



10. Soldering extension lead wires

Solder an extension lead wire to the terminal wires on the opposite side of the connecting terminals. Clip off any excess extension lead wire with a pair of pliers or wire cutters.



LEAD WIRES

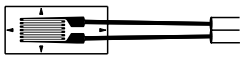
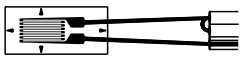
Effects of lead wire temperature

General wiring method and bridge configuration

Bridge configuration	Lead wires	Availability during measurment with temperature change
Quarter bridge with 2-wire	Paralleled 2-wire	Not available
Quarter bridge with 3-wire	Paralleled 2-wire	Available
Half bridge	Paralleled 2-/3-wiire	Available
Full bridge	4-core cable	Available

With 2-wire system, changes in lead wire temperature cause changes in the lead wire resistance which in turn generate thermal output.
The lead wire temperature has not effect on thermal output for quarter bridge with 3-wire system.

Connections of strain gauge and extension lead wires

Lead wires connection	Strain gauge connection
Paralleled 2-wire pre-attached to quarter bridge	
Paralleled 3-wire pre-attached to quarter bridge with 3-wire system	

Gauge factor correction due to the lead wire

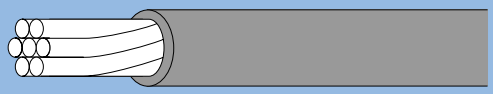
The lead wire resistance between the strain gauge and the strainmeter can noticeably lower the gauge factor. Calculation for the correction should be required depending on the measurement method and on the lead wire type and length.

In case of 2-wire	In case of 3-wire system
A: Correction coefficient of lead wire $A = \frac{R}{R + rL}$ K_0: Gauge factor corrected $K_0 = \frac{R}{R + rL} K = A K$	A: Correction coefficient of lead wire $A = \frac{R}{R + \frac{rL}{2}}$ K_0: Gauge factor corrected $K_0 = \frac{R}{R + \frac{rL}{2}} K = A K$
,where K : Gauge factor shown on package	R : Nominal gauge resistance (Ω) r : Total resistance per meter of lead wire (Ω／m) L : Length of lead wire (m)

Total resistance per meter of lead wire

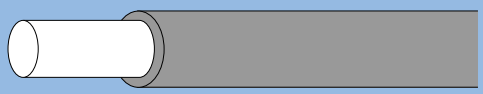
In strain gauges, the lead wire resistance produces a deterioration of gauge sensitivity and thermal drift. The lead wire should always be as thick and as short as possible.

Stranded wire/Twisted wire



Construction core/diameter	7/0.12	10/0.12	7/0.16	7/0.18	12/0.18	20/0.18
Cross section area of lead wire (mm²)	0.08	0.11	0.14	0.18	0.3	0.5
Total resistance of lead wire per meter (Ω)	0.44	0.32	0.24	0.20	0.12	0.07

Single-core wire



Construction	Polyimide wire (φ0.14mm)	Polyimide wire (φ0.18mm)
Cross section area of lead wire (mm²)	0.015	0.025
Total resistance of lead wire per meter (Ω)	2.5	1.5

Setting the gauge factor to the strainmeter

Static strainmeter/Data Logger

$C_S = \frac{2.00}{K_0}$

C_S : Coefficient set
K_0 : Gauge factor corrected with lead wire attached

STRAIN GAUGE EXTENSION LEADWIRES

Most gauges used for strain measurement are equipped with lead wires to simplify the installation procedure. Many TML strain gauges are provided with lead wires for added customer convenience. TML can provide most strain gauges with the type of lead wires requested by the customer. Please feel free to contact our sales representative regarding gauge lead wires.

EXTENSION LEAD WIRES

Vinyl lead wires (standard length : 1m, 3m and 5m)

Vinyl lead wires are widely used as strain gauge lead wires, and are available in a variety of types. Because the vinyl sheath can be colored, these wires allow color-coding for rosette gauges. The stranded core wires are flexible and easy to handle, and allow easy wire connection and terminal attachment.

- **Small diameter vinyl wires**
  These lead wires feature a thin vinyl sheath and small diameter core wires to achieve an outside diameter of 0.4mm. They are used for wiring in tight spaces. The stranded wires are flexible and minimize breakage due to repeated bending.
- **Shielded vinyl wires**
  This lead wire consists of three 0.08mm² stranded vinyl wires spirally covered with aluminium foill. The outside diameter is 3mm. This lead wire offers a noise shielding function.

Lead wire type	Core/diameter (cross section area)	Applicable temperature (℃)	Total resistance of lead wire per meter (Ω)	Outside sheath dimensions (mm)	Length per roll (m)
0.08mm² paralleled vinyl lead wire	7/0.12 (0.08mm²)	−20～+80	0.44	1.1×2.2	200
0.08mm² 3-wire paralleled vinyl lead wire				1.1×3.3	
0.08mm² twisted vinyl lead wire	7/0.12 (0.08mm²)	−20～+80	0.44	φ1.6	—
0.08mm² 3-wire twisted vinyl lead wire				φ1.9	
0.11mm² paralleled vinyl lead wire	10/0.12 (0.11mm²)	−20～+80	0.32	1.4×2.8	200
0.11mm² 3-wire paralleled vinyl lead wire				1.4×4.2	100
0.3mm² paralleled vinyl lead wire	12/0.8 (0.3mm²)	−20～+80	0.12	1.9×3.8	200
0.3mm² 3-wire paralleled vinyl lead wire				1.9×5.7	100
0.5mm² paralleled vinyl lead wire	20/0.18 (0.5mm²)	−20～+80	0.07	2.5×5.0	100
0.5mm² 3-wire paralleled vinyl lead wire				2.1×6.3	
0.02mm² twisted vinyl lead wire	5/0.07 (0.02mm²)	−20～+100	1.8	φ0.8	—
0.02mm² 3-wire twisted vinyl lead wire				φ1.0	
3mm-dia. 3-core shielded vinyl lead wire	7/0.12 (0.08mm²)	−20～+80	0.44	φ3	200
5mm-dia. 3-core shielded vinyl lead wire	7/0.26 (0.3mm²)	−20～+80	0.1	φ5	200

Enamel lead wires (standard length : 0.3m, 0.5m and 1m)

Enamel lead wires have a single core covered with a resin sheath. Heat resistance and handling methods vary depending on the sheath type. Because the wire mass and diameter are small, enamel lead wires are used for strain measurement of rotating specimens and measurement of multiple points located in close proximity. Since the enamel lead wire contains one core covered with a thin sheath, it must be handled with care.

- **Polyurethane lead wires**
  Polyurethane lead wires allow easy post-processing because the sheath can be removed with a soldering iron. The sheath is not strong, therefore, polyurethane wires must be handled with care.
- **Polyester lead wires**
  Polyester lead wires have a stronger sheath than urethane wires, but require a special peeling agent to remove the sheath (which cannot be removed with a soldering iron).
- **Polyimide lead wires**
  Polyimide lead wires have a stronger sheath than polyester wires. (A soldering iron cannot be used for post-processing.)

Lead wire type	Core/diameter	Applicable temperature (℃)	Total resistance of lead wire per meter (Ω)	Outside sheath dimensions (mm)	Length per roll (m)
0.14mm-dia. Polyurethane lead wire	1/0.14	−10～+120	2.5	ϕ0.16	—
0.18mm-dia. Polyurethane lead wire	1/0.18		1.5	ϕ0.20	
0.14mm-dia. Polyester lead wire	1/0.14	−196～+200	2.5	ϕ0.16	—
0.18mm-dia. Polyester lead wire	1/0.18		1.5	ϕ0.20	
0.14mm-dia. Polyimide lead wire	1/0.14	−269～+300	2.5	ϕ0.16	—
0.18mm-dia. Polyimide lead wire	1/0.18		1.5	ϕ0.20	

Cross-linked vinyl sheathed wire (standard lengths : 1m, 3m and 5m)

The cross-linked vinyl sheath provides improved resistance against environmetal elements. It is often used for underwater measurement under ordinary temperature.

Cross-linked polyethylene sheathed wire (standard lengths : 1m, 3m and 5m)

The cross-linked polyethylene sheath offers higher durability than the cross-linked vinyl sheath. Cross-linked polyethylene sheathed lead wires can be used in steam, warm water and concrete with virtually no insulation degradation.

Lead wire type	Core/diameter (cross section area)	Applicable temperature (℃)	Total resistance of lead wire per meter (Ω)	Outside sheath dimensions (mm)	Length per roll (m)
0.14mm² 2-wire twisted cross-linked vinyl sheathed lead wire	7/0.16 (0.14mm²)	−20～+100	0.24	ϕ3.0	—
0.09mm² 3-wire twisted cross-linked vinyl sheathed lead wire	7/0.127 (0.09mm²)		0.4	ϕ2.0	200
0.09mm² 3-wire twisted cross-linked polyethylene sheathed lead wire	7/0.127 (0.09mm²)	−60～+125	0.4	ϕ2.0	—

Fluorinated resin sheathed wire (standard lengths : 1m, 3m and 5m)

With a fluorinated resin sheath, these lead wires can be used in a wide range of temperature from extremely low to high temperatures. Fluorinated resin resists most chemicals. Surface treatment (tetra-etching) is required for some coatings.

Lead wire type	Core/diameter (cross section area)	Applicable temperature (℃)	Total resistance of lead wire per meter (Ω)	Outside sheath dimensions (mm)	Length per roll (m)
0.18mm² 3-wire twisted fluorinated resin(FEP) sheathed lead wire	7/0.18 (0.18mm²)	−269～+200	0.2	ϕ2.0	100
0.2mm-dia. 3-wire twisted fluorinated resin(FEP) sheathed lead wire	1/0.2		1.05	ϕ1.1	—
0.14mm² 3-wire twisted cross-linked fluorinated resin(PTFE) sheathed lead wire	7/0.16 (0.14mm²)	−269～+260 NB: Also available upto +300℃ for short-term use	0.24	ϕ1.9	100
0.2mm-dia. 3-wire twisted cross-linked fluorinated resin(PTFE) sheathed lead wire	1/0.2		1.05	ϕ1.1	—

Special wire for temperature-integrated gauge (standard lengths : 1m, 3m and 5m)

Special wires for temperature-integrated gauge consist of 2-core copper and 1-core constantan. To extend this wire, the exclusive wire should be applied properly.

Lead wire type	Core/diameter (cross section area)	Applicable temperature (℃)	Total resistance of lead wire per meter (Ω)	Outside sheath dimensions (mm)	Length per roll (m)
0.08mm² 3-wire paralleled vinyl lead wire	7/0.12 (0.08mm²)	−20～+80	0.44	1.2×3.6	—
0.2mm-dia. 3-wire twisted fluorinated resin(FEP) sheathed lead wire	1/0.2	−196～+200	1.05	ϕ1.1	—

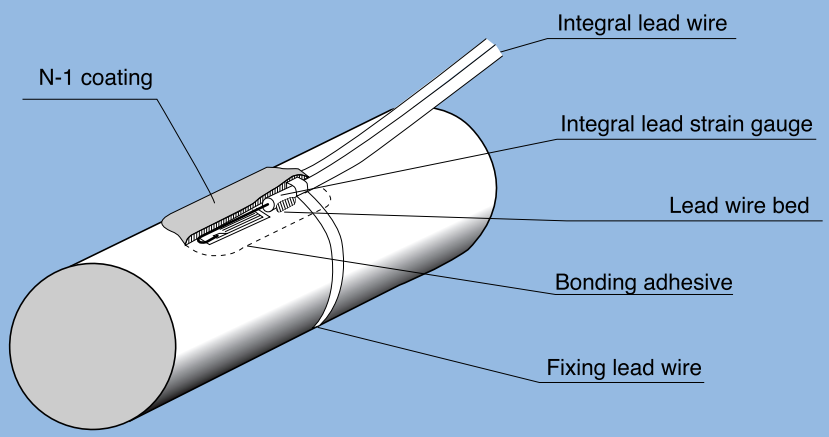
STRAIN GAUGE APPLICATIONS

Strain gauges are normally installed by bonding with adhesive or by spot welding. For bondable strain gauges, the surface of the test specimen must be suitably prepared, followed by bonding, wiring, and the application of a protective coating. For weldable strain gauges, rustproofing, welding and wiring are required. The following are typical installation procedures for various specimens.

WITH BONDABLE STRAIN GAUGES

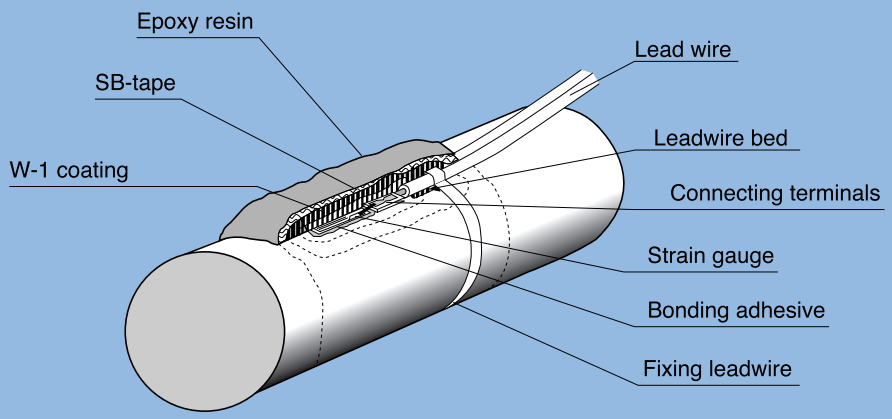
Metal surfaces

■Typical installation with bonding to metal surface for use in relatively well conditions such as in laboratory and short term period.



Metal specimen

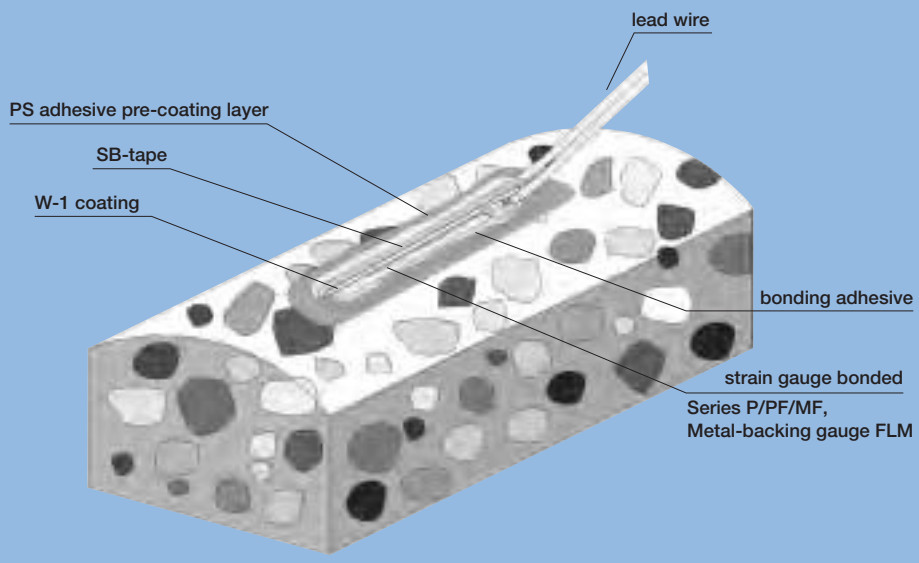
■Typical installation onto a metal surface for use in harsh conditions, such as under water for a long period or onto a reinforcing bar to be embedded into concrete.



Metal specimen

Concrete surfaces

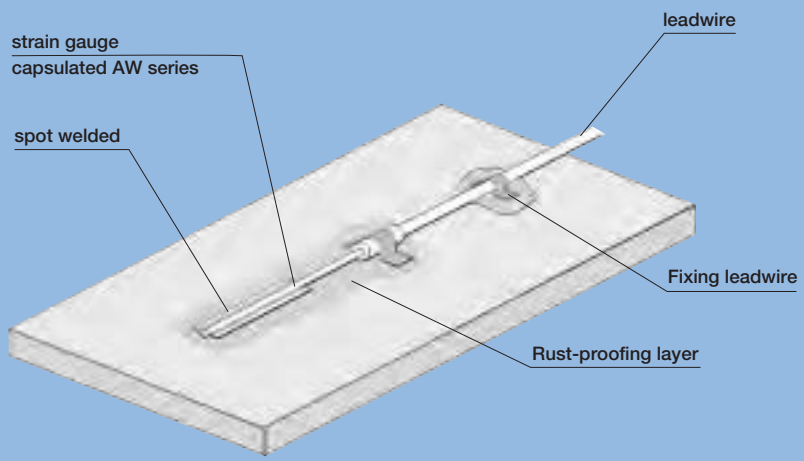
■Gauges are typically installed onto concrete surface or concrete specimens for loading tests. Stran gauges with an integral lead do not require lead wire connection with connecting terminals.



Concrete specimen

WITH WELDABLE STRAIN GAUGES SERIES AW

■These gauges are typically installed by spot-welding onto metal surfaces for use in harsh environments, such as on engines, heated turbines, or field sites for long periods.



Metal specimen

N.B.: For underwater use, an overcoating is strongly recommended to maintain the rust-proofing effect.

TML STRAINMETERS

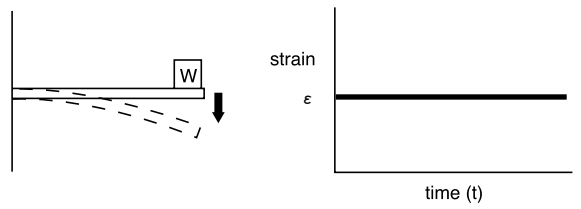
As the resistance change of strain gauges is extremely small, it is indicated or recorded by means of an amplifier, except for special cases and semiconductor gauges. The strainmeter is designed to convert the small resistance change of the strain gauge into a voltage output, amplifying it to output either digital or analog data. TML provides various types of strainmeters for static and dynamic strain measurements. Histogram recording system is also specially designed for analyzing the frequency distribution of various phenomena that accompany strain gauge measurement.

STATIC AND DYNAMIC STRAIN

The strain characteristics in strain measurement are classified into static, dynamic or a combined behavior according to the rapidity of the phenomena. Static strain varies slowly or not at all with time, while dynamic strain oscillates with time. As strainmeter are designed specifically for such strain performance, it is important to determine the appropriate strain type in order to select the correct strainmeter.

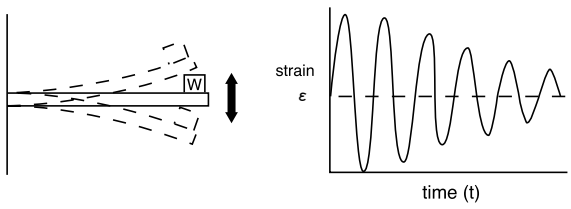
Static strain

Strain varies slowly or not at all with time.



Dynamic strain

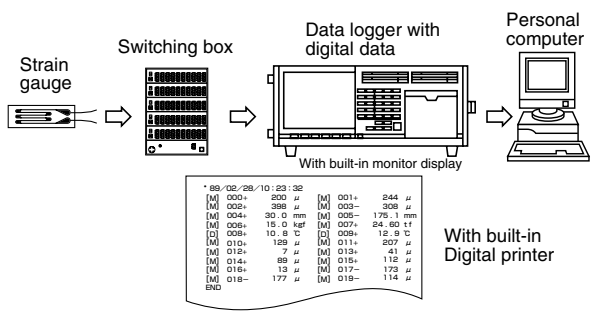
Strain oscillates with time.



STATIC STRAINMETER

Static strain remains almost constant during measurement, and the strain can be converted to digital values. Furthermore, for multi-point measurement, one unit of instrument makes automatic switching possible. The TML Data Logger is a typical static strainmeter and can measure a maximum of 1,000 points at high speed by cascading automatic switching boxes. It also features a number of processing functions. The TML digital indicator and instrumentation signal conditioner are in same field of instruments or strain gauge type transducers.

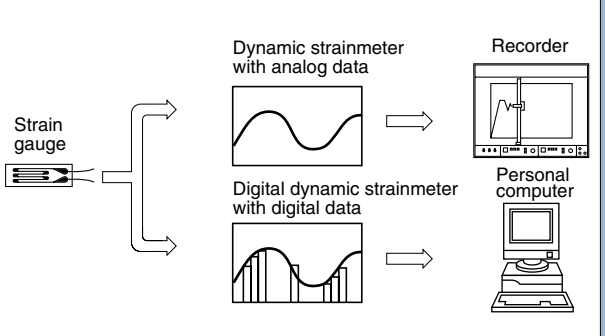
Data Logger/Static Strainmeter



DYNAMIC STRAINMETER

Dynamic strain varies with time and their data are converted to analog output signals. The measured strain is amplified by the dynamic strainmeter and output to an external recorder. One strainmeter is required for each measurement point. Using a processing unit such as an A/D converter, digital data can be output and saved in memory, then transferred to computer. The TML digital dynamic strainmeter is compatible with this architecture. The histogram recorder system is specially designed to measure a frequency distribution of dynamic strains.

Dynamic Strainmeter

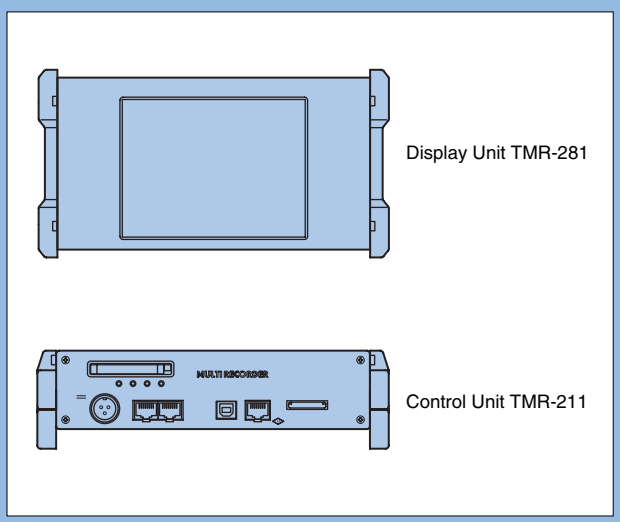


TMR-200 MULTI-RECORDER

The multi-recorder TMR-200 series is a small multi-channel data acquisition system enabling combination of various measuring units according to experimental purposes. The testing objects are analog input such as stress, load, pressure, acceleration, etc. using strain gauges and strain gauge based transducers and digital input/output such as CAN, etc. on vehicle onboard measurement.

PRODUCT CONCEPT

Conventional dynamic measuring instruments are specialized for strain, voltage and/or temperature measurements. If a system is set up in combination with strain and temperature or voltage and temperature, locations and wiring becomes troublesome, and settings for input and synchronous signal and output to an external device require a skilled work. As the TMR-200 can voluntarily combine various input units for strain, temperature and so on. complicate system can be simplified. For example, strain and temperature measurements in a material testing get possible by merely connecting the strain full bridge unit and voltage/thermocouple unit to the control unit. The number of measuring channels can be extended up to 80 by adding the necessary units.

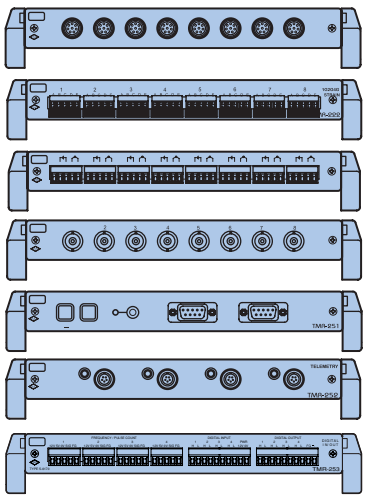


EXPANDABILITY OF APPLICATION

Due to smallness and lightweight, the TMR-200 can be easily installed onto not only fixed structures such as machines and bridges but a moving body such as automobiles, aircrafts and shipping. In a vehicle measurement, there are so many and versatile testing themes as to comfortableness and safety with the development of computer-controlled products, and the related various sensors have being developed day by day. In compatibility with such versatile sensors, expanded units such as CAN/VOICE/GPS unit and telemeter unit are added to ordinary strain, voltage and temperature measuring units. Moreover, installation of an histogram analysis library (option) into the control unit TMR-211 makes real-time histogram analysis possible.

