PRODUCT CATALOGUE

Strain Gauges

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Glue - Solder Terminals
Explanations - Instructions

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Strain gauges - An introduction

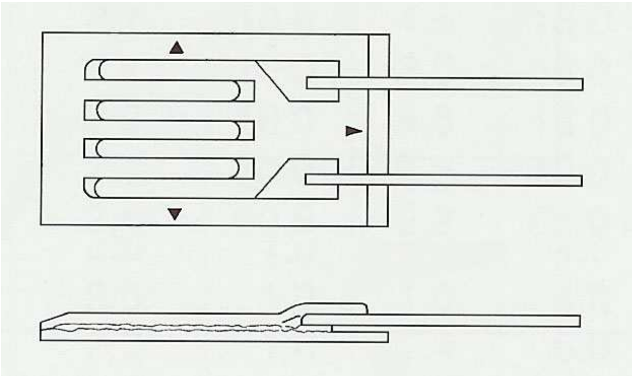
Showa's strain gauges

Showa's strain gauges, adhesives and measuring instruments have been sold in Sweden for over 40 years. Today the businesses have expanded to include several markets within Europe, and we will continue to offer competitive and qualitative products for our customers.

Properties of the strain gauges

- The gauges are fitted with or without lead wires
- Almost no effect on test object
- Distant and multi-points measurements are possible
- Applicable on both static and dynamic strains
- Both surfaces being completely laminated, the gauge grids are entirely protected
- Easy to handle and apply
- Top quality
- Competitive price
- Quality assured

Basic structure

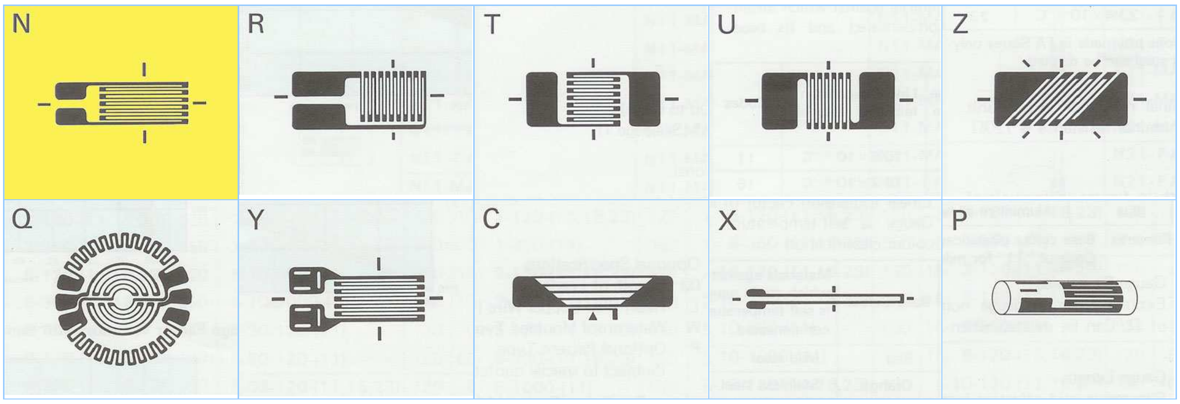


Strain gages are of the stucture, in which a metallic foil film in the thickness of a few microns is glued on a thin electrically insulated sheet (such as polyimide, polyester and so on). This foil film is cut down by photo-etching method in the shape of strain gages which can be made with the negative film masks of the strain gage patterns. These photo-etched strain gage patterns are trimmed to have a standard resistance value satisfying requirements as the strain gages.

Basic patterns, combinations and model configurations

Basic patterns

Example configuration: **N**11-FA-5-350-16-L03



N,R: **Basic strain gauges for measuring and analysis of stress and strains.**

T,U: **Strain gauges with the leads at both ends.**

Z: **For shearing stress and torque measurement.**

Q: **Pressure sensor.**
4 elements.

Y: **Yielding type.**
For measurement of large strains ranging to plastic sphere.
Designed not to cause stress concentration at the point where leads are soldered.

C: **For crack analysis.**
Gauge grids are arranged in parallell. Gauge resistance increases in the form of stairs when a crack takes place somewhere within the grids.

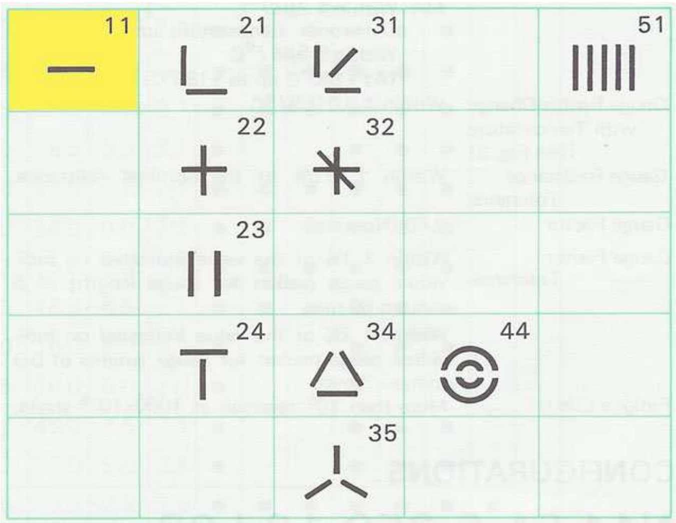
X: **For crack propagation detection.**
With the lengthy grid of this gauge, cracks propagating extensively can be sensed.

P: **For application to internal surface of pipes or threaded holes where gauges are difficult to install.**
The test object is perforated for installation of this gauge inside. Note however that application is considerably critical as the gauge is likely to be damaged when installed or its performance is affected by air bubbles introduced during installation.

W: **Waterproof moulded type strain gauge.**
Vinyl cable (2 parallel wires of 1 mm. in external dia., resp.) is being connected with strain gauge and the gauge is moulded with special Epoxy resins. No special protection for waterproofing is necessary after its having been installed on the test object. This feature can be applied to all versions in Nxx-FA series of gauge length from 2mm. to 10mm., except N34, N35 and N51**.**

Basic pattern combinations

Example configuration: N**11**-FA-5-350-16-L03



11. Uniaxial
21. Plane layout
22. Biaxial, stacked rosette
23. Parallell
24. 2-element
31. Plane layout
32. Triaxial, stacked rosette
34. Δ (Delta) type, plain layout
35. Y type, plain layout
44. For pressure sensor
51. 5-element

Material

Base material

Example configuration: N11-**F**A-5-350-16-L03

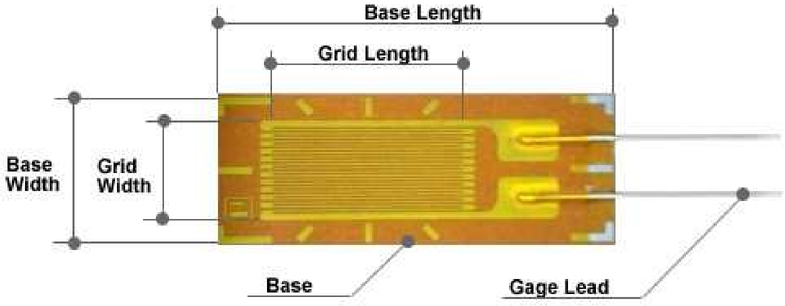
F: Polyester
M: Polyimid

Foil material

Example configuration: N11-F**A**-5-350-16-L03

A: Copper-Nickel alloy

Dimensions of the gauge



Grid length

Example configuration: N11-FA-**5**-350-16-L03

5 in example configuration express effective length of the grid in the unit mm.

Other dimensions

You can find information about Length and width for grid and base for each gauge in the specifications.
See Specifications – Patterns – Models on page 10.