Measuring Units

Voluntary combination of various inputs according to purposes



FOIL STRAIN GAUGE series "F"

metal

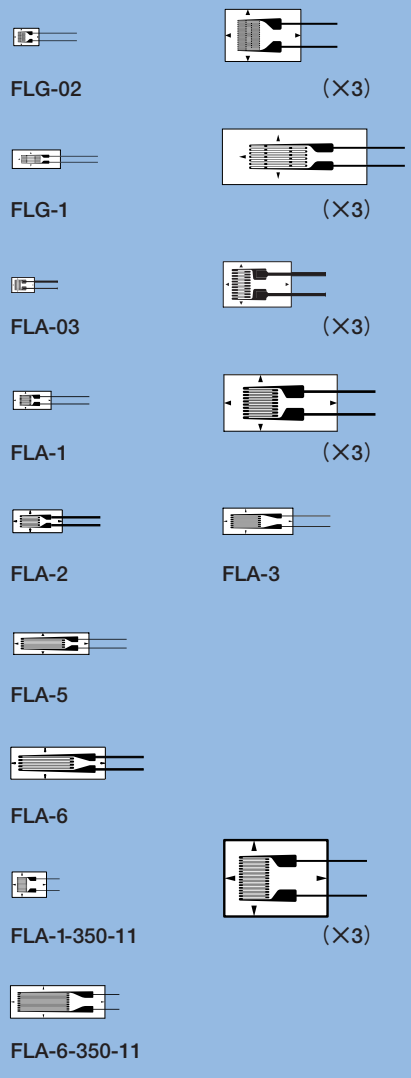
Compatible adhesive & Operational temperature
CN : −20～+80℃
P-2 : −20～+80℃　EB-2 : −20～+80℃

Operational temperature　−20～+80℃
Temperature compensation range　+10～+80℃

GENERAL USE

This gauge employs alloy foils which are 0.003 to 0.007 mm thick. Its gauge backing is made of epoxy resin with thickness of 0.03 mm which exhibits excellent electrical insulation performance. The backing is color coded for distinction of object specimen material for self temperature compensation.

■Single-element (G.F. 2.1 approx.)

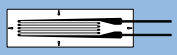
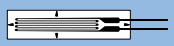


Gauge pattern	Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
		L : length	W : width (Unit : mm)			
Single-element	FLG-02-11 -17 -23	0.2	1.4	3.5	2.5	120
	FLG-1-11 -17 -23	1	1.1	6.5	2.5	120
	FLA-03-11 -17 -23	0.3	1.4	3.0	2.0	120
	FLA-05-11 -17 -23	0.5	1.2	5.0	2.2	120
	FLA-1-11 -17 -23	1	1.3	5.0	2.5	120
	FLA-2-11 -17 -23	2	1.5	6.5	3.0	120
	FLA-3-11 -17 -23	3	1.7	8.8	3.5	120
	FLA-3-60-11 -17 -23	3	1.2	8.0	3.0	60
	FLA-5-11 -17 -23	5	1.5	10.0	3.0	120
	FLA-6-11 -17 -23	6	2.2	12.5	4.3	120
350Ω	FLA-1-350-11 FLA-1-350-17 FLA-1-350-23	1	2.0	5.0	4.0	350
	FLA-2-350-11 FLA-2-350-17 FLA-2-350-23	2	1.9	6.1	3.5	350
	FLA-3-350-11 FLA-3-350-17 FLA-3-350-23	3	3.2	8.5	5.0	350
	FLA-6-350-11 FLA-6-350-17 FLA-6-350-23	6	2.6	12.5	4.5	350

Each package contains 10 gauges.

Compatible adhesive & Operational temperature
CN：−20～+80℃
P-2：−20～+80℃　EB-2：−20～+80℃

GENERAL USE

Gauge pattern		Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
			L : length	W : width (Unit : mm)			
		FLA-6-1000-11 -17 -23	6	4.6	13.5	7.0	1000
 FLA-10	Single-element	FLA-10-11 -17 -23	10	2.5	16.7	5.0	120
 FLA-30		FLA-30-11 -17 -23	30	2.0	36.1	5.1	120
 FLK-1	FLK-type with narrow gauge width	FLK-1-11 -17 -23	1	0.7	4.5	1.4	120
 FLK-2		FLK-2-11 -17 -23	2	0.9	5.5	1.5	120
 FLK-6		FLK-6-11 -17 -23	6	1.0	11.2	2.2	120
 FLK-10		FLK-10-11 -17 -23	10	1.6	16.2	3.8	120

FLA-1 -11 Materials for S-T-C

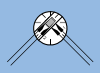
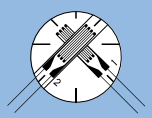
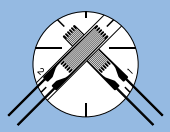
Gauge length
- 11 Mild steel
- 17 Stainless steel
- 23 Aluminium

Each package contains 10 gauges.

FOIL STRAIN GAUGE series "F"

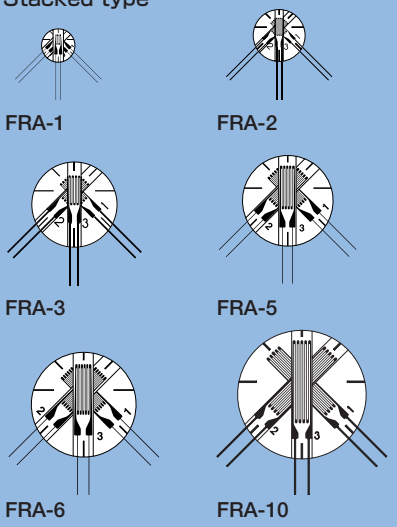
metal

GENERAL USE

Gauge pattern		Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
●90° 2-element Cross (G.F. 2.1 approx.) Stacked type			L : length	W : width (Unit : mm)			
 FCA-1	90° 2-element Cross, Stacked type	FCA-1-11 -17 -23	1	0.7	φ4.5		120
 FCA-2		FCA-2-11 -17 -23	2	0.9	φ7.0		120
 FCA-3		FCA-3-11 -17 -23	3	1.7	φ11.0		120
 FCA-5		FCA-5-11 -17 -23	5	1.9	φ12.0		120
 FCA-6		FCA-6-11 -17 -23	6	2.4	φ14.0		120
 FCA-10		FCA-10-11 -17 -23	10	2.5	φ17.0		120
	350 Ω	FCA-3-350-11 FCA-3-350-17 FCA-3-350-23	3	2	φ11.0		350

Each package contains 10 gauges.

GENERAL USE

Gauge pattern		Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
●45°/90° 3-element Rosette (G.F. 2.1 approx.) Stacked type			L : length	W : width (Unit : mm)			
 FRA-1 FRA-2 FRA-3 FRA-5 FRA-6 FRA-10	45°/90° 3-element Rosette, Stacked type	FRA-1-11 -17 -23	1	0.7	φ4.5		120
		FRA-2-11 -17 -23	2	0.9	φ7.0		120
		FRA-3-11 -17 -23	3	1.7	φ11.0		120
		FRA-5-11 -17 -23	5	1.9	φ12.0		120
		FRA-6-11 -17 -23	6	2.4	φ14.0		120
		FRA-10-11 -17 -23	10	2.5	φ17.0		120
	350Ω	FRA-3-350-11 FRA-3-350-17 FRA-3-350-23	3	2	φ11.0		350

Each package contains 10 gauges.

Point

●Gauge size

The location of gauge installation and the material on which it is installed impose restrictions on the strain gauge size. Also, because lead wires have to be connected to the connecting terminals and a coating materials applied to protect the gauge from moisture, the space required for the coating materials must also be considered.

●Gauge length

Gauges with short gauge lengths are used to measure localized strain, while gauges with long gauge lengths can be used to measure averaged stress over a larger area.

●Gauge width

Strain gauges with the same gauge length are also available in a narrower width (FLK-type). Select narrow strain gauges for thin specimens such as cylindrical pipes, etc.

FOIL STRAIN GAUGE series "F"

metal

Compatible adhesive & Operational temperature
CN : −20～+80℃
P-2 : −20～+80℃ EB-2 : −20～+80℃

Operational temperature −20～+80℃
Temperature compensation range +10～+80℃

SPECIAL USE

Gauge pattern		Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
			L : length	W : width (Unit : mm)			
Shearing strain measurement FLT-05A FLT-05B (Not actual size shown)	Shearing strain measurement	FLT-05A-11 -17 -23	0.5	0.66	4.0	1.3	120
		FLT-05B-11 -17 -23	0.5	0.66	4.0	1.3	120
Torque measurement FCT-2 FCT-2-350	Torque measurement	FCT-2-11 -17 -23	2	1.5	8.7	6.5	120
		FCT-2-350-11 -17 -23	2	1.7	7.6	5.3	350
90° 2-element Cross, Plane type FCB-2	90° 2-element Cross, Plane type	FCB-2-11 -17 -23	2	1.5	8.2	8.0	120
		FCB-6-350-11 -17 -23	6	2.0	10.0	13.0	350
3-element Residual Stress measurement FRAS-2	Residual Stress measurement Gauge-center diameter ϕ7.0mm	FRAS-2-11 -17 -23	2	1.1	9.0	9.0	120
FRS-2 FRS-3	Residual Stress measurement ϕ5.14mm	FRS-2-11 -17 -23	1.5	1.3	ϕ9.5		120
	Residual Stress measurement ϕ10.26mm	FRS-3-11 -17 -23	3	2.6	ϕ17.5		120

Each package contains 10 gauges.

GLASS/CERAMIC MATERIALS

glass ceramic

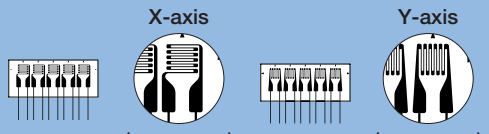
Gauge pattern		Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
			L : length	W : width (Unit : mm)			
●Single-element (G.F. 2.1 approx.) FLA-5-8	Single-element	FLA-2-8	2	1.5	6.5	3.0	120
		FLA-5-8	5	1.5	10.0	3.0	120
●90° 2-element Cross (G.F. 2.1 approx.) Stacked type FCA-2-8	90° 2-element Cross, Stacked type	FCA-2-8	2	0.9	ϕ7.0		120
		FCA-5-8	5	1.9	ϕ12.0		120
●45°/90° 3-element Rosette (G.F. 2.1 approx.) Stacked type FRA-5-8	45°/90° 3-element Rosette, Stacked type	FRA-2-8	2	0.9	ϕ7.0		120
		FRA-5-8	5	1.9	ϕ12.0		120

Each package contains 10 gauges.

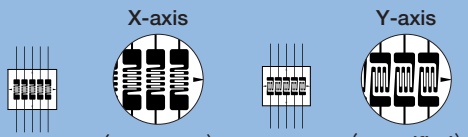
metal

STRESS CONCENTRATION MEASUREMENT

●5-element Single-axis (G.F.2.1 approx.)



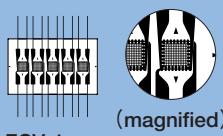
FXV-1-11-002LE　　FYV-1-11-002LE



FBXV-04　　FBYV-06

●10-element 2-axis

X and Y axis



FCV-1

Y-axis leadwire is marked for identification.

●Single-element (G.F. 2.1 approx.)

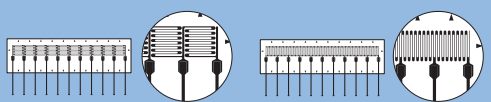
Single element cut away from Stress Concentration gauge

FBX-04　　(×3)

FBY-06　　(×3)

FLX-1　　(×3)

●Chain Strain Gauges CCFXX/CCFYX



CCFXX-1　(magnified)　CCFYX-1　(magnified)
X-axis 10-element　　Y-axis 10-element

Gauge pattern	Type		Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
			L : length	W : width (Unit : mm)			
5-element Single-axis [gauge pitch 2mm]	FXV-1-11 -17 -23	-002LE	1	1.3	5.0	12.0	120
	FYV-1-11 -17 -23	-002LE	1	1.4	5.0	12.0	120
5-element Single-axis [gauge pitch 1mm]	FBXV-04-11	-005LE	0.4	1.3	5.4	7.4	120
	FBYV-06-11	-005LE	0.6	0.8	5.3	7.0	120
10-element 2-axis [gauge pitch 2mm]	FCV-1-11 -17 -23	-005LE	1	1.4	7.5	12.0	120
Single-element	FBX-04-11	-005LE	0.4	1.3	5.4	1.0	120
	FBY-06-11	-005LE	0.6	0.8	5.3	1.0	120
	FLX-1-11 -17 -23	-002LE	1	1.3	5.0	2.0	120
	Gauge leads	-002LE : Polyimide -005LE : Polyimide			2cm pre-attached 5cm pre-attached		
10-element Single-axis [gauge pitch 1.5mm]	CCFXX-1		1	1.5	16.4	4.5	120
	CCFYX-1		1	1.5	16.4	4.5	120

These gauges are specially designed to use TML New method for strain measurement and need our Data Logger TDS-303 and TDS-602 with built-in the method. For the details, contact TML.

Each package contains 10 gauges.

Leadwire -integrated series "F"

metal

Compatible adhesive & Operational temperature
CN : −20～+80℃
P-2 : −20～+80℃ EB-2 : −20～+80℃

Operational temperature −20～+80℃
Temperature compensation range +10～+80℃
Quarter bridge with 3-wire system is usable to avoid an unexpected effect of resistance change with temperature.

GENERAL USE

This gauge has a pre-attached vinyl lead wire to F series strain gauge. Works for lead wire connection such as strain gauge terminal installation and lead wire soldering are not required. It saves much time and labor.

●Single-element (G.F. 2.1 approx.)

0.11mm² integral vinyl leadwire
Total leadwire resistance per meter : 0.32Ω

2-wire system

Grey

(Not actual size shown)

3-wire system

Blue stripe (independent)

(Not actual size shown)

Gauge pattern		Type		Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
				L : length	W : width (Unit : mm)			
	2-wire system Single-element	FLA-1-11 -17 -23	-1L	1	1.3	5.0	2.5	120
		FLA-2-11 -17 -23		2	1.5	6.5	3.0	120
		FLA-3-11 -17 -23	-3L	3	1.7	8.8	3.5	120
		FLA-5-11 -17 -23	-5L	5	1.5	10.0	3.0	120
		FLA-6-11 -17 -23		6	2.2	12.5	4.3	120
	3-wire system Single-element	FLA-1-11 -17 -23		1	1.3	5.0	2.5	120
		FLA-2-11 -17 -23		2	1.5	6.5	3.0	120
		FLA-3-11 -17 -23	-3LT -5LT	3	1.7	8.8	3.5	120
		FLA-5-11 -17 -23		5	1.5	10.0	3.0	120
		FLA-6-11 -17 -23		6	2.2	12.5	4.3	120

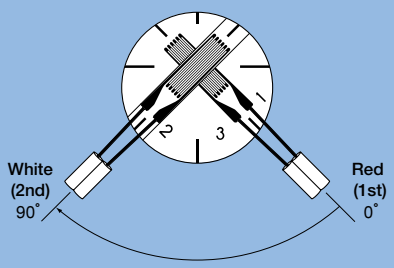
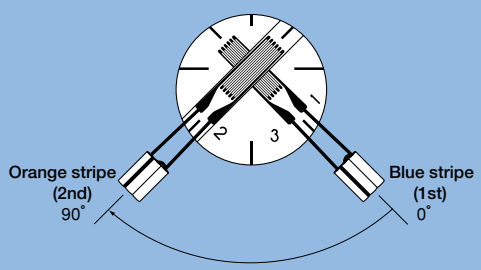
FLA-1-11-3LT
Length of integral leadwire (m)
Code of integral leadwire

Minimum order is 10 gauges or more.
Other gauge is also available for leadwire-integrated service, contact TML or your local representatives.

metal

Quarter bridge with 3-wire system is usable to avoid an unexpected effect of resistance change with temperature.

GENERAL USE

Gauge pattern	Type		Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
			L : length		W : width (Unit : mm)		
●90° 2-element Cross (G.F. 2.1 approx.)							
Stacked type 0.08mm² integral vinyl leadwire Total leadwire resistance per meter : 0.44 Ω 2-wire system  (Not actual size shown)	2-wire system 90° 2-element Cross Stacked type	FCA-1-11 -17 -23	-1L	1	0.7	φ4.5	120
		FCA-2-11 -17 -23		2	0.9	φ7.0	120
		FCA-3-11 -17 -23	-3L	3	1.7	φ11.0	120
		FCA-5-11 -17 -23	-5L	5	1.9	φ12.0	120
		FCA-6-11 -17 -23		6	2.4	φ14.0	120
		FCA-10-11 -17 -23		10	2.5	φ17.0	120
3-wire system  (Not actual size shown)	3-wire system 90° 2-element Cross Stacked type	FCA-1-11 -17 -23	-3LT	1	0.7	φ4.5	120
		FCA-2-11 -17 -23		2	0.9	φ7.0	120
		FCA-3-11 -17 -23		3	1.7	φ11.0	120
		FCA-5-11 -17 -23	-5LT	5	1.9	φ12.0	120
		FCA-6-11 -17 -23		6	2.4	φ14.0	120
		FCA-10-11 -17 -23		10	2.5	φ17.0	120

Minimum order is 10 gauges or more.

Leadwire -integrated series "F"

metal

Compatible adhesive & Operational temperature
CN : −20～+80℃
P-2 : −20～+80℃ EB-2 : −20～+80℃

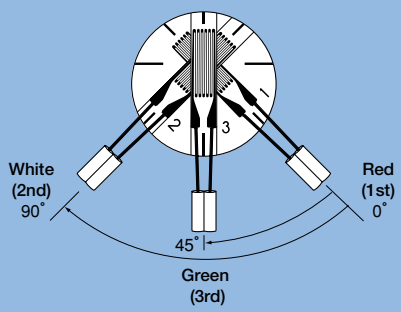
Operational temperature −20～+80℃
Temperature compensation range +10～+80℃
Quarter bridge with 3-wire system is usable to avoid an unexpected effect of resistance change with temperature.

GENERAL USE

●45˚/90˚ 3-element Rosette (G.F. 2.1 approx.)

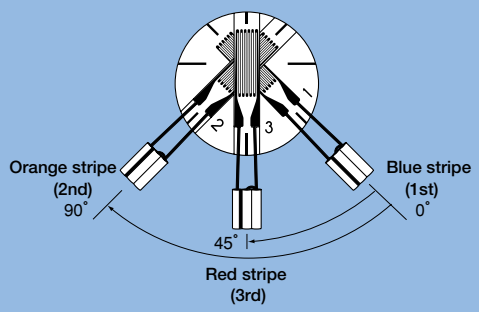
Stacked type
0.08mm² integral vinyl leadwire
Total leadwire resistance per meter : 0.44Ω

2-wire system



(Not actual size shown)

3-wire system



(Not actual size shown)

Gauge pattern	Type		Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
			L : length		W : width (Unit : mm)		
2-wire system 45˚/90˚ 3-element Rosette Stacked type	FRA-1-11 -17 -23	-1L	1	0.7	φ4.5		120
	FRA-2-11 -17 -23		2	0.9	φ7.0		120
	FRA-3-11 -17 -23	-3L	3	1.7	φ11.0		120
	FRA-5-11 -17 -23	-5L	5	1.9	φ12.0		120
	FRA-6-11 -17 -23		6	2.4	φ14.0		120
	FRA-10-11 -17 -23		10	2.5	φ17.0		120
3-wire system 45˚/90˚ 3-element Rosette Stacked type	FRA-1-11 -17 -23	-3LT	1	0.7	φ4.5		120
	FRA-2-11 -17 -23		2	0.9	φ7.0		120
	FRA-3-11 -17 -23		3	1.7	φ11.0		120
	FRA-5-11 -17 -23	-5LT	5	1.9	φ12.0		120
	FRA-6-11 -17 -23		6	2.4	φ14.0		120
	FRA-10-11 -17 -23		10	2.5	φ17.0		120

Minimum order is 10 gauges or more.

WATERPROOF STRAIN GAUGE series "WF"

metal

Compatible adhesive & Operational temperature
CN : 0～+80℃
P-2 : 0～+80℃

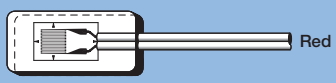
Operational temperature 0～+80℃
Temperature compensation range +10～+80℃
Quarter bridge with 3-wire system is usable to avoid an unexpected effect of resistance change with temperature.

WATERPROOF STRAIN GAUGE

This is F-series gauge having a pre-attached vinyl lead wire and an entire coating with epoxy resin. The coating is transparent and flexible, which ensures easy installation of the gauge.

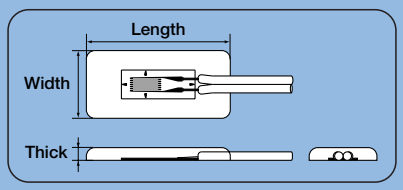
●Single-element (G.F. 2.1 approx.)

0.08mm² integral vinyl leadwire
Total leadwire resistance per meter : 0.44 Ω
2-wire system

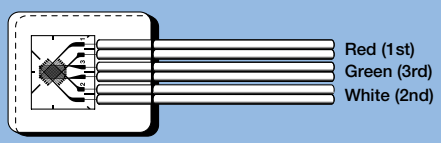


WFLA-3-350-11-1L

WFLA-3-11-1L

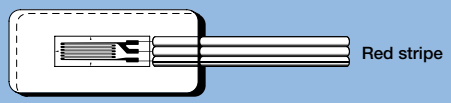


●45°/90° 3-element Rosette (G.F. 2.1 approx.)
2-wire system



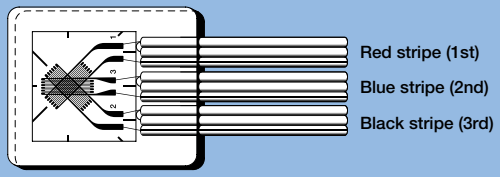
WFRA-3-11-1L

●Single element (G.F. 2.1 approx.)
3-wire system



WFLA-6-11-3LT

●45°/90° 3-element Rosette (G.F. 2.1 approx.)
3-wire system



WFRA-6-11-3LT

Each package contains 10 gauges.

Gauge pattern	Type		Gauge size L	Gauge size W	Backing L	Backing W	Backing T	Resistance in Ω
			L : length W : width T : thickness (Unit : mm)					
2-wire system	WFLA-3-11 -17 -23		3	1.7	17.0	8.0	1.5	120
Single element	WFLA-3-350-11 -17 -23		3	3.2	17.0	8.0	1.5	350
	WFLA-6-11 -17 -23	-1L	6	2.2	25.0	11.0	1.5	120
90° 2-element Cross Stacked type	WFCA-3-11 -17 -23	-3L	3	1.7	19.0	16.0	1.5	120
	WFCA-6-11 -17 -23	-5L	6	2.3	25.0	21.0	1.5	120
45°/90° 3-element Rosette Stacked type	WFRA-3-11 -17 -23		3	1.7	19.0	16.0	1.5	120
	WFRA-6-11 -17 -23		6	2.3	25.0	21.0	1.5	120
3-wire system	WFLA-3-11 -17 -23		3	1.7	17.0	8.0	1.5	120
Single element	WFLA-6-11 -17 -23		6	2.2	25.0	11.0	1.5	120
90° 2-element Cross Stacked type	WFCA-3-11 -17 -23	-3LT	3	1.7	19.0	16.0	1.5	120
	WFCA-6-11 -17 -23	-5LT	6	2.3	25.0	21.0	1.5	120
45°/90° 3-element Rosette Stacked type	WFRA-3-11 -17 -23		3	1.7	19.0	16.0	1.5	120
	WFRA-6-11 -17 -23		6	2.3	25.0	21.0	1.5	120

Temperature series "FLA-T" -integrated

metal

Series F — Compatible adhesive & Operational temperature
CN : −20～+80℃
P-2 : −20～+80℃
Operational temperature −20～+80℃

Series QF — Compatible adhesive & Operational temperature
NP-50 : −20～+200℃
C-1 : −20～+200℃ CN : −20～+120℃
Operational temperature −20～+200℃

THERMOCOUPLE USE

A T-type thermocouple is integrated with an ordinary strain gauge. The T-type thermocouple is composed of the Cu and the Cu-Ni wire which are used as a lead wire of the strain gauge. Both of strain measurement with quarter bridge 3-wire method and temperature measurement are possible when combined with TML data loggers.

L : length W : width (Unit : mm)

●Single-element (G.F. 2.1 approx.)