Gauge resistance

Example configuration: N11-FA-5-**350**-16-L03

350 in example configuration, express strain gauge nominal resistance in the unit of ohm (Ω).

Linear expansion factor

Example configuration: N11-FA-5-350-**16**-L03

Linear expansion factor of material against which strain gauge is self-temperature compensated and its base colour classification.

Base color	Materials against which strain gauge is self-temperature compensated	Linear expansion factor of materials	Codes
Red	Mild steel	10.8×10^{-6}/ºC	11
Orange	Stainless steel	16.2×10^{-6}/ºC	16
Blue	Aluminium alloy	23.4×10^{-6}/ºC	23

Specifications for lead wires

Example configuration: N11-FA-5-350-16-**L03**

Specifications for lead wires						
Suffix	Color (Suffix)	Length [m] (suffix)	Size [mm^2]	Leaders per wire	Resistance [Ω/m]	Others
VS	Green (E)	1 (1)/3 (3)/5 (5)	Φ12	7	0,44	Parallel vinyl-coated leadwire
VM	Green (E)	3 (3)/5 (5)	Φ12	10	0,32	Parallel vinyl-coated leadwire
VL	Green (E)	3 (3)/ 5 (5)	Φ18	7	0,20	Parallel vinyl-coated leadwire
FE		3 (3)	Φ18	7	0,20	Teflon-coated leadwire
L		0,3 (03)/0,5(05)	Φ18	1	2,24	Polyester-coated leadwire
W		1 (1)/3 (3)	Φ12	7	0,44	Waterproof Moulded strain gage

Color code of VS type lead wire		
Code	Color	Standard/Not standard
E	Green	Standard
B	Black	Not standard
W	White	Not standard
R	Red	Not standard

Lead wire colors on parallel vinyl-coated leadwires of type VS with 1 to 3 elements			
Number of elements	Gauge	Lead wire colors	Color codes
1	Uniaxial	Green	E
2	Biaxial	Green and Red	Not given*
3	Triaxial	Green, Red and White	Not given*

* The color symbols are not given in the designations of biaxes and triaxes strain gages (VS1, VS3 and so on, for example).

Standard specifications

Gauge length	0.3 mm. to 60 mm. max.
Measurable strain	2 to 4% maximum, up to 10% with foil yielding strain gauges.
Temperature range	FA (polyester base) -30°C to +80°C MA (polyimide base) -30°C to +180°C
Thermal output (See Fig. 1 on next page)	FA within ± 2με/°C (at room temperature up to +80°C) MA within ± 2με/°C (at room temperature up to +160°C) within ± 52με/°C (at +160°C up to + 180°C)
Gauge factor change with temperature	See Fig. 2 on next page
Gauge resistance tolerance	within ± 0.5% of the nominal resistance
Gauge factor	2.00 (Nominal)
Gauge factor tolerance	within ± 1% of the value indicated on individual gauge packet for gauge lengths of 5 mm. to 60 mm. within ± 2% of the value indicated on individual gauge packet for gauge lengths of 0.3 mm. to 3 mm.
Fatique life	More than 10^5 reversals at 1000 x 10^{-6} strain.

General performances of type N11-MA-5-120-11

Thermal Output Characteristics

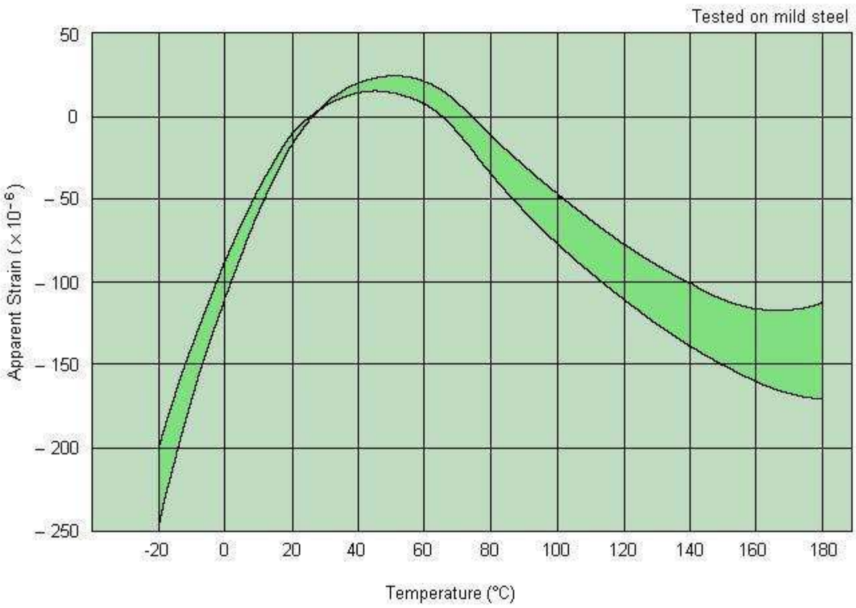


Figure 1

Gauge Factor variation with temperature

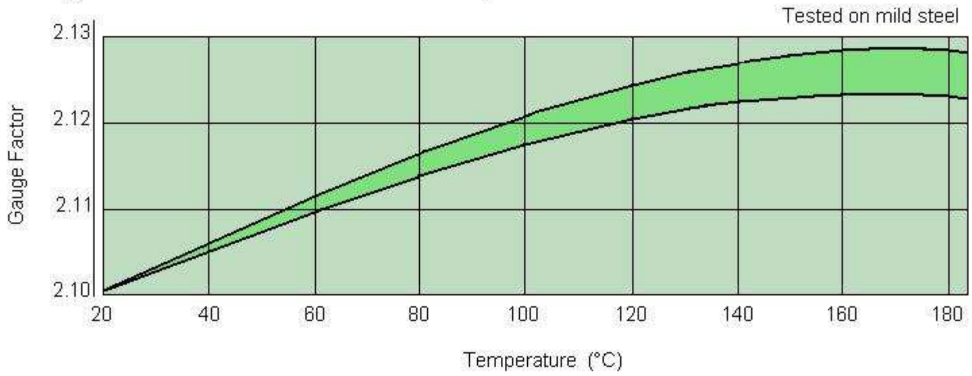
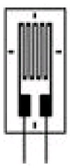
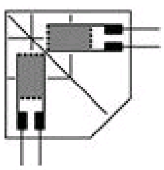
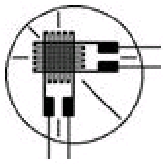
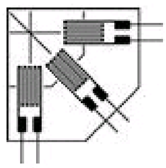
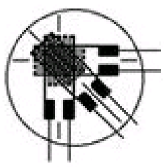


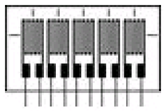
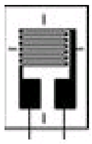
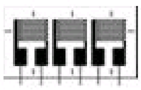
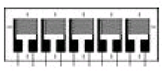
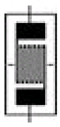
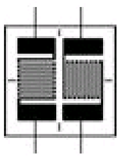
Figure 2

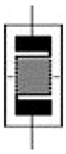
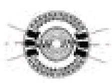
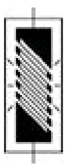
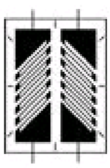
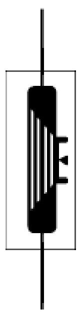
Specifications – Patterns – Models without lead wires