Series F

0.08mm² integral vinyl leadwire
Total leadwire resistance per meter : 0.44Ω

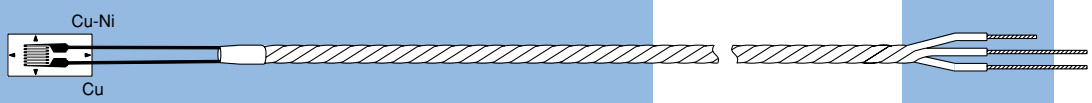
FLA-2T-11-3LT

Blue-Cu
White-Cu-Ni
Red-Cu

Gauge pattern	Leadwire pre-attached	Type		Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
	3-wire system	FLA-1T-11 -17 -23		1	1.3	5.0	2.5	120
		FLA-2T-11 -17 -23	-3LT	2	1.5	6.5	3.0	120
		FLA-5T-11 -17 -23		5	1.5	10.0	3.0	120

Series QF

ϕ0.2mm fluorinated resin (FEP) sheathed leadwire of 3m
Total leadwire resistance per meter : 1.05Ω



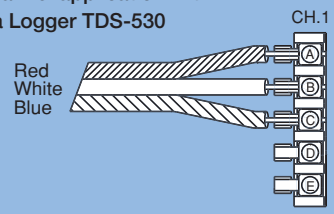
QFLA-2T-11-6FB-3LT

Blue-Cu
White-Cu-Ni
Red-Cu
(independent)

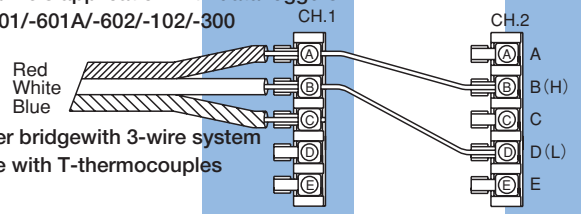
Gauge pattern	Leadwire pre-attached	Type		Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
	3-wire system	QFLA-1T-11		1	1.3	5.0	2.5	120
		QFLA-2T-11	-6FB-3LT	2	1.5	6.5	3.0	120
		QFLA-5T-11		5	1.5	10.0	3.0	120

●Wiring method

A: 1 channel application with Data Logger TDS-530



B: Continuous 2 channels application with data loggers TDS-302/-303/-601/-601A/-602/-102/-300



CH.1 for srain Quarter bridgewith 3-wire system
CH.2 for temperature with T-thermocouples

＊For extension of leadwires, apply exclusive leadwires.
＊Refer to operation manual for wiring method.

FOIL STRAIN GAUGE series "UF"

metal

Compatible adhesive & Operational temperature
CN : −20～+120℃
NP-50 : −20～+150℃　　EB-2 : −20～+150℃

Operational temperature　−20～+150℃
Temperature compensation range　+10～+100℃

GENERAL USE

Gauge pattern

The backing of this gauge is made of polyimide-amide resin, which enables the gauge to be used in 150˚C maximum. The backing is thin and it is easy to bond the gauge even on a curved surface without deterioration of the performance. The backing is color coded for distinction of object specimen material for self temperature compensation as same as F series.

●Single-element (G.F. 2.1 approx.)

UFLG-02　(×3)

UFLA-03　(×3)

UFLA-1　(×3)

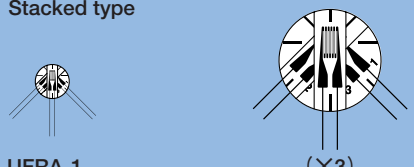
UFLK-1　(×3)

●90˚ 2-element Cross (G.F. 2.1 approx.)
Stacked type

UFCA-1　(×3)

UFCA-2　UFCA-5

●45˚/90˚ 3-element Rosette (G.F. 2.1 approx.)
Stacked type



UFRA-1　(×3)

UFRA-2　UFRA-5

Each package contains 10 gauges.

Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
	L : length	W : width (Unit : mm)			
Single-element					
UFLG-02-11 -17 -23	0.2	1.4	3.5	2.5	120
UFLA-03-11 -17 -23	0.3	1.4	3.0	2.0	120
UFLA-1-11 -17 -23	1	1.3	5.0	2.5	120
UFLA-2-11 -17 -23	2	1.5	6.5	3.0	120
UFLA-5-11 -17 -23	5	1.5	10.0	3.0	120
UFLK-1-11 -17 -23	1	0.7	4.5	1.4	120
UFLK-2-11 -17 -23	2	0.9	5.5	1.5	120
90˚ 2-element Cross, Stacked type					
UFCA-1-11 -17 -23	1	0.7	φ4.5		120
UFCA-2-11 -17 -23	2	0.9	φ7.0		120
UFCA-5-11 -17 -23	5	1.9	φ12.0		120
45˚/90˚ 3-element Rosette, Stacked type					
UFRA-1-11 -17 -23	1	0.7	φ4.5		120
UFRA-2-11 -17 -23	2	0.9	φ7.0		120
UFRA-5-11 -17 -23	5	1.9	φ12.0		120

FOIL STRAIN GAUGE series "UF"

metal

Compatible adhesive & Operational temperature
CN：−20～+120℃
NP-50：−20～+150℃　EB-2：−20～+150℃

Operational temperature　−20～+150℃
Temperature compensation range　+10～+100℃

GENERAL USE

Gauge pattern		Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
			L : length	W : width (Unit : mm)			
●Single-element (G.F. 2.1 approx.)							
UFLA-1-350	(×3)	UFLA-1-350-11 -17 -23	1	1.6	4.6	3.0	350
UFLA-3-350	(×3)	UFLA-2-350-11 -17 -23	2	1.9	6.1	3.5	350
UFLA-5-350	(×3)	UFLA-3-350-11 -17 -23	3	1.6	7.2	3.0	350
		UFLA-5-350-11 -17 -23	5	1.8	9.4	3.8	350
●90° 2-element Cross (G.F. 2.1 approx.) Stacked type							
UFCA-1-350	(×3)	UFCA-1-350-11 -17 -23	1	1.6	φ8.0		350
UFCA-2-350	UFCA-5-350	UFCA-2-350-11 -17 -23	2	1.9	φ9.5		350
		UFCA-3-350-11 -17 -23	3	2.0	φ10.0		350
		UFCA-5-350-11 -17 -23	5	1.8	φ10.0		350
●45°/90° 3-element Rosette (G.F. 2.1 approx.) Stacked type							
UFRA-1-350	(×3)	UFRA-1-350-11 -17 -23	1	1.6	φ8.0		350
UFRA-2-350	UFRA-5-350	UFRA-2-350-11 -17 -23	2	1.9	φ9.5		350
		UFRA-3-350-11 -17 -23	3	2.0	φ10.0		350
		UFRA-5-350-11 -17 -23	5	1.8	φ10.0		350

Leadwire-integral service is also available, contact TML.
Minimum order is 10 gauges or more.

Leadwire -integrated series "UF"

M metal

Compatible adhesive & Operational temperature
CN : −20～+120℃
NP-50 : −20～+150℃ EB-2 : −20～+150℃

Operational temperature −20～+150℃
Temperature compensation range +10～+100℃
Quarter bridge with 3-wire system is usable to avoid an unexpected effect of resistance change with temperature.

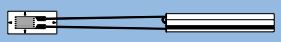
GENERAL USE

This gauge has a pre-attached vinyl lead wire to UF series strain gauge. Works for lead wire connection such as strain gauge terminal installation and lead wire soldering are not required. It saves much time and labor. When operating temperature of strain gauge exceeds 80℃, fluorinated resin sheathed extension wire should be ordered. (UF series utilizes polyimide gauge lead.)

●Single-element (G.F. 2.1 approx.)
0.08mm² integral vinyl leadwire
Total leadwire resistance per meter : 0.44Ω

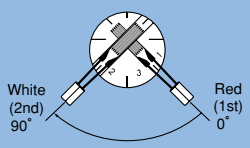
2-wire system

3-wire system

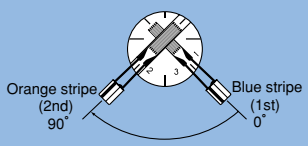


●90° 2-element Cross (G.F. 2.1 approx.)
Stacked type
0.08mm² integral vinyl leadwire
Total leadwire resistance per meter : 0.44Ω

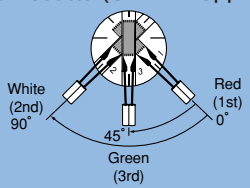
2-wire system



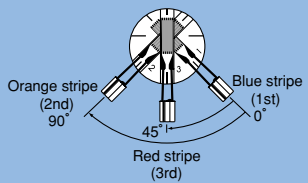
Stacked type
3-wire system



●45°/90° 3-element Rosette (G.F. 2.1 approx.)
Stacked type
2-wire system



Stacked type
3-wire system



(Not actual size shown)

Standard leadwire is vinyl leadwire and is available −20～+80℃.

Gauge pattern	Type		Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
			L : length	W : width (Unit : mm)			
Single-element 2-wire system	UFLA-1-11 -17 -23	-1L	1	1.3	5.0	2.5	120
	UFLA-2-11 -17 -23	-3L	2	1.5	6.5	3.0	120
	UFLA-5-11 -17 -23	-5L	5	1.5	10.0	3.0	120
Single-element 3-wire system	UFLA-1-11 -17 -23	-3LT	1	1.3	5.0	2.5	120
	UFLA-2-11 -17 -23		2	1.5	6.5	3.0	120
	UFLA-5-11 -17 -23	-5LT	5	1.5	10.0	3.0	120
90° 2-element Cross, Stacked type, 2-wire system	UFCA-1-11 -17 -23	-1L	1	0.7	φ4.5		120
	UFCA-2-11 -17 -23	-3L	2	0.9	φ7.0		120
	UFCA-5-11 -17 -23	-5L	5	1.9	φ12.0		120
90° 2-element Cross, Stacked type, 3-wire system	UFCA-1-11 -17 -23	-3LT	1	0.7	φ4.5		120
	UFCA-2-11 -17 -23		2	0.9	φ7.0		120
	UFCA-5-11 -17 -23	-5LT	5	1.9	φ12.0		120
45°/90° 3-element Rosette, Stacked type, 2-wire system	UFRA-1-11 -17 -23	-1L	1	0.7	φ4.5		120
	UFRA-2-11 -17 -23	-3L	2	0.9	φ7.0		120
	UFRA-5-11 -17 -23	-5L	5	1.9	φ12.0		120
45°/90° 3-element Rosette, Stacked type, 3-wire system	UFRA-1-11 -17 -23	-3LT	1	0.7	φ4.5		120
	UFRA-2-11 -17 -23		2	0.9	φ7.0		120
	UFRA-5-11 -17 -23	-5LT	5	1.9	φ12.0		120

Minimum order is 10 gauges or more.
For UFLK/UFLG gauges, leadwire-integral service is also available, contact TML.

HIGH TEMPERATURE series "QF" STRAIN GAUGE

M metal

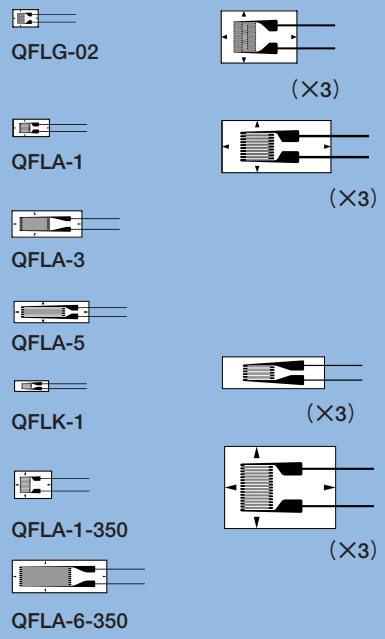
Compatible adhesive & Operational temperature
NP-50：−20～+200℃
C-1：−20～+200℃　　CN：−20～+120℃

Operational temperature　−20～+200℃
Temperature compensation range　+10～+100℃

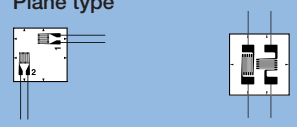
HIGH TEMPERATURE USE

This gauge utilizes polyimide resin as a backing. Strain measurement in high temperature is easily realized by bonding the gauge with room temperature curing adhesive NP-50.

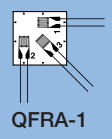
●Single-element (G.F. 2.1 approx.)



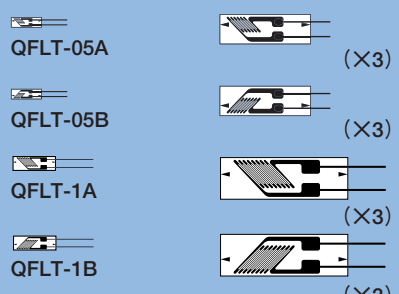
●90° 2-element Cross (G.F. 2.1 approx.)
Plane type



●45°/90° 3-element Rosette (G.F. 2.1 approx.)
Plane type



●Single-element (G.F. 2.1 approx.)
Shearing strain measurement



(Not actual size shown)
Each package contains 10 gauges.

Gauge pattern	Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
		L : length	W : width (Unit : mm)			
General purpose	QFLG-02-11	0.2	1.4	3.5	2.5	120
	QFLA-1-11	1	1.3	5.0	2.5	120
	QFLA-2-11	2	1.5	6.5	3.0	120
	QFLA-3-11	3	1.7	8.8	3.5	120
	QFLA-5-11	5	1.5	10.0	3.0	120
	QFLA-6-11	6	2.2	12.5	4.3	120
FLK-type with narrow gauge width	QFLK-1-11	1	0.7	4.5	1.4	120
	QFLK-2-11	2	0.9	5.5	1.5	120
For magnesium alloy	QFLK-2-28	2	0.9	5.5	1.5	120
High gauge resistance 350Ω, 1000Ω	QFLA-1-350-11	1	2.0	5.0	4.0	350
	QFLA-2-350-11	2	1.9	6.1	3.5	350
	QFLA-3-350-11	3	3.2	8.5	5.0	350
	QFLA-6-350-11	6	2.6	12.5	4.5	350
	QFLA-6-1000-11	6	4.6	13.5	7.0	1000
90° 2-element Cross, Plane type	QFCA-1-11	1	1.3	7.2	7.2	120
	QFCA-3-11	3	1.7	11.0	11.0	120
	QFCB-2-11	2	1.5	8.2	8.0	120
45°/90° 3-element Rosette, Plane type	QFRA-1-11	1	1.3	7.2	7.2	120
	QFRA-3-11	3	1.7	11.0	11.0	120
Single-element Shearing strain measurement	QFLT-05A-11	0.5	0.66	4.0	1.3	120
	QFLT-05B-11	0.5	0.66	4.0	1.3	120
	QFLT-1A-11	1	1.1	5.7	2.0	120
	QFLT-1-350A-11 -002LE	1	1.1	5.7	2.0	350
	QFLT-1B-11	1	1.1	5.7	2.0	120
	QFLT-1-350B-11	1	1.1	5.7	2.0	350

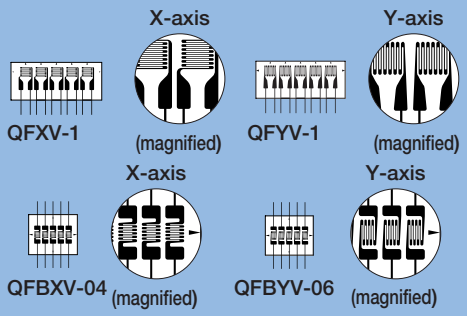
Gauge leads　-002LE：Polyimide　2cm pre-attached

metal

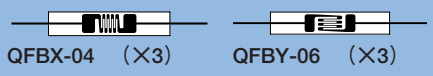
STRESS CONCENTRATION MEASUREMENT

Gauge pattern

●5-element Single-axis (G.F. 2.1 approx.)
X and Y-axis



●Single-element (G.F. 2.1 approx.)
Single element cut away from
Stress Concentration gauge



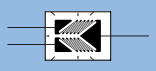
Each package contains 10 gauges.

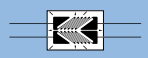
	Type		Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
			L : length	W : width	(Unit : mm)		
5-element Single-axis [gauge pitch 2mm]	QFXV-1-11	-002LE	1	1.3	5.0	12.0	120
	QFYV-1-11	-002LE	1	1.4	5.0	12.0	120
5-element Single-axis [gauge pitch 1mm]	QFBXV-04-11	-005LE	0.4	1.3	5.4	7.4	120
	QFBYV-06-11	-005LE	0.6	0.8	5.3	7.0	120
Single-element	QFBX-04-11	-005LE	0.4	1.3	5.4	1.0	120
	QFBY-06-11	-005LE	0.6	0.8	5.3	1.0	120
	QFLX-1-11	-002LE	1	1.3	5.0	2.0	120
	Gauge leads	-002LE : Polyimide 2cm pre-attached -005LE : Polyimide 5cm pre-attached					

TORQUE MEASUREMENT

Gauge pattern

●90° 2-element Cross (G.F. 2.1 approx.)


QFCT-2-11


QFCT-2-350-11

Each package contains 10 gauges.

	Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
		L : length	W : width	(Unit : mm)		
Torque measurement	QFCT-2-11	2	1.5	8.7	6.5	120
	QFCT-2-350-11	2	1.7	7.6	5.3	350

Leadwire-integrated QF series (made-to-order)

Operational temperature range varies with different materials of lead wire outer sheath. Before use, be sure the temperature range for lead wire.

Lead wires	Operational temperature range	Gauge type exampled	Colors of Lead wire
2-wire Parallel vinyl wire	−20～+80℃	L : QFLA-1-11-3LJC	Grey
3-wire Parallel vinyl wire	−20～+80℃	LT : QFLA-1-11-3LJCT	Blue stripe (Independent wire)
Crosslinked vinyl sheath wire	−10～+100℃	LJRTA : QFLA-1-11-3LJRTA	Red-Green-Black
3-wire strand FEP sheath wire	−269～+200℃	6F : QFLA-1-11-6FA-3LT	Red-Green-Blue (7-core 0.18mm-dia.)
		6F : QFLA-1-11-6FB-3LT	Red-Green-Blue (Single-core 0.2mm-dia.)

* Red is independent wire.

HIGH TEMPERATURE series "ZF" STRAIN GAUGE

Compatible adhesive & Operational temperature
NP-50 : −20～+300℃
C-1 : −20～+200℃　　CN : −20～+120℃

Operational temperature　−20～+300℃
Temperature compensation range　+10～+100℃

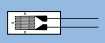
M metal

GENERAL USE

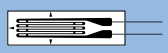
Gauge pattern

This is a foil gauge having a polyimide resin backing. Owing to the use of Ni-Cr alloy and special grid design for the strain sensing element, creep characteristics in high temperature has been much improved.

●Single-element (G.F. 2.1 approx.)

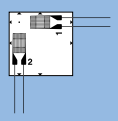

ZFLA-1

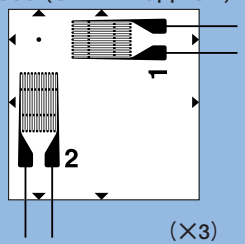

ZFLK-2


ZFLA-6

●90° 2-element Cross (G.F. 2.1 approx.)

Plane type

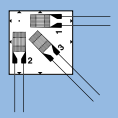

ZFCA-1-350



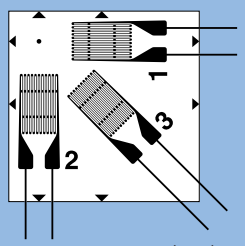
(×3)

●45°/90° 3-element Rosette (G.F. 2.1 approx.)

Plane type


ZFRA-1-350

Stacked type



(×3)


ZFCAL-1


ZFRAL-1

Each package contains 10 gauges.

Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
	L : length	W : width (Unit : mm)			
Single-element	ZFLK-2-11	2	0.5	5.4	1.4	120
	ZFLA-1-11	1	1.8	7.0	3.0	120
	ZFLA-3-11	3	1.8	10.5	3.5	120
	ZFLA-6-11	6	2.5	15.5	4.5	120
	ZFLA-3-60-11	3	0.7	7.7	2.6	60
Single-element 350Ω	ZFLA-1-350-11	1	1.7	6.6	3.2	350
	ZFLA-3-350-11	3	3.2	10.2	5.1	350
	ZFLA-6-350-11	6	2.8	16.0	5.5	350
90° 2-element Cross, Plane type 350Ω	ZFCA-1-350-11	1	1.7	8.5	8.5	350
	ZFCA-3-350-11	3	1.4	10.5	10.5	350
Stacked type	ZFCAL-1-11	1	1.0	φ5.4		120
45°/90° 3-element Rosette, Plane type 350Ω	ZFRA-1-350-11	1	1.7	8.5	8.5	350
	ZFRA-3-350-11	3	1.4	10.5	10.5	350
Stacked type	ZFRAL-1-11	1	1.0	φ5.4		120

For self-temperature-compensated (S-T-C) gauge, other linear thermal expansion coefficient is also available such as for stainless steel and aluminium alloy.

Leadwire-integrated ZF series (made-to-order)

Operational temperature range varies with different materials of lead wire outer sheath.　Before use, be sure the temperature range for lead wire.

Lead wires	Operational temperature range	Gauge type exampled	Colors of Lead wire
2-wire Parallel vinyl wire	−20～+80℃	L : ZFLA-3-350-11-3LJC	Grey
3-wire Parallel vinyl wire	−20～+80℃	LT : ZFLA-3-350-11-3LJCT	Blue stripe
Crosslinked vinyl sheath wire	−10～+100℃	LJRT : ZFLA-3-350-11-3LJRTA	Red-Green-Black
3-wire strand FEP sheath wire	−269～+200℃	6F : ZFLA-3-350-11-6FA-3LT	Red-Green-Blue (7-core 0.18mm-dia.)
		6F : ZFLA-3-350-11-6FB-3LT	Red-Green-Blue (Single-core 0.2mm-dia.)
3-wire strand PTFE sheath wire	−269～+260℃ (+300℃ usable for short time measurement)	4F : ZFLA-3-350-11-4FA-3LT	Red-Black-White (7-core 0.16mm-dia.)
		4F : ZFLA-3-350-11-4FB-3LT	Red-Black-White (Single-core 0.2mm-dia.)

* Red is independent wire.

CRYOGENIC TEMPERATURE series "CF" STRAIN GAUGE

Compatible adhesive & Operational temperature
EA-2A：−269～+50℃
CN：−196～+80℃　　C-1：−269～+80℃

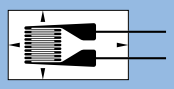
Operational temperature　−269～+80℃
Temperature compensation range　approximately　−196～+80℃

CRYOGENIC TEMPERATURE USE

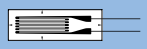
This is a foil gauge having an epoxy resin backing. The sensing element is made of special alloy. The gauge enables stable strain measurement in a cryogenic temperature as well as in a room temperature.

●Single-element (G.F. 2.1 approx.)

CFLA-1-350

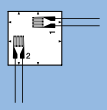


(×3)



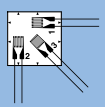
CFLA-6-350

●90° 2-element Cross (G.F. 2.1 approx.)
Plane type



CFCA-1-350

●45°/90° 3-element Rosette (G.F. 2.1 approx.)
Plane type



CFRA-1-350

Each package contains 10 gauges.

Gauge pattern	Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
		L : length	W : width (Unit : mm)			
Single-element 350Ω	CFLA-1-350-11 -17 -23	1	1.6	5.4	3.2	350
	CFLA-3-350-11 -17 -23	3	1.7	8.8	3.5	350
	CFLA-6-350-11 -17 -23	6	2.2	12.5	4.3	350
90° 2-element Cross, Plane type 350Ω	CFCA-1-350-11 -17 -23	1	1.3	7.2	7.2	350
	CFCA-3-350-11 -17 -23	3	1.7	11.0	11.0	350
45°/90° 3-element Rosette, Plane type 350Ω	CFRA-1-350-11 -17 -23	1	1.3	7.2	7.2	350
	CFRA-3-350-11 -17 -23	3	1.7	11.0	11.0	350

Leadwire-integrated CF series (made-to-order)

Operational temperature range varies with different materials of lead wire outer sheath.　Before use, be sure the temperature range of lead wire.

Lead wires	Operational temperature range	Gauge type exampled	Colors of Lead wire
3-wire strand FEP sheath wire	−269～+200℃	6F：CFLA-1-350-11-6FA-3LT	Red-Green-Blue (7-core 0.18mm-dia.)
		6F：CFLA-1-350-11-6FB-3LT	Red-Green-Blue (Single-core 0.2mm-dia.)

* Red is independent wire.

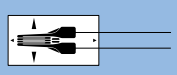
WIDE RANGE TEMPERATURE series "CEF" STRAIN GAUGE

Compatible adhesive & Operational temperature
C-1：−269～+200℃

Operational temperature　−269～+200℃
Temperature compensation range　approximately　−196～+80℃

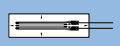
WIDE RANGE TEMPERATURE USE

CEFLA-1



(×3)

CEFLA-3



CEFLA-6

Each package contains 10 gauges.

Gauge pattern	Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
		L : length	W : width (Unit : mm)			
Single-element	CEFLA-1-11 -17 -23	1	0.5	4	2.2	120
	CEFLA-3-11 -17 -23	3	0.6	6.9	2.8	120
	CEFLA-6-11 -17 -23	6	1	10.6	3.1	120

HIGH TEMPERATURE WELDABLE STRAIN GAUGE series "AW"

metal

WELDABLE STRAIN GAUGE(AWM/AWMD/AWH/AWHU)

These gauges are fully encapsulated in a corrosion-resisting metal tube for use in various environments, including gas-filled atmospheres and underwater. These gauges can be easily installed by using dedicated spot welder W-50R.

AW series coding system

①	②	③④	⑤	⑥	⑦	⑧
AWM	8	1 B		2		17.0
AWMD	5	A	KM	2	(6F)	1.6Hz*
AWMD	8	A		2		1.6Hz*
AWH	8	7 A		2		11.0
AWHU	5	9 A	KM	2	(6F)	12.7

*High-pass filter only for AWMD Either one available among 1.6, 7.2 or 16Hz

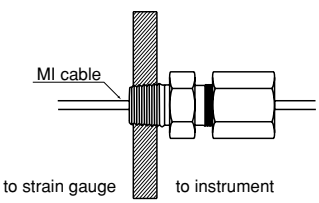
①Type	②Gauge length	③Temperature compensation range	④Backing materials*1	⑤Option
AWM : static/dynamic 300℃	8 : 8mm	0 : −196℃～RT 1 : RT～+300℃ 2 : RT～+350℃ 3 : RT～+400℃ 4 : RT～+450℃ 5 : RT～+500℃ 6 : RT～+550℃ 7 : RT～+600℃ 8 : RT～+650℃ 9 : RT～+800℃ 10 : Others NB1: Dynamic use AWMD is not applicable NB2: RT Room temperature	A : Inconel 600 Applicable thermal expansion coefficient of 11ppm/℃ or closer B : AWH SUS321 AWM SUS304 Applicable thermal expansion coefficient of 17ppm/℃ or closer	E: Ground earth F: Compression fittings K: Narrow gauge width W=3mm (5mm standard) M: Small junction type of sleev B φ2.0mm L=20mm AWHU and AWMD-5 are normally provided with small junction P: NDIS type plug attached*2 R: Bend of gauge backing or pipes Z: Filter-less (AWMD)
AWMD : dynamic only 800℃	5 : 5mm 8 : 8mm			
AWH : static 600℃ dynamic 650℃	4 : 4mm 8 : 8mm			
AWHU : static/dynamic 800℃	5 : 5mm 8 : 8mm			

*1 Select code A for thermal expansion coefficient of 11ppm/℃ or closer, or B for coefficient of 17ppm/℃ or closer.

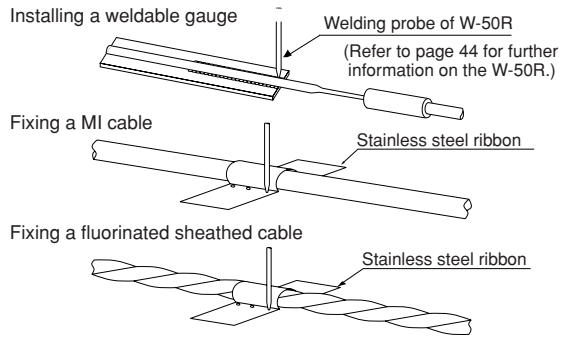
*2 For option code P, NDIS plug with φ3mm shielded chloroprene cable of 2m is positioned to Temperature-compensation board or High-pass filter. Available with AWMD-8/AWH/AWHU

⑥MI cable	⑦Supplied cable length	⑧Temperature compensation materials or High-pass filter
2 : φ1.6mm 2m Core cable of heat-resistive copper	No marks : φ4.1mm shielded vinyll cable of 0.5m long Except for standard length, required length is given in bracket. Example: 4.5m long to (4.5) (6F) φ1.6mm shielded fluoroethylene propylene cable (FEP) of 0.5m long for AWHU-5, -8, AWMD-5 Except for standard length, required length is given after suffix 6F. Example: 4.5m long to (6F4.5)	Materials available for temperature-compensation 10.9 : SUS430 or equivalent 11.0 : Mild steel (ferritic) or equivalent 12.7 : INCONEL 600 or equivalent 17.0 : SUS304 or equivalent High-pass filter for only AWMD 1.6 : 1.6Hz 7.2 : 7.2Hz 16 : 16 Hz

Option code F for Compression fittings available with AWM/AWMD/AWH/AWHU



Examples of installation



HIGH TEMPERATURE WELDABLE STRAIN GAUGE series "AW"

metal

Operational temperature AWM −196～+300℃ AWMD −196～+800℃

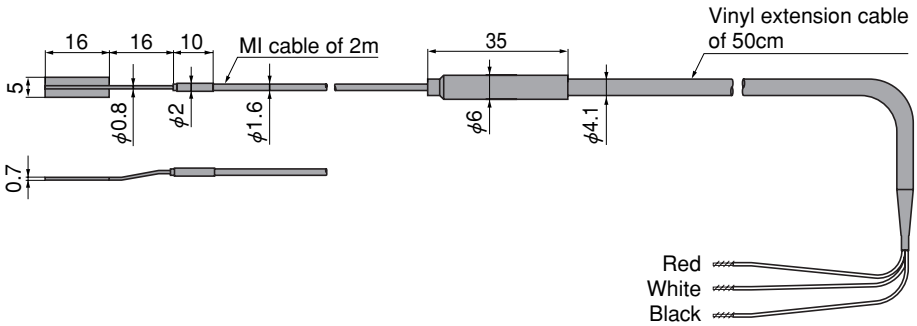
WELDABLE STRAIN GAUGE (AWM・AWMD)

■AWM-8 Quarter bridge with 3-wire system

The AWM is usable up to 300˚C for both static and dynamic measurement. The backing material is available in Inconel 600 or SUS304 which should be selected according to the test specimen material.

Type		Gauge length (mm)	Gauge base		Operational temperature 〈Temperature compensation range〉 (℃)	Resistance in Ω
			Dimension (mm)	Materials		
Static/Dynamic measurement 300℃	AWM- 8-1A-2-11.0	8	16×5	Inconel 600	−196～+300	120
	AWM- 8-1B-2-17.0			SUS 304	〈Room-temperature～+300〉	

AWM-8



■AWMD-5, AWMD-8 (for dynamic measurement only : −196 to +800˚C) Full bridge

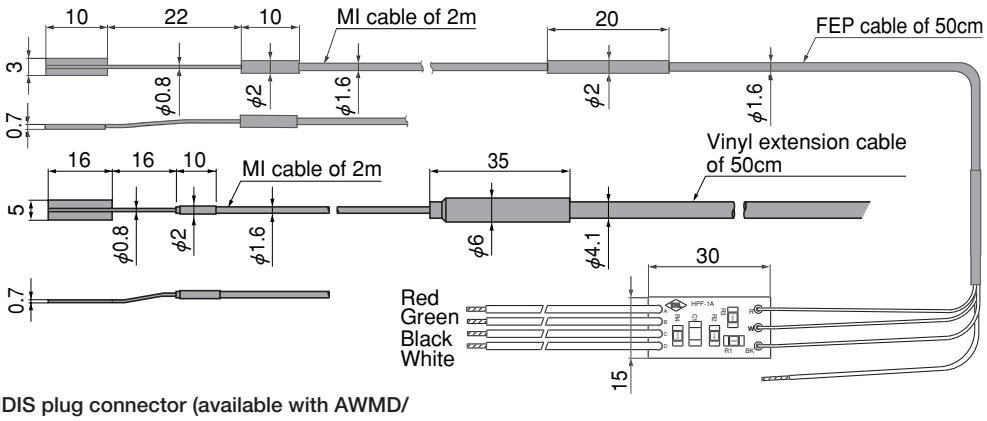
The AWMD is applicable up to 800˚C and it is dedicated to dynamic strain measurement. A high pass filter is a standard accessory. Using the high pass filter, unnecessary direct current component or low frequency component (thermal output, drift etc.) in the measurement signal can be neglected. The DC exciting dynamic strainmeter (DC-96A/DC-97A) or the smart strain recorder (DC-104R, DC-204R), Multi-Recorder TMR-200 should be used for measurement.

Type		Gauge length (mm)	Gauge base		Operational temperature 〈Temperature compensation range〉 (℃)	Resistance in Ω
			Dimension (mm)	Materials		
Dynamic use only 800℃	AWMD-5-AKMS-2 (6F)-1.6Hz※	5	10×3	Inconel 600	−196～+800	60
	AWMD-8-A-2-1.6Hz※	8	16×5		〈————〉	120

*Either one available among 1.6, 7.2 or 16Hz

AWMD-5

AWMD-8



Option code P for NDIS plug connector (available with AWMD/ AWH/AWHU) attached to Temperature-compensation board or High-pass filter

High-pass filter

HIGH TEMPERATURE WELDABLE STRAIN GAUGE series "AW"

metal

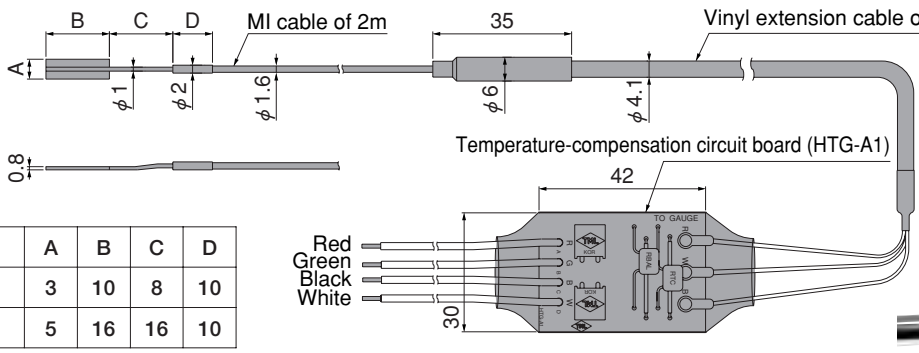
Operational temperature AWH Static −196～+600℃ Dynamic −196～+650℃ AWHU −196～+800℃

WELDABLE STRAIN GAUGE (AWH・AWHU)

■AWH-4, AWH-8 Fulll bridge

The backing material is available in Inconel 600 or SUS321 which should be selected according to the test specimen material. Although it has a half bridge construction consisting of active and dummy gauges, the measurement is made by the full bridge method using the supplied temperature compensation circuit board. The maximum operational temperature is 600˚C for static measurement and 650˚C for dynamic measurement.

Type		Gauge length (mm)	Gauge base		Operational temperature 〈Temperature compensation range〉 (℃)	Resistance in Ω
			Dimension (mm)	Materials		
Static measurement 600℃	AWH-4-7A-2-11.0	4	10×3	Inconel 600	Static−196～+600 〈Room-temperature～+600〉	60
	AWH-4-7B-2-17.0			SUS321		
Dynamic measurement 650℃	AWH-8-7A-2-11.0	8	16×5	Inconel 600	Dynamic−196～+650 〈Room-temperature～+650〉	120
	AWH-8-7B-2-17.0			SUS321		

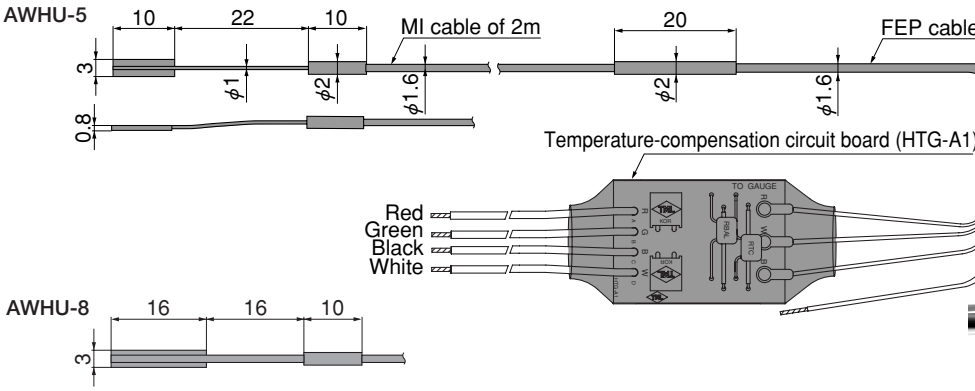


Type	A	B	C	D
AWH-4	3	10	8	10
AWH-8	5	16	16	10

■AWHU-5, AWHU-8 Fulll bridge

These gauges are usable up to 800˚C for both static and dynamic measurement. Although it has a half bridge construction consisting of active and dummy gauges, the measurement is made by the full bridge method using the supplied temperature compensation circuit board. The gauge base, junction part and cable of this gauge are constructed small as a standard specification and it is suited for being mounted on a narrow or a curved part.

Type		Gauge length (mm)	Gauge base		Operational temperature 〈Temperature compensation range〉 (℃)	Resistance in Ω
			Dimension (mm)	Materials		
Static／Dynamic measurement 800℃	AWHU-5-9AKM-2 (6F)-12.7	5	10×3	Inconel 600	−196～+800 〈Room-temperature～+800〉	60
	AWHU-8-9AKM-2 (6F)-12.7	8	16×5			120



HIGH TEMPERATURE WELDABLE STRAIN GAUGE series "AW"

Operational temperature AW −196～+300℃ AWC −20～+100℃

WELDABLE STRAIN GAUGE(AW・AWC)

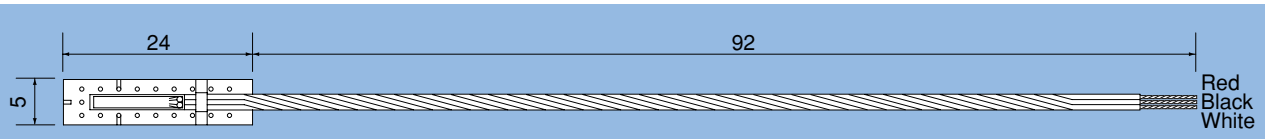
These gauges have corrosion-resisting stainless steel backing with thickness of 0.08mm. They are easily installed by using dedicated spot welder W-50R.

■AW-6-350-11-01LT Quarter bridge with 3-wire system

This gauge is suited for strain measurement in high temperature up to 300˚C, for measurement of specimen to which adhesion is not applicable or for long term measurement.

Extension leadwire: ϕ0.2mm fluorinated resin sheath (PTFE) of 0.1m standard

Type	Gauge length (mm)	Materials of gauge base	Operational temperature (℃)	Temperature compensation range (℃)	Test specimen	Resistance in Ω
AW-6-350-11-01LT	6	SUS 304	−196～+300	+10～+100	Mild steel	350



Each package contains 5 gauges.

■AWC-2B-11-3LQ 1-Gauge 4-Wire system
■AWC-8B-11-3LT Quarter bridge with 3-wire system

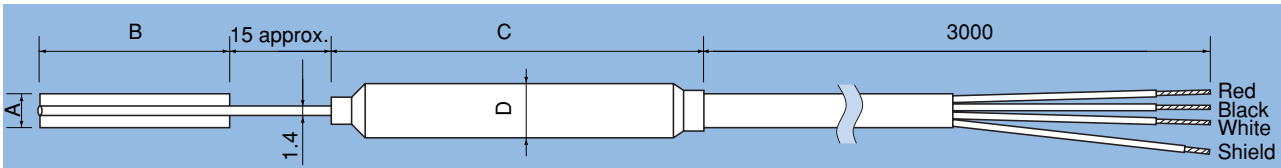
These gauges are fully encapsulated in a stainless steel tube. It enables long term strain measurement in harsh environment.

Extension leadwire:

AWC-2B-11-3LQ : ϕ3mm 0.05mm² 4-core shielded chloroprene of 3m standard

AWC-8B-11-3LT : ϕ5mm 0.3mm² 3-core shielded vinyl of 3m standard

Type	Gauge length (mm)	Materials of gauge base	Operational temperature (℃)	Temperature compensation range (℃)	Test specimen	Resistance in Ω
AWC-2B-11-3LQ	2	SUS 304	−20～+100	0～+100	Mild steel	120
AWC-8B-11-3LT	8			+10～+100		



Type	A	B	C	D
AWC-2B-11-3LQ	5	16	35	ϕ5
AWC-8B-11-3LT	5	28	35	ϕ8

NB : AWC-2B-11-3LQ has 4-core leadwire.

Each package contains 1 gauge.

SPOT WELDER W-50R

This is a capacitive charge spot welder used for installing weldable strain gauges and fixing lead wires. The welding energy is controlled in 2 ranges of 1～10/5～50 watt second continuously, and a stabilizing circuit cancels the effect of changes in the power source voltage. Projecting parts such as electrical cables is packed inside, it is extremely convenient for field applications.

■SPECIFICATIONS

Welding energy	1～10 watt sec./5～50 watt sec. continuous 60 watt sec. Max. (110V ac. 50Hz)
Output voltage	approx. 32V Max.
Output pulse width	approx. 5 msec.
Repetion use	2 welds/sec. at 50 watt sec.
Rated output	20 min./1.5 welds/sec. at 50 watt sec.
Welding probe	III type probe
Welding force	4.9～19.8N
Welding tip	Arm ϕ3mm, Nose ϕ1mm
Cable length	2m
Operation environment	0～+50℃ 85%RH or less (no condensation) allowed

Power source	90～110V ac., 50/60Hz 550VA peak (160msec.), 210VA/2 welds/sec.
Dimensions	300(W)×195(H)×195(D)mm
Weight	13 kg.
Standard accessory	
Operation manual	1
AC Power cable(CR-01)	1
Welding tip	3
Protective cap	2
Abrasive paper (#400)	5
Hexagon head wrench (M2.5)	1
Carrying belt	1

POLYESTER WIRE series "P" STRAIN GAUGE

C concrete M metal R rock

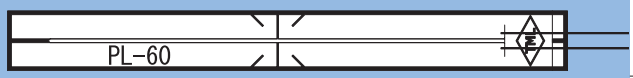
Compatible adhesive & Operational temperature
CN-E : −20～+80℃
RP-2 : −20～+80℃

Operational temperature −20～+80℃
Temperature compensation range +10～+80℃
Quarter bridge with 3-wire system is usable to avoid an unexpected effect of resistance change with temperature.

CONCRETE, MORTAR, ROCK MATERIALS USE

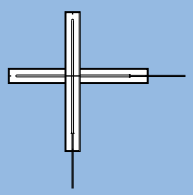
This is a wire strain gauge having polyester resin backing. It is mainly used for measurement on concrete, mortar or rock.

●Single-element (G.F. 2.1 approx.)



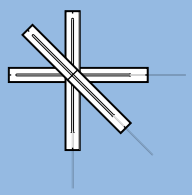
PL-60-11

●90° 2-element Cross (G.F. 2.1 approx.)



PLC-60-11 (×1／4)

●45°/90° 3-element Rosette (G.F. 2.1 approx.)



PLR-60-11 (×1／4)

Each package contains 10 gauges.

Gauge pattern / Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
	L : length	W : width (Unit : mm)			
Single-element					
PL-60-11	60	1	74	8	120
PL-90-11	90	1	105	8	120
PL-120-11	120	1	135	8	120
90° 2-element Cross					
PLC-60-11	60	1	74	74	120
45°/90° 3-element Rosette					
PLR-60-11	60	1	74	74	120

Leadwire-integral P series

This gauge has a pre-attached vinyl lead wire to P series. Works for lead wire connection such as strain gauge terminal installation and lead wire soldering are not required. It saves much time and labor.

●Single-element (G.F. 2.1 approx.)
0.11mm² integral vinyl leadwire
Total leadwire resistance per meter : 0.32Ω

2-wire system

PL-60-11-1L

Gauge pattern / Type		Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
PL-60-11	-1L	60	1	74	8	120
PL-90-11	-3L -5L -3LT -5LT	90	1	105	8	120
PL-120-11		120	1	135	8	120

3-wire system

PL-60-11-3LT

PL-60-11-3LT
Gauge length (mm)
Length of integral leadwire (m)
Code of integral leadwire

Each package contains 10 gauges.
Leadwire-integral service is not available with 2-element, 3-element gauge of P series.

POLYESTER FOIL STRAIN GAUGE series "PF"

metal mortar concrete

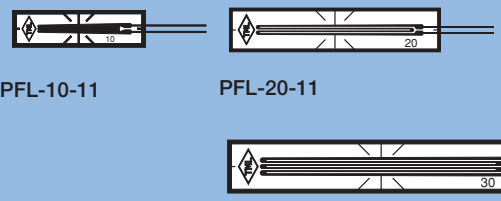
Compatible adhesive & Operational temperature
CN : −20～+80℃
RP-2 : −20～+80℃

Operational temperature −20～+80℃
Temperature compensation range +10～+80℃

STEEL, CONCRETE, MORTAR MATERIALS USE

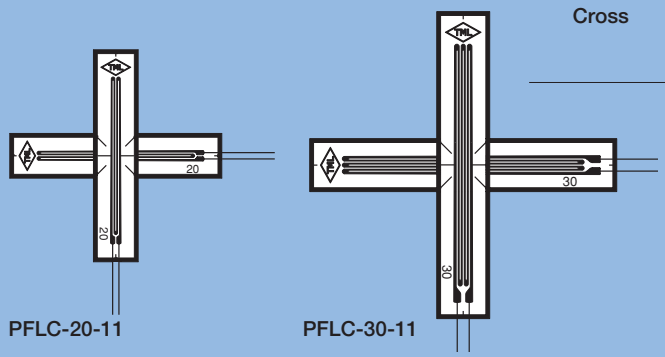
This is a foil strain gauge having polyester resin backing. It is mainly used for measurement on steel, concrete or mortar.

●Single-element (G.F. 2.1 approx.)



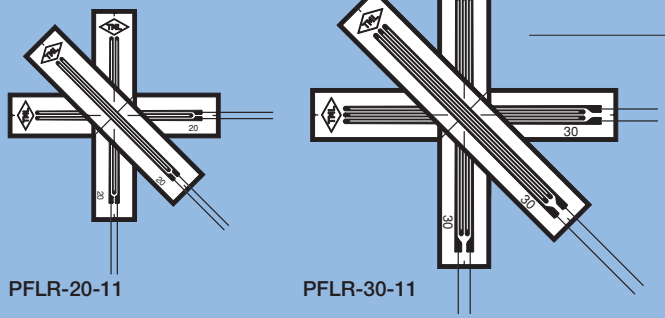
PFL-10-11 PFL-20-11 PFL-30-11

●90° 2-element Cross (G.F. 2.1 approx.)



PFLC-20-11 PFLC-30-11

●45°/90° 3-element Rosette (G.F. 2.1 approx.)



PFLR-20-11 PFLR-30-11

Each package contains 10 gauges.

Gauge pattern	Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
		L : length	W : width (Unit : mm)			
Single-element	PFL-10-11	10	0.9	17.5	5	120
	PFL-20-11	20	1.2	28	6	120
	PFL-30-11	30	2.3	40	7	120
90° 2-element Cross	PFLC-20-11	20	1.2	28	28	120
	PFLC-30-11	30	2.3	40	40	120
45°/90° 3-element Rosette	PFLR-20-11	20	1.2	28	28	120
	PFLR-30-11	30	2.3	40	40	120

LEADWIRE-INTEGRAL series "PF" POLYESTER GAUGE

metal mortar concrete

Compatible adhesive & Operational temperature
CN : −20～+80℃
PR-2 : −20～+80℃

Operational temperature −20～+80℃
Temperature compensation range +10～+80℃
Quarter bridge with 3-wire system is usable to avoid an unexpected effect of resistance change with temperature.

STEEL, CONCRETE, MORTAR MATERIALS USE

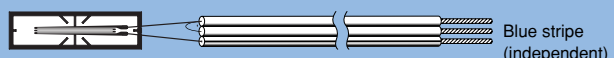
This gauge has a pre-attached vinyl lead wire to PF series. Works for lead wire connection such as strain gauge terminal installation and lead wire soldering are not required. It saves much time and labor.

●Single-element (G.F. 2.1 approx.)
0.11mm² integral vinyl leadwire
Total leadwire resistance per meter : 0.32Ω

2-wire system

PFL-10-11-1L

3-wire system



PFL-10-11-3LT

Each package contains 10 gauges.
Other gauges of PF series are also available with leadwire-integral service, contact TML.
PFLC-30-11, PFLR-30-11 are not available for the service.

Gauge pattern	Type		Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
			L : length	W : width (Unit : mm)			
	PFL-10-11	-1L	10	0.9	18	6	120
	PFL-20-11	-3L -5L -3LT	20	1.2	28	6	120
	PFL-30-11	-5LT	30	2.3	40	7	120

METAL BACKING series "FLM/WFLM" STRAIN GAUGE

concrete

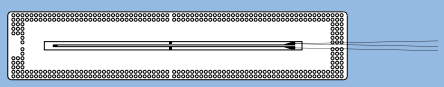
Compatible adhesive & Operational temperature
PS : −20～+80℃

Operational temperature −20～+80℃
Temperature compensation range +10～+80℃

CONCRETE MATERIAL USE

This gauge has a thin stainless steel backing which prevents the lowering of insulation resistance caused by the penetration of moisture from the concrete surface. It is suited to long term measurement. The WFLM has integral lead wire and moisture proof coating over the gauge.