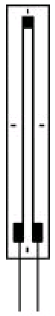
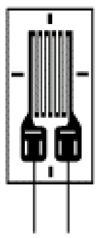
Strain gauge pattern	Type	Nominal resistance (Ohm Ω)	Approx. gauge factor	Dimensions (mm)				Remarks	Gauges per packet
				Grid		Base			
				Length	Width	Length	Width		
	N11-FA-03-120-(11,16,23)	120	1,9	0,3	1,8	3,5	2,5		10
	N11-FA- 1-120-(11,16,23)	120	2,0	1,0	1,5	4,0	2,5		10
	N11-FA- 1-120-(11,16,23)-P4	120	2,0	1,0	1,0	4,0	2,0		10
	N11-FA- 1-350-11	350	2,0	1,0	2,4	5,0	4,0		10
	N11-FA- 2-120-(11,16,23)	120	2,0	2,0	1,6	6,0	2,5		10
	N11-FA- 2-350-(11,16,23)	350	2,0	2,0	2,2	7,0	3,5		10
	N11-FA- 3-120-(11,16,23)	120	2,1	3,0	1,6	7,0	2,8		10
	N11-FA- 5-120-(11,16,23)	120	2,1	5,0	1,8	9,5	3,5		10
	N11-FA- 5-350-(11,16,23)	350	2,1	5,0	2,6	11,0	4,0		10
	N11-FA- 5-1000-11	1000	2,1	5,0	3,2	9,5	5,0		10
	N11-FA- 6-120-(11,16,23)	120	2,1	6,0	2,0	11,0	3,5		10
	N11-FA- 8-120-(11,16,23)	120	2,1	8,0	2,0	13,0	4,0		10
	N11-FA- 8-350-11	350	2,1	8,0	4,0	14,0	6,0		10
	N11-FA-10-120-(11,16,23)	120	2,1	10,0	2,2	15,0	5,0		10
	N11-FA-10-350-(11,16,23)	350	2,1	10,0	4,5	18,0	6,5		10
	N11-FA-10-600-11	600	2,1	10,0	3,0	16,0	5,0		10
	N11-FA-10-1000-11	1000	2,0	10,0	4,5	16,0	6,0		10
	N11-FA-30-120-11	120	2,0	30,0	1,2	40,0	4,5		10
	N11-FA-60-120-11	120	2,0	60,0	2,2	65,0	5,5	Uniaxial	10
	N11-MA-03-120-(11,16,23)	120	2,0	0,3	1,8	3,5	2,5		10
	N11-MA- 1-120-(11,16,23)	120	2,0	1,0	1,5	4,0	2,5		10
	N11-MA- 1-120-(11,16,23)-P4	120	2,0	1,0	1,0	4,0	2,0		10
	N11-MA- 1-350-(11,23)	350	2,0	1,0	2,4	5,0	4,0		10
	N11-MA- 2-120-(11,16,23)	120	2,0	2,0	1,6	6,0	2,5		10
	N11-MA- 2-350-(11,16,23)	350	2,0	2,0	2,2	7,0	3,5		10
	N11-MA- 3-120-(11,16,23)	120	2,0	3,0	1,6	7,0	2,8		10
	N11-MA- 3-350-(11,16,23)	350	2,0	3,0	3,0	7,0	4,5		10
	N11-MA- 5-120-(11,16,23)	120	2,0	5,0	1,8	9,5	3,5		10
	N11-MA- 5-350-11	350	2,0	5,0	2,6	11,0	4,0		10
	N11-MA- 5-1000-11	1000	2,0	5,0	3,2	9,5	5,0		10
	N11-MA- 6-120-(11,16,23)	120	2,0	6,0	2,0	11,0	3,5		10
	N11-MA- 8-120-(11,16,23)	120	2,0	8,0	2,0	13,0	4,0		10
	N11-MA- 8-350-11	350	2,0	8,0	4,0	14,0	6,0		10
	N11-MA-10-120-(11,16,23)	120	2,0	10,0	2,2	15,0	5,0		10
	N11-MA-10-350-11	350	2,0	10,0	4,5	18,0	6,5		10
	N11-MA-10-600-11	600	2,0	10,0	3,0	16,0	5,0		10
	N11-MA-10-1000-11	1000	2,0	10,0	4,5	16,0	6,0		10