●Single-element (G.F. 2.0 approx.)

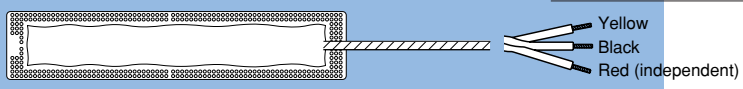


FLM-60-11 (×1/2)

WATERPROOF TYPE

●Single-element (G.F. 2.0 approx.)
0.09mm² integral crosslinked polyethylene sheath leadwire of 2m standard
Total leadwire resistance per meter : 0.4Ω

3-wire system



WFLM-60-11 (×1/2)

Each package contains 10 gauges.
Other length of leadwire is also available on request.

Gauge pattern	Type		Gauge size L	Gauge size W	Backing L	Backing W	Backing T	Resistance in Ω
			L : length	W : width	T : thickness (Unit : mm)			
Single-element	FLM-30-11		30	0.5	60	18	0.12	120
	FLM-60-11		60	0.7	90	18	0.12	120
Waterproof type Single-element	WFLM-30-11	-2LT	30	0.5	60	18	4	120
	WFLM-60-11		60	0.7	90	18	4	120

MOLD STRAIN GAUGE series "PM"

concrete mortar

Operational temperature −20~+60℃

CONCRETE, MORTAR MATERIALS USE

This gauge has been exclusively designed for measuring interior strain in concrete or mortar under loading test.

●Single-element (G.F. 2.1 approx.)

0.3mm² integral vinyl leadwire of 2m standard

Total leadwire resistance per meter : 0.12Ω

2-wire system

PML-60

Each package contains 5 gauges.

L : length W : width (Unit : mm)

*For long-term period use, Strain Transducer KM should be applied.

Type		Gauge (mm) Length	Width	Backing a	b	c	d	Resistance in Ω
PML-60	-2L -2LT※	60	1	125	13	5	40	120
PML-120		120	1	180	13	5	65	120

※3-wire system(-2LT) is made to order.

MOLD STRAIN GAUGE series "PMF"

concrete mortar

Operational temperature −20~+60℃

CONCRETE, MORTAR MATERIALS USE

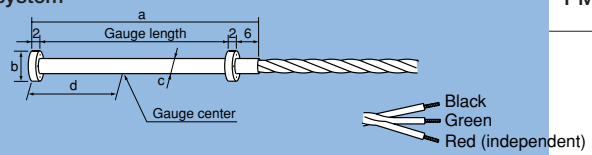
This gauge has been designed for measuring interior strain in concrete or mortar under loading test. It employs super engineering plastics capable of superior water proofing characteristics. Its small construction enables installation even in a small specimen. Measurement of both strain and temperature is possible by combining the temperature integrated gauge with TML data logger.

●Single-element (G.F. 2.0 approx.)

0.09mm² integral crosslinked vinyl sheath leadwire of 2m standard

Total leadwire resistance per meter : 0.4Ω

3-wire system



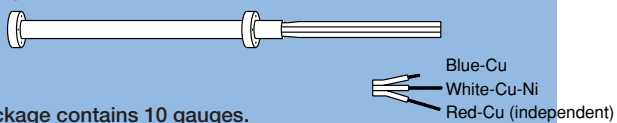
Temperature Sensor integrated

●Single-element (G.F. 2.0 approx.)

0.08mm² integral vinyl leadwire of 3m standard

Total leadwire resistance per meter : 0.44Ω

3-wire system



Each package contains 10 gauges.

L : length W : width T : thickness (Unit : mm)

*For long-term period use, Strain Transducer KM should be applied.

Type		Gauge length (mm)	Backing L	W	T	Resistance in Ω
			a	b	c	d	
PMFL-50	-2LT	50	60	φ8	φ4	27	120
PMFL-60		60	70	φ8	φ4	32	120
			a	b	c	d	
PMFL-50T	-3LT	50	60	φ8	φ4	27	120
PMFL-60T		60	70	φ8	φ4	32	120

For wiring method, refer to page 33.

These gauges are made to order.

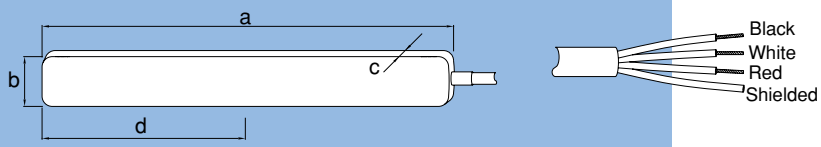
Asphalt Mold STRAIN GAUGE series "PMFLS"

Operational temperature −20～+60℃

ASPHALT PAVEMENT USE

Gauge pattern	Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
		L : length	W : width (Unit : mm)			
				a b c d		
The gauge is embedded in asphalts and used for testing in loading application such as rolling compaction. The material of the gauge base is super engineering plastics with water and heat resistance. The gauge withstands a high temperature up to 200℃ expected when asphalts are placed and is self-temperature-compensated for the asphalts.	PMFLS-60-50-2LT	60		120 13 7 60		120

●Single element
Leadwires used: 6mm dia. 4-core shielded chloroprene insulated, 2m long
Total resistance per meter of leadwires : 0.11 Ω
3-wire quarter bridge configuration



Pavement surface series "SSM-360" STRAIN GAUGE

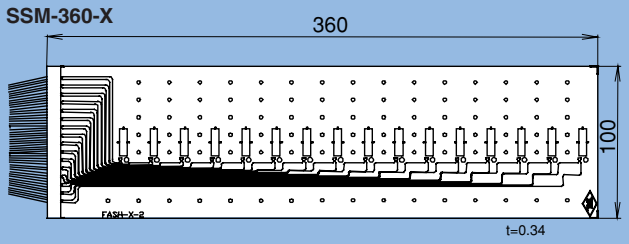
Compatible adhesive & Operational temperature
PS (−20～+80℃)
RP-2 (−20～+80℃)

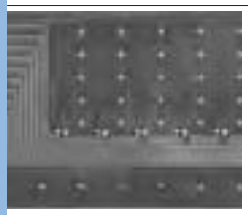
Operational temperature −20～+80℃
Temperaturecompensation range +10～+80℃

PAVEMENT SURFACE

Gauge pattern	Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
		L : length	W : width (Unit : mm)			
The gauge has 16 strain elements in X or Y direction on the same gauge base. The gauge is stuck on the surface of pavement and can monitor strain distribution of the surface.	SSM-360-X	10	0.9	360	100	120
	SSM-360-Y	10	0.9	360	100	120

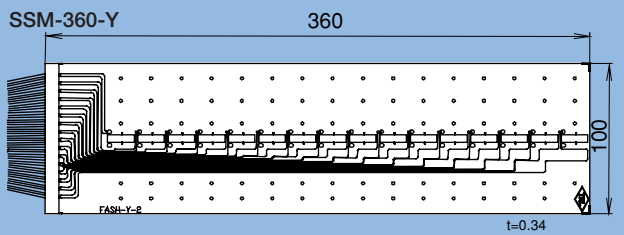
SSM-360-X

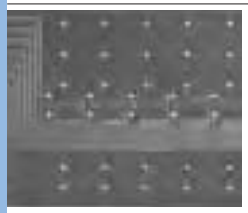




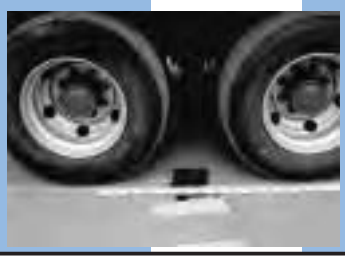
●Single element
X direction 16 strain elements

SSM-360-Y





●Single element
Y direction 16 strain elements



This series is a joint development product with National Institute for Land and Infrastructure Management - Airport Department, Toa Road Corporation and TML.
Patent No.4260864

A test conducted for some pavement study demonstrated that the strains in the longitudinal direction of the pavement measured by the surface strain gauge almost coincided with the strains obtained by multilayer elastic analysis.

COMPOSITE STRAIN GAUGE series "UBF"

composite

Compatible adhesive & Operational temperature
CN : −20～+120℃ EB-2 : −30～+150℃

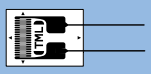
Operational temperature −30～+150℃
Temperature compensation range –

COMPOSITE MATERIALS USE

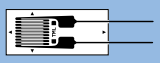
Gauge pattern

The UBF gauge is designed for measurement on composite materials. It has a specially designed grid configuration to reduce the tightening effect of the gauge to the specimen. Developing soft carrier backing, this series feature advanced characteristics of thermal cycle examination and gauge creep.

●Single element



UBFLA-03 (×3)



UBFLA-01 (×3)

Each package contains 10 gauges.
Leadwire-integral service is available on request.

Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
	L : length	W : width (Unit : mm)			
Static measurement : −30～+120℃ Dynamic measurement : −30～+150℃					
UBFLA-03	0.3	1.9	3.4	2.5	120
UBFLA-1	1	1.3	4.5	2	120

Point

Composite materials such as GFRP (glass fibers), CFRP(carbon fibers), or AFRP(aramid fibers) for reinforced plastics have different elastic modulus and linear thermal expansion coefficient depending on their fiber orientation. For strain measurement, consideration of materials property and fiber orientation should be taken.

COMPOSITE STRAIN GAUGE series "BF"

composite

Compatible adhesive & Operational temperature
CN : −20～+120℃ NP-50 : −20～+200℃
EB-2 : −20～+150℃

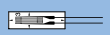
Operational temperature −20～+200℃
Temperature compensation range +10～+80℃

COMPOSITE MATERIALS USE

Gauge pattern

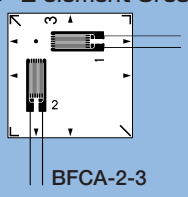
This gauge is designed for measurement on composite materials. It has a specially designed grid configuration to reduce the tightening effect of the gauge to the specimen. As the temperature compensation is available for material with thermal expansion coefficient of 3, 5 or 8ppm/℃, this series is recommendable for ceramic, carbon, and composite materials.

●Single-element



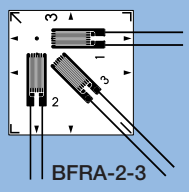
BFLA-2-3

●90° 2-element Cross Plane type



BFCA-2-3

●45°/90° 3-element Rosette Plane type



BFRA-2-3

Each package contains 10 gauges.
Leadwire-integral service is available on request.

	Type		Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
			L : length	W : width (Unit : mm)			
Single-element	BFLA-2	-3	2	0.9	7.6	2.5	120
		-5					
	BFLA-5	-8	5	1.5	12.3	3.3	120
90° 2-element Cross Plane type	BFCA-2	-3	2	1.3	8	8	120
		-5					
	BFCA-5	-8	5	1.5	11.5	11.5	120
45°/90° 3-element Rosette Plane type	BFRA-2	-3	2	1.3	8	8	120
		-5					
	BFRA-5	-8	5	1.5	11.5	11.5	120

Point

Composite materials such as GFRP (glass fibers), CFRP(carbon fibers), or AFRP(aramid fibers) for reinforced plastics have different elastic modulus and linear thermal expansion coefficient depending on their fiber orientation. For strain measurement, consideration of materials property and fiber orientation should be taken.

LOW ELASTIC STRAIN GAUGE series "GF"

Compatible adhesive & Operational temperature
CN : −20～+80℃

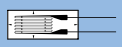
Operational temperature −20～+80℃
Temperature compensation range approximately +10～+80℃

plastics

LOW ELASTIC MATERIALS - PLASTICS USE

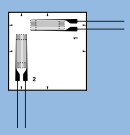
This gauge is suited for measurement on materials such as plastics having low elastic modulus compared to metal. Its specially designed grid reduces the tightening effect of the gauge to the specimen material.

●Single-element (G.F. 2.1 approx.)



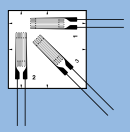
GFLA-3

●90° 2-element Cross (G.F. 2.1 approx.)
Plane type



GFCA-3

●45°/90° 3-element Rosette (G.F. 2.1 approx.)
Plane type



GFRA-3

Each package contains 10 gauges.

Gauge pattern	Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
		L : length	W : width (Unit : mm)			
Single-element	GFLA-3-50 -70	3	2.3	9.5	4.0	120
	GFLA-6-50 -70	6	2.5	14.0	5.0	120
	GFLA-3-350-50 -70	3	2.9	10.0	5.0	350
	GFLA-6-350-50 -70	6	2.7	15.0	5.0	350
90° 2-element Cross, Plane type	GFCA-3-50 -70	3	1.7	10.5	10.5	120
	GFCA-3-350-50 -70	3	2.9	15.0	15.0	350
45°/90° 3-element Rosette, Plane type	GFRA-3-50 -70	3	1.7	10.5	10.5	120
	GFRA-3-350-50 -70	3	2.9	15.0	15.0	350
	50 : Epoxy resin 70 : Acrylic resin, ABS resin					

Leadwire-integrated GF series (made-to-order)

Operational temperature range varies with different materials of lead wire outer sheath. Before use, be sure the temperature range for lead wire.

Lead wires	Operational temperature range	Gauge type exampled	Colors of Lead wire
2-wire Parallel vinyl wire	−20～+80℃	L: GFLA-3-50-3L	Grey
3-wire Parallel vinyl wire	−20～+80℃	LT: GFLA-3-50-3LT	Blue stripe (independent)

Point

●Effect of test specimen elastic modulus

The gauge factor of strain gauges is tested at the elastic modulus for steel of 206GPa equivalent to 21000kgf/mm². When a strain gauge is installed on materials such as plastic that have a low elastic modulus, the stress distribution where the gauge is installed is distorted, which has the effect of reducing the gauge factor. This phenomenon is referred to as the strain gauge constraint effect and increases as the elastic modulus of the test specimen decreases. For materials with an elastic modulus of 2.9GPa equivalent to 300kgf/mm² or less, a preparatory test must be conducted separately to correct the gauge factor.

●Effect of Joule's heat generation

GF series gauges have a TML originated gauge pattern designed to reduce an effect of Joule's heat. In general, strain gauges have an allowable current of 30mA for metallic specimens, while 10mA or less should be applied to plastic materials.

LOW ELASTIC STRAIN GAUGE series "LF"

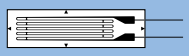
Compatible adhesive & Operational temperature
CN-E : −20～+80℃

Operational temperature −20～+80℃
Temperature compensation range +10～+80℃

LOW ELASTIC MATERIALS - WOOD, GYPSUM USE

This is a foil gauge having epoxy resin backing. Its specially designed grid reduces the tightening effect of the gauge to the specimen material.

●Single-element (G.F. 2.1 approx.)



LFLA-10-11

Each package contains 10 gauges.

Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
	L : length	W : width (Unit : mm)			
LFLA-10-11	10	3.1	18.5	5.3	120

WOOD-LONG TERM STRAIN GAUGE "PFLW/PLW"

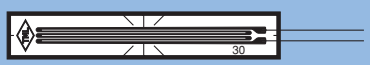
Compatible adhesive & Operational temperature
PS : −20～+80℃

Operational temperature −20～+80℃
Temperature compensation range +10～+80℃

LONG TERM OF PERIOD - WOOD USE

This gauge has a thin metal backing for long term measurement on woods, not affected by moisture contained in wood. The gauge is bonded with PS adhesive.

●Single-element (G.F. 2.1 approx.)



PFLW-30-11

PLW-60-11

Each package contains 10 gauges.

Type		Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
		L : length	W : width (Unit : mm)			
PFLW-30-11		30	2.3	40	7	120
PLW-60-11		60	1	74	8	120
PFLW-30-11	-1L -3L -5L	30	2.3	40	7	120
PLW-60-11	-3LT -5LT	60	1	74	8	120

Leadwire-integrated PFLW/PLW series

The PFLW and PLW series are available with a pre-attached extension leadwire in 2-wire parallel (code suffix -L) or 3-wire parallel (code suffix -LT) vinyl lead wire.

MAGNETIC FIELD series " MF " STRAIN GAUGE

Compatible adhesive & Operational temperature
CN : −20～+80℃
CN-E : −20～+80℃ RP-2 : −20～+80℃

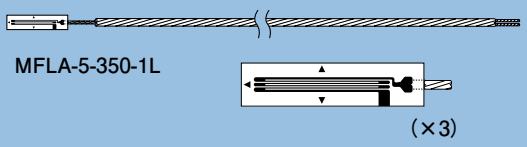
Operational temperature −20～+80℃

mortar concrete

MAGNETIC FIELD USE

This gauge is designed for measurement in magnetic field. It uses an element material which exhibits low magnetoresistance. Also its grid is designed to eliminate the influence of induction.

●Single-element (G.F. 2.1 approx.)
0.08mm² integral stranded vinyl leadwire of 1m standard
Total leadwire resistance per meter : 0.44Ω



MFLA-5-350-1L

(×3)

Shielded leadwire
ϕ3.2mm 2-core shielded stranded vinyl leadwire of 1m standard
Total leadwire resistance per meter : 0.44Ω

MFLA-5-350-1LS

for CONCRETE MATERIALS

●Single-element (G.F. 2.1 approx.)
0.08mm² integral stranded vinyl leadwire of 1m standard
Total leadwire resistance per meter : 0.44Ω

MFLA-60-350-1L

Shielded leadwire
ϕ3.2mm 2-core shielded stranded vinyl leadwire of 1m standard
Total leadwire resistance per meter : 0.44Ω

MFLA-60-350-1LS

Each package contains 10 gauges.

Gauge pattern	Type		Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
			L : length	W : width (Unit : mm)			
	MFLA-2-350	-1L -1LS	2	0.5	4.7	1.9	350
	MFLA-5-350		5	0.5	7.9	1.9	350
	MFLA-60-350	-1L -1LS	60	0.1	64	5	350

Point

●Countermeasure against Noise interference in magenetic field

In case that a magnetic field strain gauge is not used, use a strain gauge with a narrow gauge width. A narrow gauge width reduces the induced voltage on the gauge leads and is preferable to a wide strain gauge. The parallel lead wire used in normal strain measurement are affected by induction. Always use twisted wires. The intertwining of twisted wires cancels out the induced voltage that is generated. Using shielded lead wires also prevents interference from noise.

POST-YIELD STRAIN GAUGE series "YEF"

metal

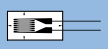
Compatible adhesive & Operational temperature
CN：−20～+80℃
CN-Y：−20～+80℃
Strain limit in room-temperature 10～15%

Operational temperature −20～+80℃

LARGE STRAIN MEASUREMENT

This gauge is designed for measurement of large strain up to 10 to 15%. Also it is durable to the measurement of repeated strain in elastic range (at strain level ±1500×10^{-6}) like as ordinary strain gauge. However it is not applicable to the measurement of repeated strain in large range. The CN-Y is recommended as an adhesive if the measurement is made after a few days or longer of strain gauge bonding. Large strain measurement is possible even after one year of bonding the gauge with the CN-Y adhesive. (Provided that the specimen is stored in room temperature.)

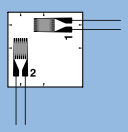
●Single-element (G.F. 2.1 approx.)



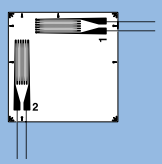
YEFLA-2

YEFLA-5

●90° 2-element Cross (G.F. 2.1 approx.)
Plane type

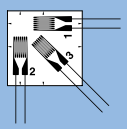


YEFCA-2

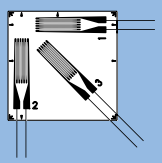


YEFCA-5

●45°/90° 3-element Rosette (G.F. 2.1 approx.)
Plane type



YEFRA-2



YEFRA-5

Each package contains 10 gauges.

Gauge pattern	Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
		L : length	W : width (Unit : mm)			
Single-element	YEFLA-2	2	1.8	7.5	4.0	120
	YEFLA-5	5	2.0	12.0	4.0	120
90° 2-element Cross, Plane type	YEFCA-2	2	1.8	10.0	10.0	120
	YEFCA-5	5	2.0	14.5	14.5	120
45°/90° 3-element Rosette, Plane type	YEFRA-2	2	1.8	10.0	10.0	120
	YEFRA-5	5	2.0	14.5	14.5	120

Leadwire-integrated YEF series (made-to-order)

Lead wires	Operational temperature range	Gauge type exampled	Colors of Lead wire
2-wire Parallel vinyl wire	−20～+80℃	L : YEFLA-2-3L	Grey
3-wire Parallel vinyl wire	−20～+80℃	LT：YEFLA-2-3LT	Blue (independent)

POST-YIELD STRAIN GAUGE series "YF"

metal

Compatible adhesive & Operational temperature
CN : −20～+80℃
CN-Y : −20～+80℃
Strain limit in room-temperature 15～20%

Operational temperature −20～+80℃

LARGE STRAIN MEASUREMENT

This gauge is designed for measurement of large strain up to 15 to 20%. It is not applicable to the measurement of repeated strain either in elastic nor in large range. The CN-Y is recommended as an adhesive if the measurement is made after a few days or longer of strain gauge bonding. Large strain measurement is possible even after one year of bonding the gauge with the CN-Y adhesive.

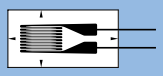
●Single-element

YFLA-2

YFLA-5

YFLA-10

YFLA-20



(×2)

・Each package contains 10 gauges.

Gauge pattern	Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
		L : length	W : width (Unit : mm)			
Single-element	YFLA-2	2	1.8	7.5	4.0	120
	YFLA-5	5	2.0	12.0	4.0	120
	YFLA-10	10	2.6	16.6	4.9	120
	YFLA-20	20	1.8	26.0	3.7	120

POST-YIELD STRAIN GAUGE series "YUF"

metal

Compatible adhesive & Operational temperature
CN : −20～+80℃
CN-Y : −20～+80℃
Strain limit in room-temperature 20～30%

Operational temperature −20～+80℃

LARGE STRAIN MEASUREMENT

This gauge is designed for measurement of large strain only up to 20 to 30%. This YUF series is not applicable to the measurement of repeated strain in both elastic and large range.

●Single-element

YUFLA-2

YUFLA-5

・Each package contains 10 gauges.

Gauge pattern	Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
		L : length	W : width (Unit : mm)			
Single-element	YUFLA-2	2	1.9	8.0	3.0	120
	YUFLA-5	5	1.7	11.0	3.0	120

Point

●YUF/YEF/YF/F applications

Gauge series	Strain limit	Fatigue limit at room temperature	Change of apparent strain due to cyclic loading of large strains
YUF	20～30% elongation	Not applicable	Not applicable
YEF	10～15% elongation	5×10^{5} cycles	2000×10^{-6} strain/10 cycles
YF	15～20% elongation	1×10^{2} cycles	2000×10^{-6} strain/10 cycles
F	3%	1×10^{6} cycles	400×10^{-6} strain/10 cycles

Fatigue limit : Cyclic loading with $\pm1500\times10^{-6}$ strain, 15Hz, Apparent strains exceeding 100×10^{-6} strain
Large strain : $\pm10000\times10^{-6}$ strain, 4 min./cycle,
Please note that YEF and YF series can not be used for cyclic large strain measurement.

BOLT STRAIN GAUGE series "BTM"

Compatible adhesive & Operational temperature
A-2：−10～+80℃

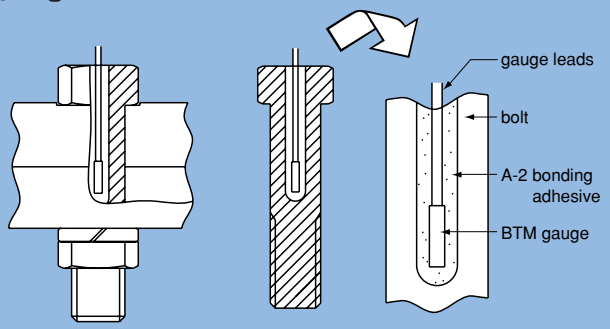
Operational temperature −10～+80℃

B bolt

BOLT AXIAL STRAIN MEASUREMENT

These gauges are used for measurement of tensile strain of bolt. These are simply inserted into a pre-drilled hole in the bolt head together with A-2 bonding adhesive and cured. The gauge series is recommendable if an ordinary strain gauge cannot be mounted on the bolt surface. Accurate tensile force measurement is possible by calibrating the bolt after installing the gauge.