Strain gauge pattern	Type	Nominal resistance (Ohm Ω)	Approx. gauge factor	Grid Length	Grid Width	Base (Length*Width)	Remarks	Gauges per packet
	N21-FA- 2-120-(11,16,23)	120	2,0	2,0	1,6	7,5*7,5		10
	N21-FA- 5-120-(11,16,23)	120	2,1	5,0	1,8	12,0*12,0		10
	N21-FA- 5-350-11	350	2,1	5,0	2,6	16,0*16,0		10
	N21-MA- 2-120-(11,16,23)	120	2,0	2,0	1,6	7,5*7,5	2-Element 0°/90° plane layout	10
	N21-MA- 5-120-(11,16,23)	120	2,1	5,0	1,8	12,0*12,0		10
	N21-MA- 5-350-11	350	2,1	5,0	2,6	16,0*16,0		10
	N21-FA- 8-120-(11,16,23)	120	2,1	8,0	2,0	Φ21		10
	N21-FA-10-120-(11,16,23)	120	2,1	10,0	2,2	Φ25		10

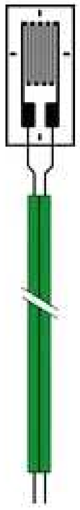
Strain gauge pattern	Type	Nominal resistance (Ohm Ω)	Approx. gauge factor	Dimensions (mm)				Remarks	Gauges per packet
				Grid		Base			
				Length	Width	Length	Width		
	N22-FA- 1-120-(11,16,23)	120	2,0	1,0	1,5	Φ6,0		Biaxial 0°/90° stacked rosette	10
	N22-FA- 2-120-(11,16,23)	120	2,0	2,0	1,6	Φ8,0			10
	N22-FA- 5-120-(11,16,23)	120	2,1	5,0	1,8	Φ11,0			10
	N22-FA- 5-350-11	350	2,1	5,0	2,6	Φ15,0			10
	N22-FA- 8-120-(11,16,23)	120	2,1	8,0	2,0	Φ15,0			10
	N22-FA-10-120-(11,16,23)	120	2,1	10,0	2,2	Φ18,0			10
	N22-MA- 1-120-(11,16,23)	120	2,0	1,0	1,5	Φ6,0			10
	N22-MA- 2-120-(11,16,23)	120	2,0	2,0	1,6	Φ8,0			10
	N22-MA- 5-120-(11,16,23)	120	2,1	5,0	1,8	Φ11,0			10
	N22-MA- 5-350-11	350	2,1	5,0	2,6	Φ15,0			10
	N31-FA- 2-120-(11,16,23)	120	2,0	2,0	1,6	9,0*9,0		3-Element 0°/45°/90° plane layout	10
	N31-FA- 5-120-(11,16,23)	120	2,1	5,0	1,8	14,0*14,0			10
	N31-FA- 5-350-11	350	2,1	5,0	2,6	16,0*16,0			10
	N31-MA- 2-120-(11,16,23)	120	2,0	2,0	1,6	9,0*9,0			10
	N31-MA- 5-120-(11,16,23)	120	2,1	5,0	1,8	14,0*14,0			10
	N31-MA- 5-350-11	350	2,1	5,0	2,6	16,0*16,0			10
	N31-FA- 8-120-(11,16,23)	120	2,1	8,0	2,0	Φ24			10
	N31-FA-10-120-11	120	2,1	10,0	2,2	Φ286			10
	N32-FA- 1-120-(11,16,23)	120	2,0	1,0	1,5	Φ6,0		Triaxial 0°/45°/90° stacked rosette	10
	N32-FA- 2-120-(11,16,23)	120	2,0	2,0	1,6	Φ8,0			10
	N32-FA- 5-120-(11,16,23)	120	2,1	5,0	1,8	Φ11,0			10
	N32-FA- 5-350-11	350	2,1	5,0	2,6	Φ16,0			10
	N32-FA- 8-120-(11,16,23)	120	2,1	8,0	2,0	Φ16,0			10
	N32-FA-10-120-(11,16,23)	120	2,1	10,0	2,2	Φ18,0			10
	N32-MA- 2-120-(11,16,23)	120	2,0	2,0	1,6	Φ8,0			10
	N32-MA- 5-120-(11,16,23)	120	2,1	5,0	1,8	Φ11,0			10
	N32-MA- 5-350-11	350	2,1	5,0	2,6	Φ16,0			10
	N34-FA-2-120-11	120	2,0	2,0	1,6	Φ10,0		Δ type, 3-Element plane layout	10
	N34-MA-2-120-11	120	2,0	2,0	1,6	Φ10,0			10
	N35-FA-2-120-11	120	2,0	2,0	1,6	Φ10,0		Y type, 3-Element plane layout	10
	N35-MA-2-120-11	120	2,0	2,0	1,6	Φ10,0			10