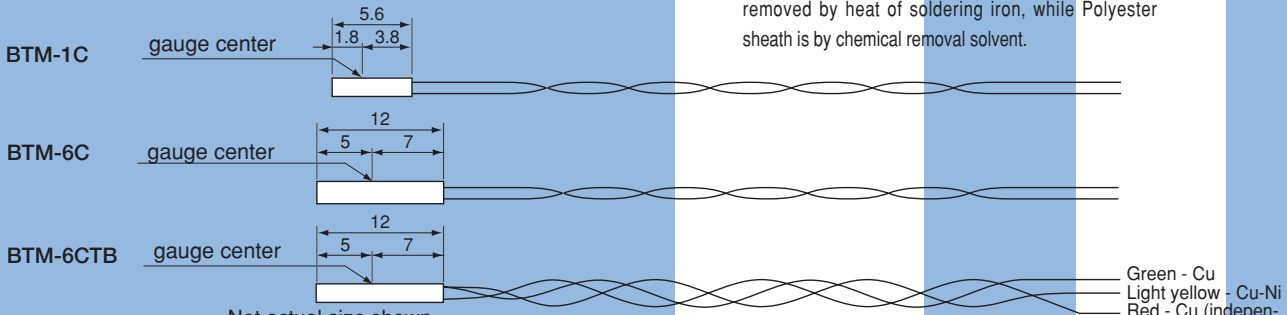
●Single-element



Gauge pattern	Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
		L : length	W : width (Unit : mm)			
	BTM-1C (Hole drilled：φ1.6mm)	1	0.7	5.6	1.4	120
	BTM-6C (Hole drilled：φ2.0mm)	6	1.0	12.0	1.7	120
	Temperature-integrated BTM-6CTB applicable in -10～+80℃ (Hole drilled：φ2.0mm)	6	1.0	12.0	1.7	120

Gauge leads
Polyurethane (Cu) φ0.14 80mm to BTM-6C/BTM-1C
Polyurethane (Cu) φ0.14 80mm to BTM-6CTB
Polyester (Cu-Ni) φ0.12 80mm to BTM-6CTB

NB: Polyurethane sheath of the gauge leads is easily removed by heat of soldering iron, while Polyester sheath is by chemical removal solvent.



Not actual size shown

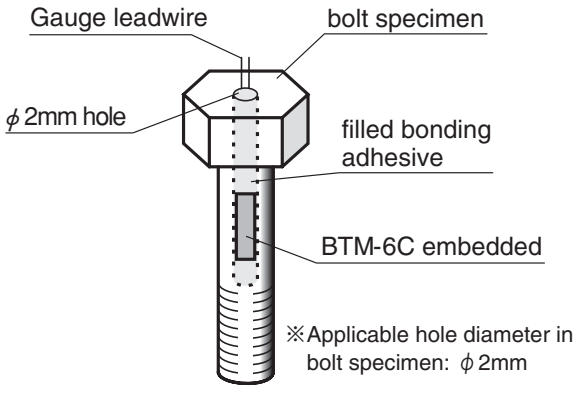
Each package contains 10 gauges.

N.B.: For extention, exclusive leadwire should be required.

■Syringe optional

Exclusive syringe for injecting A-2 adhesive into the pre-drilled hole before BTM-1C or BTM-6C gauge is embedded

■Single element



BOLT AXIAL FORCE MEASUREMENT WRENCH series "BTMP-10A"

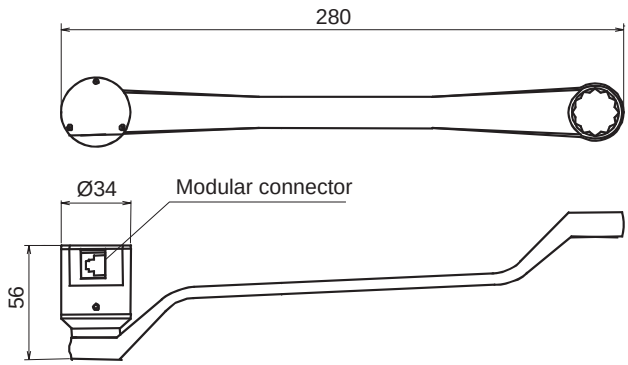
B bolt

BOLT AXIAL FORCE MEASUREMENT

The bolt axial force can be easily measured by merely sticking the exclusive terminal on the head of a hexagonal bolt and setting the BTMP-10A wrench on the bolt head. There is no need for attaching or detaching the leadwires when tightening the bolt. For other than M10 bolt, please consult us.

- No need for connecting or disconnecting the leadwires when tightening a bolt.(The exclusive terminal is necessary.)
- 1-gauge 4-wire connection — No effect of contact resistance on the indicated value.
  Applicable instruments: TDS-630, TDS-530, TC-32K

Dimensional drawing



M10 bolt wrench (size: 17)

*Minimum order quantity: 1 piece

An Installation Example of Exclusive Terminal

1-Gauge 4-Wire Measurement Method

Our developed and patented 1-gauge 4-wire method allows strain gauge to be connected by a modular plug through 4-wire leadwires. Since soldering of leadwires is not needed but only plugging in, wiring time and labor can be largely saved, especially in multipoint measurement.

The built-in switching boxes of our data logger TDS-630 and TDS-530 incorporate connectors mating with the 1-gauge 4-wire modular plug.

[Patent: 3546203, 3681359, 3681361, 3848661, 40381193]

ONE-SIDE STRAIN GAUGE series "DD"

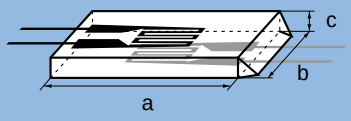
metal

Compatible adhesive & Operational temperature
CN : −10～+70℃
P-2 : −10～+70℃

Operational temperature −10～+70℃

ONE-SIDE STRAIN GAUGE

This gauge can measure tensile strain and bending strain separately by simply bonding the gauge to one side of a plate or a beam.



Each package contains 5 gauges.
Leadwire-integral service is available on request.

Gauge pattern	Thickness of applicable specimen (mm)	Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
			L : length	W : width (Unit : mm)			
					a	b c	
	Approx. 5 or less	DD-1-15	3	2.9	15	7 1	350
	Approx. 5～10	DD-2-30			30	7 2	
	Approx. 10～15	DD-3-45			45	7 3	

CRACK DETECTION GAUGE series "FAC"

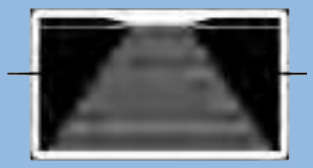
concrete metal

Compatible adhesive & Operational temperature
CN : −20～+80℃
RP-2 : −20～+80℃

Operational temperature −20～+80℃

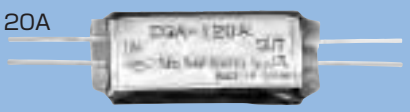
CRACK LENGTH AND PROPAGATION MEASUREMENT

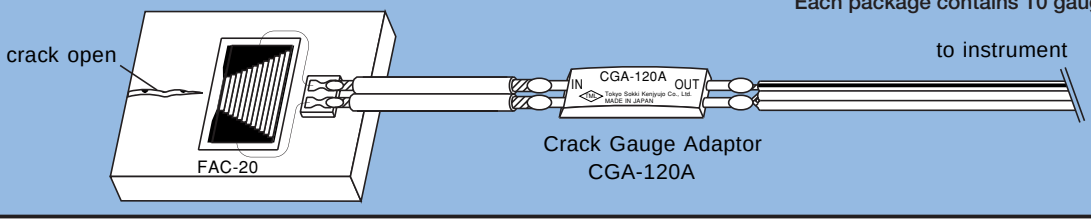
This gauge is designed to measure the progress (length) of a crack and its rate of growth in a metal specimen. This gauge is bonded to the location where the generaiton of crack is pre-determined. The grids of the gauge which are aligned with interval of 0.5mm are disconnected one by one by the progress of the crack. The gauge is used together with the crack gauge adaptor CGA-120A and the disconnection of one grid is measured as the change of 50 x 10^{-6} strain by strainmeter.



CRACK GAUGE FAC-20
Measuring range : 20mm
Gauge resistance : 1 Ω
Grid interval : 0.5mm
Number of grid : 41
Backing size : 43×25mm
Quantity per package : 10
Each package contains 10 gauges.

Crack Gauge Adaptor CGA-120A
Output per grid :
50×10^{-6} strain approx.
Bridge connection:
Quarter bridge with 3-wire system 120 Ω





Crack Gauge Adaptor
CGA-120A

STRESS GAUGE series "SF"

metal

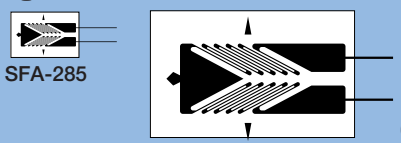
Compatible adhesive & Operational temperature
NP-50 : −20～+200℃
C-1 : −20～+200℃ CN : −20～+120℃

Operational temperature −20～+200℃
Temperature compensation range +10～+100℃

AXIAL STRESS MEASUREMENT

This gauge is sensitive not only in axial direction but also in transverse direction and the sensitivity of transverse direction is proportional to the Poisson's ratio of the specimen. Also the gauge is not sensitive to shearing strain. Accordingly the output of the gauge is proportional to the stress of the axial direction. The stress along the gauge axis can be measured easily.

●Single element



SFA-285 (×3)

Each package contains 10 gauges.
Leadwire-integral service is available on request.

Gauge pattern	Poisson's ratio of specimen	Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
			L : length	W : width (Unit : mm)			
	0.285	SFA-285-11	4	3	9	6	120
	0.305	SFA-305-17					
	0.330	SFA-330-23					

TRANSDUCER-SPECIFIC STRAIN GAUGES

TML gauges are not only used for strain measurement, but also as sensors for strain gauge-type transducers. Strain gauge-type transducers convert various types of physical quantities to mechanical strain in the stress-generating body (elastic body) and use strain gauges to convert mechanical strain to electric output. Strain gauge-type transducers are generally categorized into the following types.

Force transducers (Load cell)
Pressure transducers
Acceleration transducers
Displacement transducers
Torque transducers

VARIOUS TYPE OF TML TRANSDUCER-SPECIFIC SRAIN GAUGES

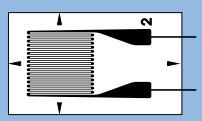
GAUGE SHAPE AND GAUGE LENGTH

Single, Rectangular 2-element, Torque(Shearing) strain measurement

Pattern	Gauge length (mm)
Single-element	2, 3
90° 2-element	2, 3, 6
Torque (Shearing strain) use	2

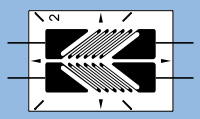
Pattern

Single-element



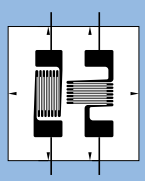
(LA)

Torque



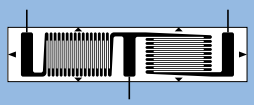
(CT)

90° 2-element



(CB)

90° 2-element



(CM)

2 types of 90° 2-element gauge are lined-up with different pattern of gauge tab.
CM-type has half-bridge configuration.

GAUGE RESISTANCE

Pattern	Gauge resistance (Ω)
Single-element	350, 1000
90° 2-element	120, 350
Torque (Shearing strain) use	350

＊1000-ohm gauge has less power consumption in bridge circuit comparing to 350-ohm gauge's and limits Joule's heat generation.

GAUGE BACKING MATERIALS

Unlike stress measurement gauges, the gauge backing materials for transducer-specific strain gauge cannot be determined based solely on the operational temperature and bonding method. To ensure maximum transducer performance, it is necessary to test various combinations using different stress-generating bodies (elastic bodies) to select the most suitable backing materials.

Operational temperature

Operational temperature range differs from heat-resistive temperature's.
F series gauge (with epoxy backing) is also available for use of heat-curing type bonding adhesives. Refer to page 61-62 for the details.

Gauge series	Gauge base materials	Operational temperature
F	Epoxy resin	−20～+80℃
QF	Polyimide resin	−20～+200℃
EF	Polyimide resin	−20～+200℃

OPERATIONAL TEMPERATURE RANGE

Operational temperature differs from heat-resistant temperature. F series gauge having epoxy resin is available with heat-curing type bonding adhesive.

CREEP ADJUSTMENT

The creep characteristic is particularly important in force transducers. The most common compensation system uses the material creep (+) of the stress-generating body (elastic body) and the gauge creep (−) to cancel each other. Various TML strain gauges are available for creep adjustment and are selectable by creep code.

Creep code

Gauge creep	Large ⟶ Small
Creep code	C2＞C4＞C6＞C8

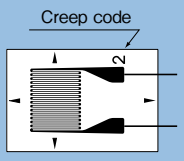
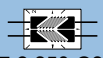
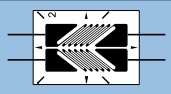
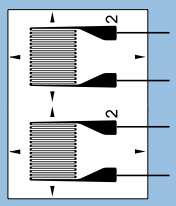
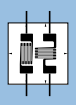
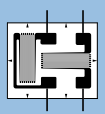
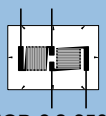
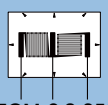
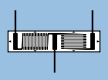
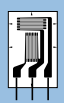
TEMPERATURE SENSITIVITY COMPENSATION

Elasticity modulus of srain-generating body (elastic body) varies with temperature variation. In the same manner, as ambient temperature around the strain-generating body varies, resulting in change of apparent strain. To reduce such temperature influence, sensitivity compensation resistor is assembled in bridge circuit.

■Coding system of Transducer-specific strain gauges

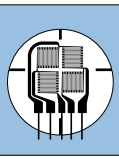
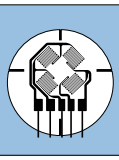
FLA-2-350-C2-11

- Gauge length
- Creep code
- 11 Mild steel
- 17 Stainless steel
- 23 Aluminium

Gauge pattern	Type	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
●Single-element (G.F. 2.1 approx.)  FLA-2-350-C2-11  Creep code (Not actual size shown)	FLA-2-350 -C2 -11 (QF) C4 17 C6 23 C8	L : length	W : width (Unit : mm)			
		2	2.9	6.8	4.6	350
	FLA-3-350 -C2 -11 (QF) C4 17 C6 23 C8	3	3.2	8.5	5.0	350
	FLA-3-1000-C2 -11 (QF) C4 17 C6 23 C8	3	4.2	9.2	5.8	1000
●Torque (Shearing strain) measurement  FCT-2-350-C2-11  (Not actual size shown)	FCT-2-350 -C2 -11 (QF) C4 17 C6 23 C8	2	1.7	7.6	5.3	350
●Single-axis 2-element  FLA-2-350-C2-2H-11  (Not actual size shown)	FLA-2-350 -C2-2H -11 (QF) C4-2H 17 C6-2H 23 C8-2H	2	2.9	6.8	9.2	350
	FLA-3-350 -C2-2H -11 (QF) C4-2H 17 C6-2H 23 C8-2H	3	3.2	8.5	10.0	350
●90° 2-element  FCB-2-11  FCB-3-350  FCB-6-350  FCB-2.8-350  FCM-2.8-350  EFCM-2-350  EFCMX-3-350  EFCMY-3-350	FCB (QF) -2 -11 17 23	2	1.5	8.2	8.0	120
	FCB (QF) -3-350 -11 17 23	3	3.2	10.5	9.1	350
	FCB (QF) -6-350 -11 17 23	6	2.0	10.0	13.0	350
	FCB (QF) -2.8-350 -11 17 23	2.8	2.8	12.0	8.5	350
	FCM-2.8-350	2.8	2.8	12.0	8.5	350
	EFCM-2-350-11	2.5	1.4	3.0	12.2	350
	EFCMX-3-350-11	3	1.6	8.0	7.5	350
	EFCMY-3-350-11	3	1.6	10.0	6.5	350

●In addition to those shown above, various other gauges for transducers are available.

Bending (Force transducer use)
Shearing (Torque transducer use)

●Detailed specifications must be discussed and decided before ordering gauges for transducers. Consult a sales representative.

TEMPERATURE GAUGE series "TF"

Compatible adhesive & Operational temperature
NP-50：−20～+200℃
C-1：−20～+200℃　CN：−20～+120℃

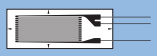
Operational temperature　−20～+200℃

TEMPERATURE GAUGE

Gauge pattern

This gauge is bonded on the specimen surface like as ordinary strain gauge for the measurement of surface temperature. It can measure not only relative temperature but also actual temperature by using optional temperature gauge adaptor (TGA) together.


TFL-2-60

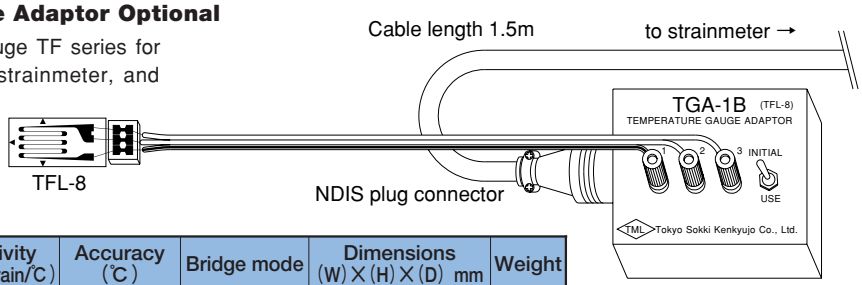

TFL-8

Type	Sensitivity (Ω／℃)	Gauge size L	Gauge size W	Backing L	Backing W	Resistance in Ω
		L : length		W : width (Unit : mm)		
TFL-2-60	0.34 approx.	2	1.9	6.1	3.5	60
TFL-3-60	0.34 approx.	3	3.2	8.5	5.0	60
TFL-6-60	0.34 approx.	6	2.6	13.0	4.5	60
TFL-8	0.68 approx.	8	3.5	14.0	5.4	120

Leadwire-integral service is available on request.

TGA-1A/TGA-1B Temperature Gauge Adaptor Optional

This adaptor is provided with temperature gauge TF series for direct reading of temperature with optional strainmeter, and converts output to 100×10⁻⁶ strain/℃.



Temperature gauge adaptor

Type of Adaptor	Gauge	Temperature (℃)	Sensitivity (×10⁻⁶strain/℃)	Accuracy (℃)	Bridge mode	Dimensions (W)×(H)×(D) mm	Weight
TGA-1A	TFL-2-60	−20～+200℃	100	±1,or less	Full bridge	100×40×70	370g
	TFL-3-60						
	TFL-6-60						
TGA-1B	TFL-8	−20～+200℃	100	±1,or less	Full bridge	100×40×70	370g

PLATINUM RTD

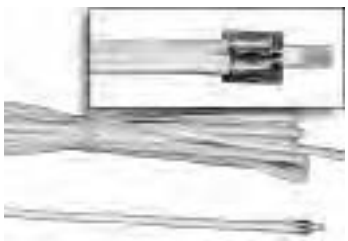
■PLATINUM RTD (Pt100)

The platinum RTD is designed to mount on a specimen and connect to a data logger to measure temperature. Easy measurement of temperature by bonding to a specimen with strain gauge adhesive. Units equipped with lead wire are also available upon request.

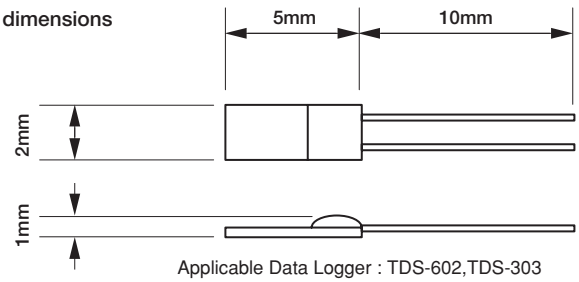
Type	Rated current	Base size (mm)	Resistance in Ω	Operational temperature (℃)
CRZ-2005	1mA or less	5.0×2.0×1.1	100 (at 0℃)	−50～+400

Vinyl sheathed leadwire pre-attached

Fluorinated resin (PTFE) sheathed leadwire pre-attached available.



Outer dimensions



Applicable Data Logger : TDS-602,TDS-303

THERMOCOUPLE

A thermocouple configures the closed circuit in which a small electric current flow in the circuit composed of a pair of dissimilar conductors, and measures temperature using thermoelectric effect produced at both ends of conductors in different temperatures.

Type	Thermo-couple code	Core diameter	Outer diameter	Sheath materials	Sheath color: Insulator +	Sheath color: Insulator −	Sheath color: Outer sheath	Heat-resistive temperature	Length per roll	Remarks
0.32×1P T-G	T	0.32mm	2.1×3.2	Heat-resistive vinyl	Red	White	Brown	100℃ approx.	100m	
0.65×1P T-G	T	0.65mm	2.6×4.0	Heat-resistive vinyl	Red	White	Brown	100℃ approx.	100m	
0.32×1P T-6F	T	0.32mm	1.0×1.6	Fluoroethylene propylene	Red	White	Brown	200℃ approx.	100m	
0.65×1P T-6F	T	0.65mm	1.5×2.5	Fluoroethylene propylene	Red	White	Brown	200℃ approx.	100m	
0.65×1P T-GS	T	0.65mm	φ7.2	Heat-resistive vinyl	Red	White	Brown	100℃ approx.	100m	shielded
0.32×1P K-H	K	0.32mm	1.4×2.3	Glass	Red	White	Blue	350℃ approx.	100m	
0.65×1P K-H	K	0.65mm	2.0×3.4	Glass	Red	White	Blue	350℃ approx.	100m	

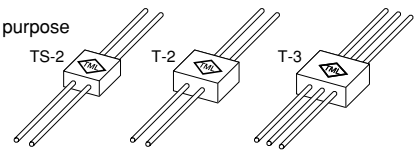
CONNECTING TERMINALS

TML Connecting Terminals provide convenient junction points to connect strain gauges to instrumentation leads.

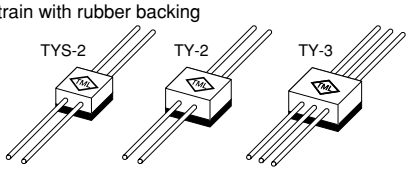
T series is made of a cubic plastic and two wires of approximately 0.8mm diameter are fixed to the cube. TY is laminated with rubber sheet and suitable for large strain measurement. TP-2 is a self-bonding terminal with two wires. TF is made of a 0.03mm thick copper foil and a glass-epoxy insulation base of approx. 0.15mm thick. TFY is laminated with rubber sheet approx. 0.8mm thick over the back side of TF series terminals.

Cubic shape

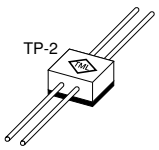
for general purpose



for large strain with rubber backing

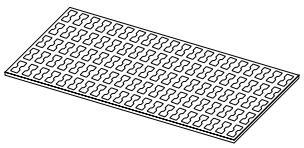


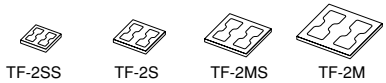
Self-bonding type
(No adhesive required)



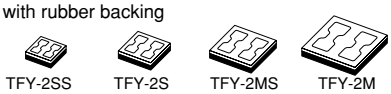
Foil shape

for general purpose

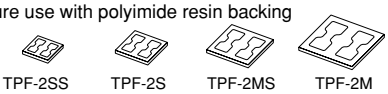




for large strain with rubber backing



High temperature use with polyimide resin backing



Type	Dimensions	Operational temperature	Quantity
T-2	10×10×5	−20～+90℃	100/ box
T-3 (3-wire system use)	10×10×5	−20～+90℃	100/ box
TS-2	7.5×7.5×5	−20～+90℃	100/ box
TYS-2	7.5×7.5×7	−20～+90℃	100/ box
TY-2	10×10×7	−20～+90℃	80/ box
TY-3 (3-wire system use)	10×10×7	−20～+90℃	80/ box
TP-2	10×10×6	−20～+60℃	100/ box
TF-2SS	5×4×0.2	−196～+180℃	50 pairs/sheet
TF-2S	6×5×0.2	−196～+180℃	50 pairs/sheet
TF-2MS	8×6.8×0.2	−196～+180℃	50 pairs/sheet
TF-2M	10×9×0.2	−196～+180℃	50 pairs/sheet
TFY-2SS	5×4×0.8	−20～+120℃	50 pairs/sheet
TFY-2S	6×5×0.8	−20～+120℃	50 pairs/sheet
TFY-2MS	8×6.8×0.8	−20～+120℃	50 pairs/sheet
TFY-2M	10×9×0.8	−20～+120℃	50 pairs/sheet
TPF-2SS	5×4×0.2	−196～+200℃	50 pairs/sheet
TPF-2S	6×5×0.2	−196～+200℃	50 pairs/sheet
TPF-2MS	8×6.8×0.2	−196～+200℃	50 pairs/sheet
TPF-2M	10×9×0.2	−196～+200℃	50 pairs/sheet
TPFH-2SS	3.8×4.8×0.1	−269～+350℃	50 pairs/sheet
TPFH-2S	5.5×6×0.1	−269～+350℃	50 pairs/sheet
TPFH-2MS	7.5×8×0.1	−269～+350℃	50 pairs/sheet

NB: TPFH series features heat-resistive connecting terminals with polyimide resin backing to TPF. It allows high temperature measurement using QF/ZF series gauges and bonding repetition on the terminals.

STRAIN GAUGE ADHESIVES

TYPE		Contents	Component	Applicable specimen	Operational temperature	Curing temperature and time
CN	Single component Room-temperature-curing	Single 2g×5	Cyanoacrylate	Metal, Plastics, Composite	−196～+120℃	Room temperature 20sec. -1 min. (thumb pressure)
CN-E	Single component Room-temperature-curing	Single 2g×5	Cyanoacrylate	Porous, Concrete, Mortar, Wood	−30～+120℃	Room temperature 40sec. -2 min. (thumb pressure)
CN-R	Single component Room-temperature-curing	Single 2g×5	Cyanoacrylate	Metal, Plastics, Composite	−30～+120℃	Room temperature 10-30 sec. (thumb pressure)
CN-Y	Single component Room-temperature-curing	Single 2g×5	Cyanoacrylate	Metal, Plastics, Composite	−30～+80℃	Room temperature 20sec. -1 min. (thumb pressure)
P-2	Two component Room-temperature-curing (Mixing ratio: 1-3%)	A:100g B:10g	Polyester	Metal	−30～+180℃	Room temperature Pressure 50-300kPa 2～3 hrs.
RP-2	Two component Room-temperature-curing (Mixing ratio: 2-4%)	A:100g B:10g	Polyester	Concrete, Mortar	−30～+180℃	Room temperature Pressure 50-300kPa 2～3 hrs.
PS	Two component Room-temperature-curing (Mixing ratio: 2-4%)	A:200g B:20g	Polyester	Concrete, Mortar	−30～+100℃	Room temperature 2～3 hrs.
NP-50	Two component Room-temperature-curing (Mixing ratio: 2-4%)	A:50g B:10g	Polyester	Metal, Composite	−30～+300℃	Room temperature Pressure 50-300kPa 2～3 hrs.
C-1	Single component Heat-curing	Single 50g	Phenol	Metal	−269～+200℃	130℃ 1hr. pressed 200℃ 1hr.
EA-2A	Two component Room-temp.-or heat curing (Mixing ratio: 2:1)	A:50g B:25g	Epoxy	Metal, Concrete, Composite	−269～+50℃	Room temp. 1 day or heating 50℃ 2hrs. Pressure 50～300kPa
EB-2	Two component Room-temperature-curing (Mixing ratio: 10:3)	A:10g×3 B:3g×3	Epoxy	Metal, Composite	−30～+150℃	Room temperature Pressure 50-300kPa 1 day
A-2	Two component Heat-curing (Mixing ratio: 10:1)	A:50g B:5g	Epoxy	Bolt	−30～+100℃	Room temperature 12 hrs. and 140℃ 3 hrs.

N.B :

Shelf life　Effective storing duration while the adhesive is properly kept in a cool, dry and dark place such as a refrigerator (+5～+10℃, do not store in a freezer).

Thumb pressure　100～300kPa

●For two-component adhesive, use the supplied mixing vessels.
Mixing vessels : Polyethylene make
75mm-diameter, 10mm depth

Point

●In general, curing condition of room-temperature-curing type adhesives varies with an ambient temperature and humidity. Taking consideration of standard application described in operation manual, test curing should be recommedable in site before measurement.

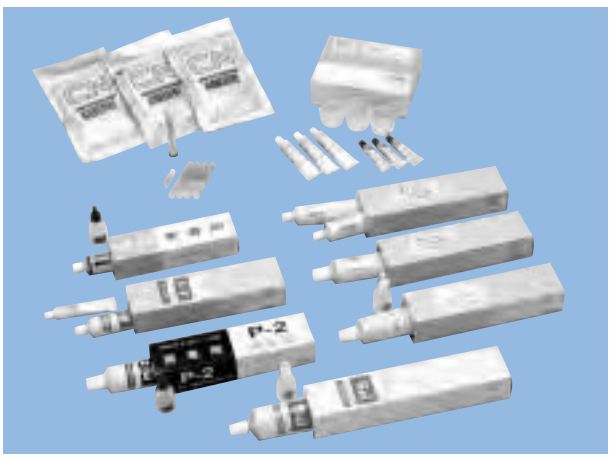
●CN Adehsive (Cyanoacrylate component) use minute quantities of moisture in the air or on the surface of the specimen to quickly polymerize and generate adhesive strength. A certain amount of moisture is required for the adhesive to harden.

TML strain gauge adhesives are specially designed for bonding strain gauges to test specimens. Various types are available for specific applications.

Shelf life	Applications
6 months	Single-component cement for strain gauges. The time required to bond the gauge is extremely short and handling is very easy. The thin bonding layer allows adhesion to plastic objects as well as metal. Curing time under normal conditions is 20～60 seconds.
6 months	Single-component cement featuring high viscosity for bonding strain gauges to porous materials such as concrete and mortar. Curing time under normal conditions is 4～120 seconds.
3 months	Single-component cement for accelerating cures in ambient lower temperature, or lower relative humidity.
6 months	A single-component adhesive designed exclusively for use on post-yield strain gauge. Offers minimum degradation n bonding performance (peel strength) due to aging. Suitable for a long-term measurement of large strain.
6 months	A two-component room-temperature-curing polyester adhesive for bonding PF, P and F series strain gauges. Put the necessary quantity of drug A in the supplied mixing vessel, then add drug B by drops to total 1～3% the weight of drug A. Use the mixed adhesive within 5～15 minutes.
3 months	A two-component room-temperature-curing polyester adhesive for bonding PF and P series strain gauges. The mixing procedure is the same as above for P-2 adhesive. Put the necessary quantity of drug A in the supplied mixing vessel, then add drug B by drops to total 2～4% the weight of drug A. Use the mixed adhesive within 10～20 minutes.
3 months	A two-component room-temperature-curing polyester adhesive. Use as a surface precoating agent for bonding P and PF series gauges to the concrete and also as an adhesive for WFLM series strain gauges. The special filler contained exhibits excellent alkali resistance and effectively shuts off moisture and gas from inside of the concrete. Its high viscosity enables use on vertical walls or ceilings. Put the necessary quantity of drug A in the supplied mixing vessel, then add drug B by drops to total 2～4% the weight of drug A.
3 months	A two-component room-temperature-curing polyester adhesive for bonding QF, ZF and BF series strain gauges. Put the necessary quantity of drug A into a mixing vessel, then add drug B by drops to total 2～4% the weight of drug A. Use the mixed ahesive within 10～15 minutes.
3 months	Single-component heat-curing type adhesive. For use on strain gauge that are subject to heat curing. Enables reliable measurement for long periods and high temperatures up to 200℃.
3 months	A two-component room-temperature-curing epoxy ahesive for bonding CF serices strain gauges for use at temperature from cryogenic (－269℃) up to room temperature. Mix the necessary quantity of drugs A and B at the weight ratio of 2 to 1.
3 months	A two-component room-temperature-curing epoxy adhesive for bonding strain gauges for use at temperatures from －30℃ to ＋150℃. Mix the necessary quantity of drug A and B at the weight ratio of 10 to 3.
3 months	A two-component heat-curing epoxy adhesive for bonding BTM strain gauges. Mix the necessary quantity of drugs A and B at the weight ratio of 10 to 1, then pour the mixed adhesive into a hole drilled of the bolt in which the gauge is inserted. Allow to set at room temperature for 12 hours, then cure at 140℃ in furnace for 3 hours.

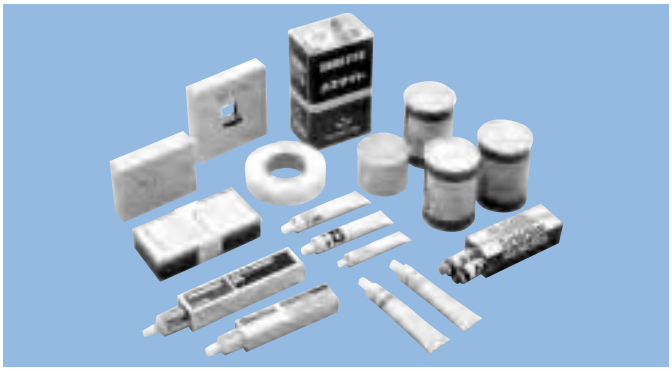
MSDS (Material Safety Data Sheet)

TML supplies an MSDS for all its strain gauge ahesives and coatings. Contact your TML supplier for more information.



COATING MATERIALS

TML coating materials are used for water- or moisture-proofing over bonded strain gauges. For long-term use or field measurement, the strain gauges and connecting terminals require protection from ambient moisture.



TYPE	Materials	Content per unit	Operational temperature	Curing conditions
W-1	Microcrystalline wax solid	Single 500g.	0～+50℃	Hot melting 100～120℃, hardening in room temperature
N-1	Neoprene rubber	90g	−30～+80℃	Air-drying solvent-thinned a half day in room temperature
K-1	Special rubber	90g	−196～+60℃	Air-drying solvent-thinned a half day in room temperature
SB tape	Buthyl	10mm×3mm 5m long/roll	−30～+80℃	Pressure sensitive
VM tape	Buthyl	38mm×1mm 6m long/roll	−20～+80℃	
Epoxy resin	Epoxy	AW106 canned 1.8kg Araldite standard tube 170㎖	−60～+100℃	Two-component room-temperature - curing Mixing ratio 10 to 8
Epoxy resin AV138	Epoxy	Canned 1.4kg	−60～+180℃	Two-component room-temperature - curing Mixing ratio 10 to 4
Three Bond 1521B	Chloroprene rubber	150㎖	−30～+100℃	Air-drying solvent-thinned a half day in room temperature
KE-348	Silicon rubber	100g	−50～+200℃	Air-drying solvent-thinned a half day in room temperature
TSE3976-B	Silicon rubber	100g	−50～+300℃	Air-drying solvent-thinned a half day in room temperature

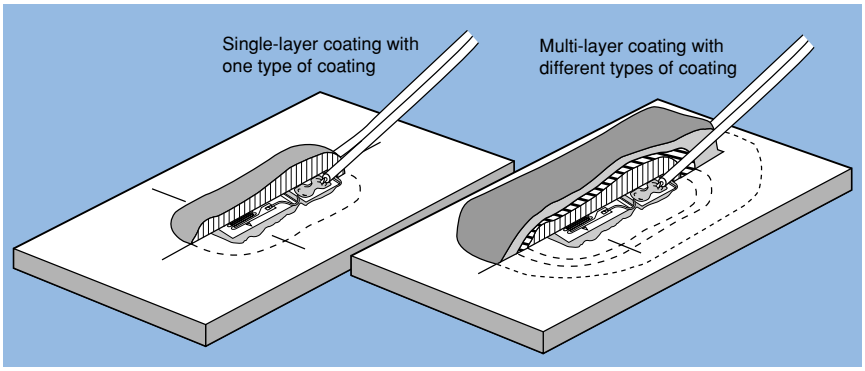
N.B.:

MSDS (Material Safety Data Sheet)

TML supplies an MSDS for all its strain gauge ahesives and coatings. Contact your TML supplier for more information.

Coatings in special substances

For use in special substances such as acids, alkalis and alcohols, contact TML or local representatives.

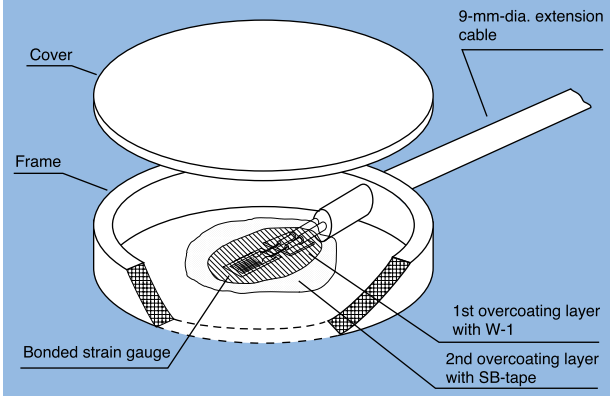


The type of coating required and the application method differ depending on the environment in which the strain gauge is to be used. In general, if one type of coating is not sufficient, multiple coatings can be combined to protect the strain gauges. At TML, the coating applied directly to the surface of the strain gauge is referred to as the first coating, with subsequent coating layers referred to sequentially as the second coating, third coating, etc. Multi-layer coatings are recommended for strain gauge protection.

Purpose	Applications
Moisture- and Water-proofing	General-purpose coating for laboratory and field requirements where mechanical protection is not needed, or as a prime-coat for duplex coating.
Moisture- and Water-proofing	General-purpose coating for laboratory and less severe field requirements where a high degree of mechanical protection is not needed. Long term stabillity
Cryogenic temperature-resistive	For laboratory requirements from cryogenic to room temperature. Does not provide a high degree of mechanical protection.
Moisture- and Water-proofing	3-mm thick tape-form coating Very convenient usage
Moisture- and Water-proofing	1-mm thick tape-form coating
Physical protection	General purpose coating for mechanical protection
Physical protection	Araldite packed in tube
Physical protection	Coating for mechanical protection in high-temperautre usage
Moisture- and Water-proofing	A finish coating for multi-layer applications.
Heat-resistive	Suitable for laboratory requirements with harsh temperature conditions where a high degree of mechanical protectioin is not needed.
Heat-resistive	Suitable for laboratory requirements with harsh temperature conditions where a high degree of mechanical protectioin is not needed.

GAUGE PROTECTOR

Sample application



This rubber protector is designed to protect gauges which are bonded onto metal surface from the environment for long-term measurement. The strain gauge is packed inside together with the applied adhesive and overcating materials. The protector is also provided with a hole for cable intake. It allows the entire area to be isolated from ambient conditions which may affect reliable measurement, and further increases the coating performance.

Caution:

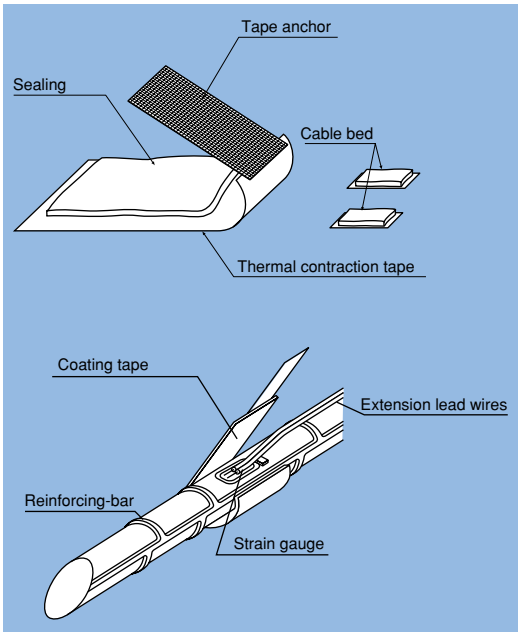
Strain gauges with a large-size backing, such as the PFL-30-11 and PL-60-11, cannot be used with the Gauge Protector.

SPECIFICATIONS

Dimensions	Frame　ϕ100mm（Inner ϕ92mm）×15mm（Height） Cover　ϕ100mm×3mm（Thick）
Operational temperature range	−20～+80℃
Extension cable	ϕ9mm measuring purpose cable recommendable

Other size is available on request.

COATING TAPE FOR REINFORCING BAR

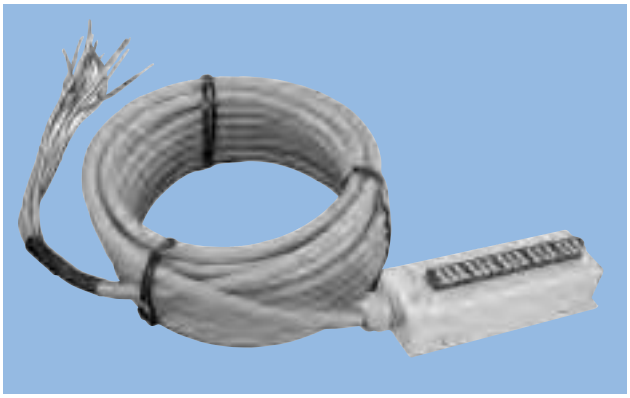


This tape is specially designed for use as a waterproof coating for strain gauges bonded onto reinforcing bars or other cylindrical surfaces. Coating is achieved by simply taping it onto the surface, saving considerable time in comparison with conventional procedures.

Operational temperature : −20～+80℃

Type	Applicable reinforcing bar	Quantity per box	Applicable strain gauges	Size finish (example)	
				Reinforcing bar	Diameter X Width (mm)
CT-D04	D4	10	FLK-2-11	D4	ϕ10×21
CT-D06	D6	10	FLK-2-11	D6	ϕ12×21
CT-D10	D10	10	FLK-2-11	D10	ϕ15×21
CT-D13	D13	10	FLA-3-11	D13	ϕ19×26
CT-D16	D16	10	FLA-3-11	D16	ϕ21×26
CT-D25	D19～D25	10	FLA-3-11	D25	ϕ31×31
CT-D35	D29～D35	10	FLA-3-11	D32	ϕ37×35

RELAY CABLES for gauges with lead wires



This relay cable consists of an extension and relay terminals of the same type as those used in the switching box. The cable allows connection of a quarter-bridge strain gauge. By routing the relay cable to a location near the test specimen, the strain gauge does not require long lead wires for attachment to the specimen. Relay cable can be used repeatedly.

Type	GLJ-5A (10)	GLJ-5A (20)
Length of cable standard (m)	10	20
No. of connection	5	
Operational temperature (℃)	0～+80	
Dimension Wide×Depth×Height (mm)	170×66×approx.46	
Core/diameter (Cross section area)	φ11.1mm 20/0.18 (0.5mm²)	

Strain Checker FGMH-1B

Utilizing friction
Adhesives are not required.
No repainting is required after the measurement.
Repeated measurements are possible.
Simultaneous multi-point measurement

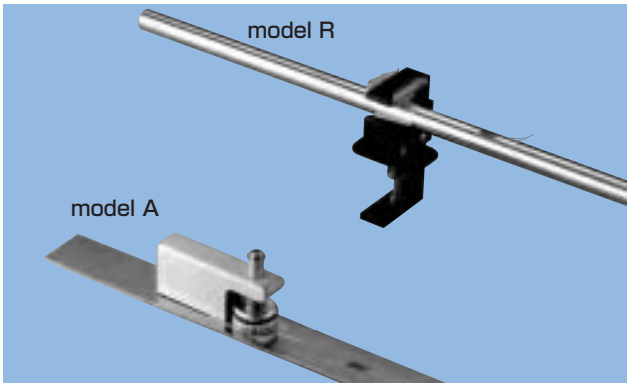
While ordinary strain gauges measure the strain generated in a structure through adhesives, Strain Checker (FGMH-1) is directly pressed against the structure with the attractive force of a magnet to measure the strain by the friction produced at the interface. Strain is easily measured by directly attaching the Strain Checker to a position of a steel bridge, crane, or any other structure where you want to measure the strain. Positions of measurement can be easily moved and the measurement can be repeated easily.

■SPECIFICATIONS

Model name	FGMH-1B
Number of axes	Single
Gauge length	6mm
Height	48mm excluding the shaft
Diameter	φ34mm
Gauge factor	Approx. 2
Gauge resistance	Approx. 122Ω
Accessory	Bridge circuit board with leadwires
Bridge	Full bridge
Option	Provision of a plug to the end of lead wires

■NOTE :
1. The installation is available with metal test specimen in which magnetic force is generated.
2. A zero drift may occur when measuring area is hammered.
3. Against high-speed vibrating specimen, precise measurement may be lost.
4. For more precise measurement, remove paints before measurement

STRAIN GAUGE CLAMP - GAUGE MATE A AND R



When bonding the strain gauges, a fixing pressure should be applied to the gauge until curing is completed. This can be easily done using the TML Gauge Mate, which is a gauge clamp device consisting of a coil spring and a permanent magnet. For use on specimens of different shapes, two types are available. Model A is for flat specimens, and model R is for round specimens. Both can be used with room-temperature curing type bonding adhesives.

Type	Applicatiom
Gauge Mate A	Flat specimen use (1mm thick or over)
Gauge Mate R	Round specimen use (φ5～φ32mm)

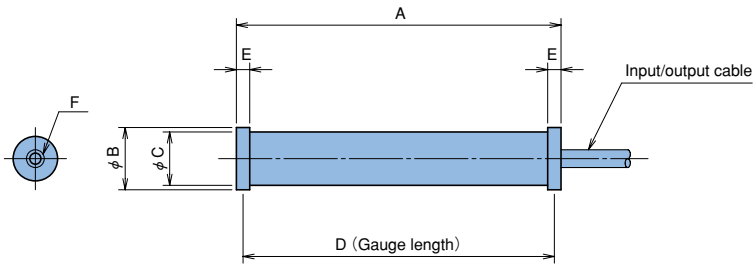
N.B : Strain Gauge clamp should be used in room temperature.

STRAIN TRANSDUCER "KM" ±5000×10⁻⁶ strain

The KM series strain transducers are designed to measure strain in materials such as concrete, synthetic resin which undergo a transition from a compliant state to a hardened state. Their extremely low modulus (40N/mm² approx. except for KM-A) and waterproof construction are ideally suited for internal strain measurement during the very early stages of curing. They are totally impervious to moisture absorption, producing excellent stability for long-term strain measurement. Relative temperature measurement is also possible with the KM-A and KM-B. The built-in thermocouple sensor of the KM-AT/KM-BT enable actual temperature measurement in addition to strain measurement. Adding to the above embedment use, surface strain measurement onto concrete, H-beam steel is also available with various optional fittings.

■FEATURES

- ●Self-temperature compensated transducer having a linear thermal expansion coefficient similar to concrete
- ●Low elastic modulus enables inner strain measurement during the very early stages of curing
- ●Simultaneous measurement of strain and temperature except for **KM-30**,**KM-50F**
- ●Surface strain measurement is also available onto retaining wall, strut, sheet pile, etc.



Type	Dimensions (mm)						Weight (g)
	A	B	C	D	E	F	
KM-30	34	12	10	31	3	M3 Depth4	12
KM-50F	54	20	17	50	4	M3 Depth6	45
KM-100A KM-100B	104	20	17	100	4	M3 Depth6	75
KM-100HB	104	20	17	100	4	M3 Depth6	80
KM-200A	205	28	23	200	5	M5 Depth8	220
KM-100AT KM-100BT	104	20	17	100	4	M3 Depth6	75
KM-200AT	205	28	23	205	5	M5 Depth8	220

■SPECIFICATIONS

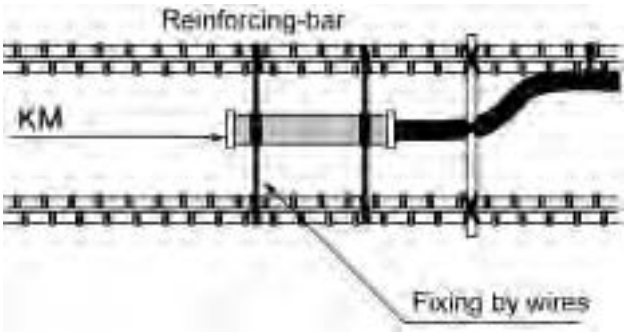
TYPE	KM-30	KM-50F	KM-100A	KM-100B	KM-100HB	KM-200A	KM-100AT	KM-100BT	KM-200AT
Capacity	±5000×10⁻⁶ strain								
Gauge length	31mm	50mm	100mm			200mm	100mm		200mm
Rated output (approxately)	2.5mV/V (5000×10⁻⁶)	4mV/V (8000×10⁻⁶)	2.5mV/V (5000×10⁻⁶)			5mV/V (10000×10⁻⁶)	2.5mV/V (5000×10⁻⁶)		5mV/V (10000×10⁻⁶)
Non-linearity	1%RO								
Apparent elastic modulus	40N/mm²		1000N/mm²	40N/mm²		1000N/mm²	40N/mm²		1000N/mm²
Integral temperature	—		※1Strain gauges (350Ω Quarter gauge with 3-wire 50×10⁻⁶ strain/℃ approx.				※2Thermocouple T		
Temperature range	−20～+60℃	−20～+80℃			−20～+180℃	−20～+80℃			
Input/Output	120Ω Half bridge	350Ω Full bridge							

*1 Relative temperature measurement possible
*2 Real temperature measurement possible

Input/output cable	KM-30	φ2.4mm	0.04mm²	3-core shielded	Vinyl cable	2m	cable-end free
	KM-50F	φ6mm	0.35mm²	4-core shielded	Chloroprene cable	2m	cable-end free
	KM-100A/-100B	φ9mm	0.3mm²	5-core shielded	Chloroprene cable	2m	cable-end free
	KM-100HB	φ6mm	0.3mm²	5-core shielded	Fluoroplastic cable	2m	cable-end free
	KM-200A	φ11.5mm	0.5mm²	5-core shielded	Chloroprene cable	2m	cable-end free
	KM-100AT/-100BT	φ9mm	0.3mm²	4-core shielded	T-thermocouple compound cable	2m	cable-end free
	KM-200AT	φ11.5mm	0.5mm²	4-core shielded	T-thermocouple compound cable	2m	cable-end free

For use of inner strain measurement

The KM Strain Transducers make possible strain measurement in materials such as concrete which undergo a transition from a compliant state to a hardened state. Various strains are produced by external force, ambient temperature, drying shrinkage, materials creep, etc., the KM is designed to measure such strains.
Applicable gauge length should require three times the diameter of the gravel pieces so as to give an averaged evaluation of the concrete.



An installation to reinfocing concrete structures inside

As shown in figure right, attach wires to KM body at 2 points, then position the KM to marked points in advance of reinforcing bar to fix it.

An installation with optional Non-stress casing KMF-51/KMF-52

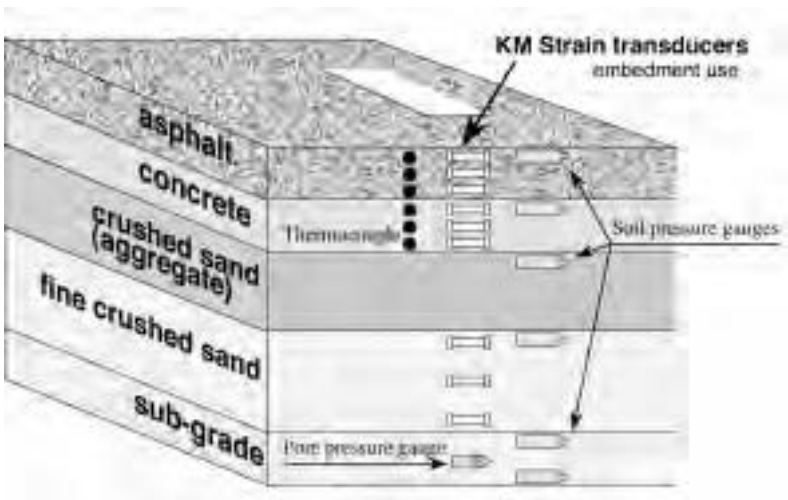
Optional Non-stress casing is available for measurement of the linear thermal expansion coefficient and dry shrinkage strain when a container with the transducer inside is embedded in concrete.

In case that the non-stress casing can not be applied, prepare the same model of concrete specimen to install the casing with the same condition of water inducement during unloaded. And linear thermal expansion coefficient and dry shrinkage strain of concrete can be measured.

An installation to pavement

During pavement construction, driving tests, loading test, and long-period deterioration tests are conducted using various types of sensors to check the degree of fatigue in relation to the load bearing capcity. The KM measures inner stress produced in each layers under road.

Measuring cables are separately positioned in advance. To protect sensors from mechanical damage, protective cover should be required, and such sensors are temporarily positioned. Then, they are fixed same time in each layer.

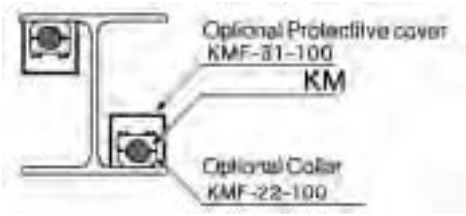


For use of surface strain measurement

Surface strain measurement onto steel and concrete structures is available with KM-100B or KM-100BT. (Optional fittings such as Spacer and Collar are available for fixing the model and positioning gauge length.)

An installation onto surface of steel structure

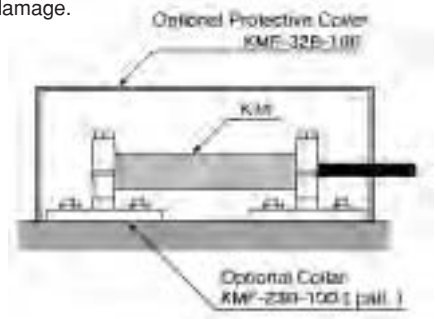
A strain transducer is installed onto surface of steel using optional Collar KMF-22-100 with welding works. Optional Protective Cover KMF-31-100 protects the transducer from physical damage.



The KM model is combined with optional Collar KMF-22-100 to install onto surface of steel by welding.

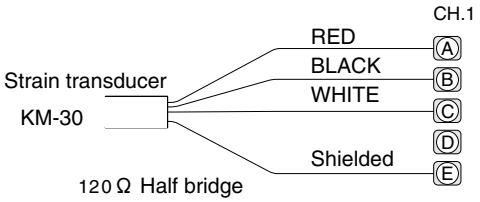
An installation onto surface of concrete structure

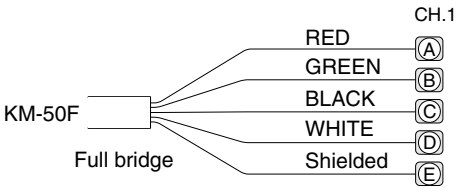
A strain transducer is installed onto surface of concrete using optional Collar KMF-23B-100 with anchoring works. Optional Protective Cover KMF-23B-100 protects the transducer from physical damage.



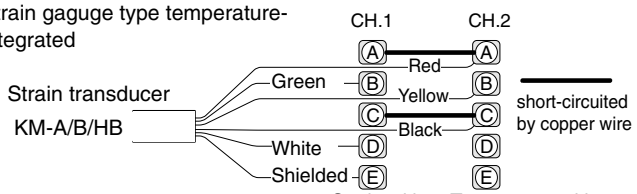
The KM model is combined with optional Collar KMF-23B-100 to install onto surface of concrete structure with anchor bolts.

■Wiring connection



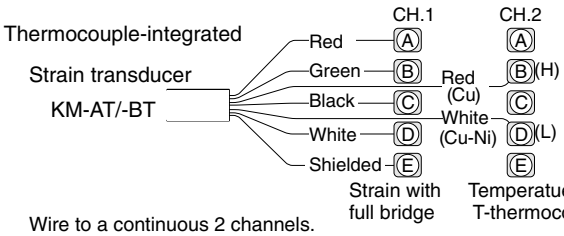


Strain gaguge type temperature-integrated



Wire to a continuous 2 channels.
Directly wire the colored cables of RED, YELLOW, BLACK to 2nd channel, while consecutive terminals A-A and C-C should be short-circuited by copper wire.

Thermocouple-integrated



Wire to a continuous 2 channels.
Directly wire the colored cables of Red, Green, Black, White and shield to 1st channel, while wire the colored thermocouple of Red (Cu) and White (Cu-Ni) to 2nd channel.

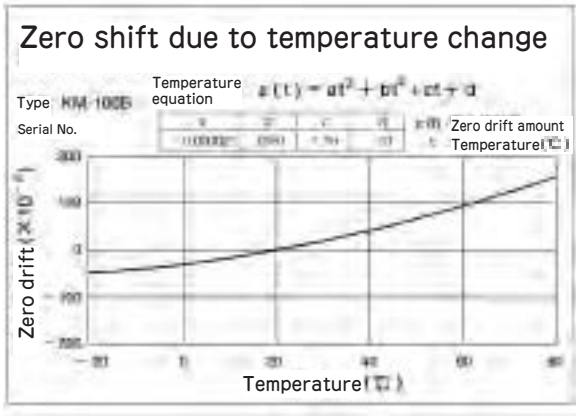
■Temperature measurement by Strain Transducer

Temperature sensor-integrated strain transducer have 2 types. One is for relative temperature measurement with strain gauge 350Ω quarter bridge with 3-wire system, another is for real temperature measurement with thermocouple sensor. Using Data Logger, it makes more precise measurement possible. Comparing to an external temperature probe use, this model can save considerable installation and wiring works.

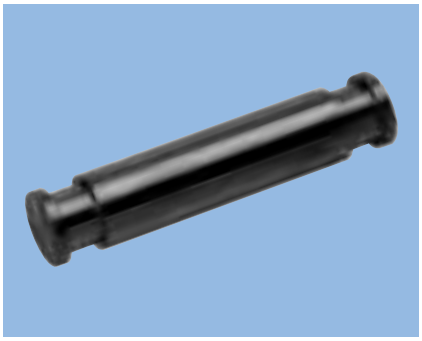
Strain gauge temperature sensor integral type
KM-100A/KM-100B/KM-100HB/KM-200A
Thermocouple sensor integral type
KM-100AT/KM-100BT/KM-200AT

For more precise strain measurement with the transducer, correction of zero shift should be required. Optional temperature data on each supply is available on request.

Example of Temperature data (optional)



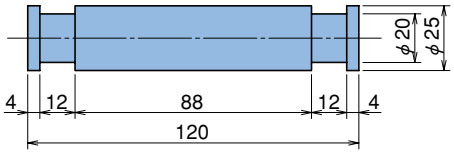
KM Optional accessory

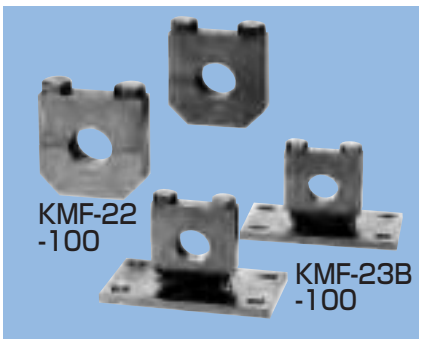


Spacer KMF-12-100

A spacer is needed whenever strain transducer is installed to measure surface strain. The KMF-12-100 spacer is used to accurately locate the gauge length needed to attach KMF-22 and KMF-23B Collars to a structure.

Applicable transducer : KM-100B
KM-100BT

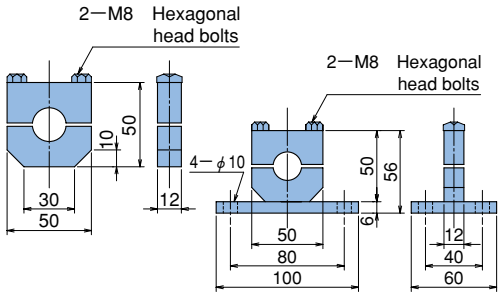


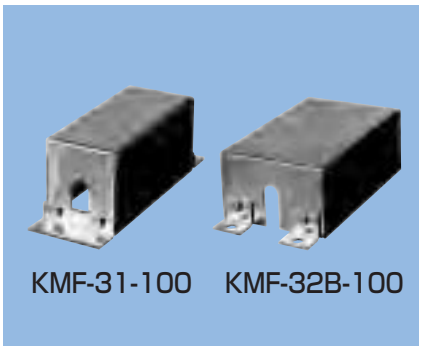


Collar KMF-22-100/KMF-23B-100

The KMF-22-100 Collars are used to mount a strain transducer to steel surface (2 per set), and KMF-23-100 Collars are used to mount the transducer to the surface of concrete (2 per set).

Applicable transducer : KM-100B
KM-100BT

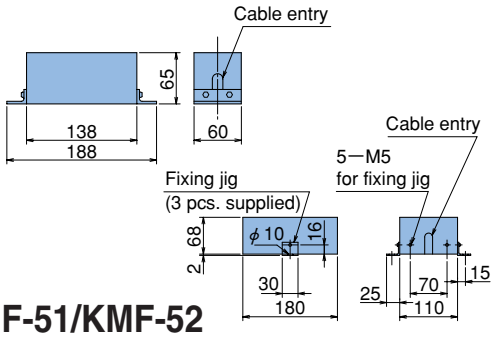


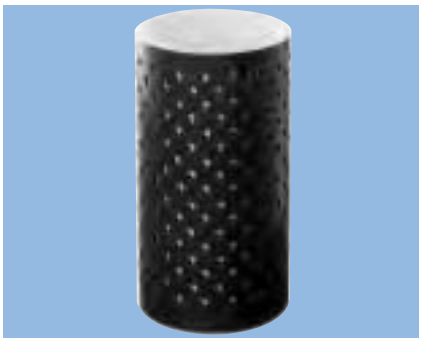


Protective Cover KMF-31-100/KMF-32B-100

The KMF-31-100 Protective Cover is used to protect the transducer attached onto steel surface with a KMF-22 Collar, and the KMF-32B-100 is the same onto concrete surface with a KMF-23B Collar.

Applicable transducer : KM-100B
KM-100BT

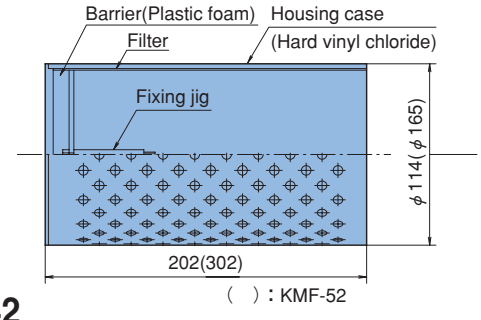


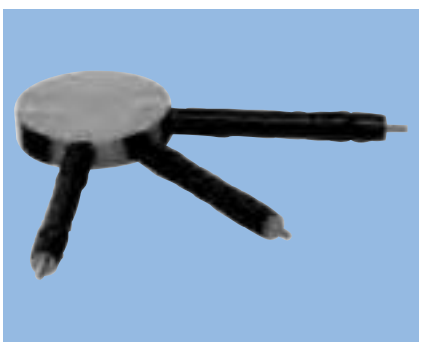


Non-stress casing KMF-51/KMF-52

KMF-51 and KMF-52 are used to measure the linear thermal expansion coefficient and dry shrinking strain with a container with the transducer inside is embedded in concrete.

Type	Applicable transducer
KMF-51	KM-100A / -100B KM-100AT / -100BT
KMF-52	KM-200A / -200AT

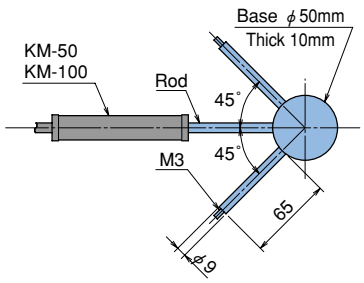




Spiders KMF-41/KMF-42

KMF-41 and KMF-42 Spiders are used to properly embed the transducer in a predetermined direction for measuring plane and threedimensional stress in structure.

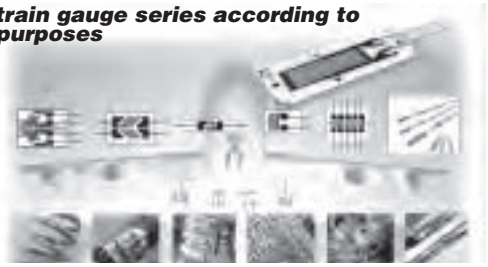
Type		Axes	Applicable transducer
2-dimensional	KMF-41-2	2	KM-50F KM-100A KM-100AT KM-100B KM-100BT
	KMF-41-3	3	
3-dimensional	KMF-42-3	3	
	KMF-42-4	4	
	KMF-42-5	5	
	KMF-42-6	6	



Miniature strain gauge application

The need for the measurement of strength in test and research fields wherein miniature and light weight is an important factor has been growing. TML strain gauges have been used as a means of measuring directly the strength of a specimen. The strain gauges introduced below have much demand in automobile, aircraft and industrial machinery fields.

Various strain gauge series according to versatile purposes



Ultra-miniature strain gauge measurement in less space area

F series	− 20 ～ + 80℃
UF series	− 20 ～ +150℃
EFLK/EFLX (Single)	− 20 ～ +300℃
EFCA/EFRA (2-/3-axial)	−196 ～ +200℃

Printed circuit boards and surface mounting parts of automobile, computers and industrial machinery have become small. The following miniature strain gauges can be installed in a very limited gauge installation space.

Compensated temperature range

F series	+10 ～ + 80℃
UF series	+10 ～ +100℃
EFLK/EFLX	+10 ～ +150℃
EFCA/EFRA	0 ～ +150℃

Bonding adhesive applicable	
CN	(−20 ～ +120℃)
EB-2	(−20 ～ +150℃)
C-1	(−20 ～ +200℃)
NP-50	(−20 ～ +300℃)

Gauge patterns	Configuration	Gauge type name	Active gauge(mm) length	Active gauge(mm) width	Backing (mm) length	Backing (mm) width	Resistance (Ω)
FLA-03 (×3)	Single axis	FLA-03	0.3	1.4	3.0	2.0	120
UFLA-03 (×3)		UFLA-03	0.3	1.4	3.0	2.0	120
EFLK-02 (×3)		EFLK-02	0.2	0.8	1.6	1.2	120
EFLX-02 (×3)		EFLX-02	0.2	0.8	1.8	1.2	120
EFRA-05	2-/3-axis stacked	EFCA-05	0.5	0.4	φ3.8		120
		EFRA-05	0.5	0.4	φ3.8		120

Shearing strain/Torque measurements

QFLT [QF series] −20 ～ +200℃

The gauges measure strains in 45-degree direction generated by shearing stress. The narrow gauge size is suitable for fine spring. The polyimide resin backing makes the use in temperatures up to 200°C possible. Standard self-temperature-compensation is for materials with a linear expansion coefficient of 11 x 10^{-6}/°C, but self-compensated strain gauges for other materials can be manufactured to order.

Compensated temperature range
+10 ～ +100℃

Bonding adhesive applicable	
CN	(−20 ～ +120℃)
C-1	(−20 ～ +200℃)
NP-50	(−20 ～ +200℃)

Gauge patterns	Configuration	Gauge type name	Active gauge(mm) length	Active gauge(mm) width	Backing (mm) length	Backing (mm) width	Resistance (Ω)
QFLT-05A (×3)	Single axis Shearing strain	QFLT-05A-11	0.5	0.66	4.0	1.3	120
QFLT-05B (×3)		QFLT-05B-11	0.5	0.66	4.0	1.3	120
QFLT-1A (×3)		QFLT-1A-11	1	1.1	5.7	2.0	120
		QFLT-1-350A-11 -002LE*	1	1.1	5.7	2.0	350
QFLT-1B (×3)		QFLT-1B-11	1	1.1	5.7	2.0	120
		QFLT-1-350B-11	1	1.1	5.7	2.0	350

*Gauge lead -002LE : Polyimide cable 2 cm attached

Special specimen materials

C composite C ceramic G glass P plastics M magnesium

Strain gauges can be used for composite materials such as CFRP and special materials such as ceramics, glass and plastics as well as metallic materials. The following strain gauges and adhesives are recommended for such applications.

Applicable specimen	Gauge series	Applicable thermal expansion (ppm/°C)	Operating temperature	Bonding adhesive
Composite	BF series	3, 5, 8	−20 ~ +200°C	CN, NP-50
	UF series	3, 5, 8*	−20 ~ +150°C	CN, NP-50, EB-2
	QF series	3, 5, 8*	−20 ~ +200°C	CN, NP-50, C-1
Glass	F series	8	−20 ~ + 80°C	CN, NP-50, EB-2
Plastics	GF series	50, 70	−20 ~ + 80°C	CN
Ceramic	QF series	3, 5, 8*	−20 ~ +200°C	CN, NP-50, C-1
	F series	3, 5, 8*	−20 ~ + 80°C	CN, NP-50, EB-2
	CF series	3, 5, 8*	−269 ~ + 80°C	CN, EA-2A, C-1
Magnesium alloy	QF series	28	−20 ~ +200°C	CN, NP-50, C-1

* Operating temperature depends on bonding adhesive.
* For the type of strain gauge and specifications, please consult us or TML distributors.

Axial force measurements

FLK type [F/QF/ZF series]

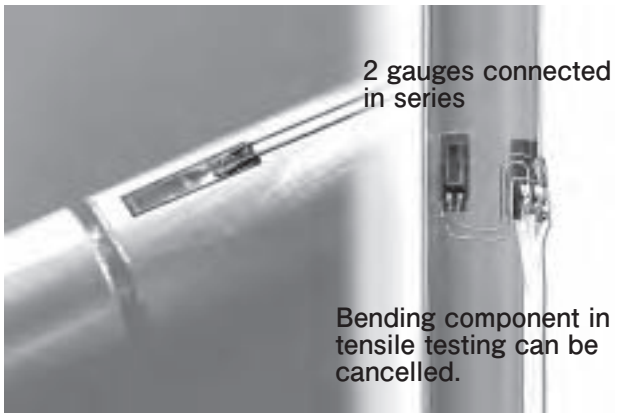
F series −20 ~ + 80°C
QF series −20 ~ +200°C
ZF series −20 ~ +300°C

The FLK type strain gauge with narrow gauge width is adequate for installation in an axial direction of bolt screw, fine pipe and round bar. The F, QF and ZF gauge series can be selected according to usage environments. Standard temperature compensation for the QF and ZF series is for materials with a linear expansion coefficient of 11 x 10^{-6}/°C, but self-temperature compensation for other materials is available on request.

Compensated temperature range

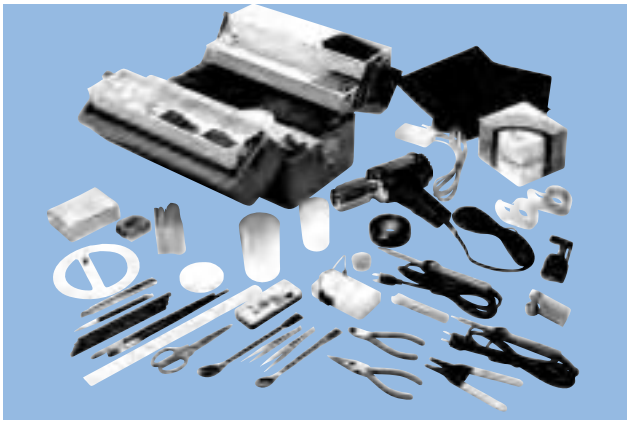
F series	+10 ~ + 80°C
QF series	+10 ~ +100°C
ZF series	+10 ~ +100°C

Bonding adhesive applicable	
NP-50	(−20 ~ +300°C)
C-1	(−20 ~ +200°C)
CN	(−20 ~ +120°C)



Gauge patterns	Gauge series	Gauge type name fundamental	Active gauge(mm) length	Active gauge(mm) width	Backing (mm) length	Backing (mm) width	Resistance (Ω)
FLK-1 QFLK-1 (×3)	F series	FLK-1	1	0.7	4.5	1.4	120
		FLK-2	2	0.9	5.5	1.5	120
		FLK-6	6	1.0	11.2	2.2	120
FLK-2 QFLK-2 (×3)	QF series	QFLK-1	1	0.7	4.5	1.4	120
		QFLK-2	2	0.9	5.5	1.5	120
		QFLK-6	6	1.0	11.2	2.2	120
ZFLK-2 (×3)	ZF series	ZFLK-2	2	0.5	5.4	1.4	120

STRAIN GAUGE INSTALLATION TOOL KIT "KIT-51"



The KIT-51 provides all of the necessary tools for bonding strain gauges from surface preparation upto complete wiring, in a single tool box.

■Tools contained

Tool box/ Sponge cushion/ Screwdirver/ Drafting tape/ Tweezers/ Polyethylene sheet/ Nipper/ Solder (melting point 180℃)/ Radio pinchers/ Paste for solder/ Measuring tape (2-meter length)/ Numbering plate/ Stainless steel scale/ Fine abrasive paper/ Mending tape/ Protractor/ Wire stripper/ Soldering tip cleaner/ Connecting terminals/ Cutter/ Marking pencil/ Soldering iron/ Compasses/ Scissors/ Acute swab(cotton)/ Heat gun/ AC plug/ Vinyl tape/ Brush for coating works, etc.

TML STRAIN GAUGE USERS' GUIDE
TML STRAIN GAUGE PERFORMANCE CHARACTERISTICS

A wide range of TML strain gauges are available to match diverse measuring conditions. Since strain gauges provide their designed functions only when they are attached to specimens, it is important to select the most appropriate gauge type in consideration of the specimen material type, gauge type in consideration of the specimen material type, operation temperature, measurement environment and installation dimensions. The Strain Gauge Users' Guide provide inexperience users with comprehensive information on strain gauges, covering various subjects ranging from step-by-step strain gauge installation instructions to cautions in handling strain gauges. The Strain Gauge Performance Characteristics compile a guide to the technology of current strain gauge for use in consideration of a limit in detection with regard to the materials and size of a test specimen, humidity, the amount of strain, speed, fatigue, environments, etc.

Tokyo Sokki Kenkyujo Co., Ltd.

www.tml.jp/e

8-2, Minami-Ohi 6-Chome, Shinagawa-Ku, Tokyo 140-8560, JAPAN
TEL: Tokyo 03-3763-5611 FAX: Tokyo 03-3763-5713
E-mail address: **sales@tml.jp**

092103X