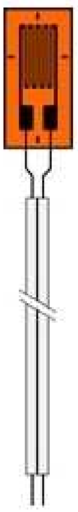
Strain gauge pattern	Type	Nominal resistance (Ohm Ω)	Approx. gauge factor	Dimensions (mm)				Remarks	Gauges per packet
				Grid		Base			
				Length	Width	Length	Width		
	N51-FA- 1-120-(11,16,23)	120	2,0	1,0	1,5	12,0	4,0	5-Element 0° leads at one end	10
	N51-FA- 2-120-(11,16,23)	120	2,0	2,0	1,6	15,0	6,0		10
	N51-MA- 1-120-(11,16,23)	120	2,0	1,0	1,5	12,0	4,0		10
	N51-MA- 2-120-(11,16,23)	120	2,0	2,0	1,6	15,0	6,0		10
	R11-FA- 1-120-(11,16,23)	120	2,0	1,0	2,2	5,5	3,0	Uniaxial 90° leads at one end	10
	R11-FA- 2-120-(11,16,23)	120	2,0	2,0	1,8	6,0	3,5		10
	R11-MA- 1-120-(11,16,23)	120	2,0	1,0	2,2	5,5	3,0		10
	R11-MA- 2-120-(11,16,23)	120	2,0	2,0	1,8	6,0	3,5		10
	R31-FA-03-120-(11,16,23)	120	2,0	0,3	1,2	5,0	3,6	3-Element 90° leads at one end	10
	R31-MA-03-120-(11,16,23)	120	2,0	0,3	1,2	5,0	3,6		10
	R51-FA-03-120-(11,16,23)-P4	120	2,0	0,3	1,2	6,0	5,0	5-Element 90° leads at one end	10
	R51-FA- 1-120-(11,16,23)	120	2,0	1,0	0,5	11,0	4,0		10
	R51-FA- 2-120-(11,16,23)	120	2,0	2,0	0,8	15,0	4,5		10
	R51-MA-03-120-(11,16,23)	120	2,0	0,3	1,2	6,0	5,0		10
	R51-MA- 1-120-(11,16,23)	120	2,0	1,0	0,5	11,0	4,0		10
	R51-MA- 2-120-(11,16,23)	120	2,0	2,0	0,8	15,0	4,5		10
	T11-FA- 1-120-(11,16,23)	120	2,0	1,0	1,5	5,5	3,0	Uniaxial 0° leads at both ends	10
	T11-FA- 2-120-(11,16,23)	120	2,0	2,0	2,5	8,0	4,0		10
	T11-FA- 5-120-(11,16,23)	120	2,1	5,0	6,0	20,0	10,0		10
	T11-MA- 1-120-(11,16,23)	120	2,0	1,0	1,5	5,5	3,0		10
	T11-MA- 2-120-(11,16,23)	120	2,0	2,0	2,5	8,0	4,0		10
	T11-MA- 5-120-(11,16,23)	120	2,1	5,0	6,0	20,0	10,0		10
	T24-FA- 2-120-(11,16,23)	120	2,0	2,0	2,5	8,0	6,0	2-Element 0°/90° leads at both ends	10
	T24-FA- 5-120-(11,16,23)	120	2,1	5,0	6,0	20,0	15,0		10
	T24-FA- 5-350-11	350	2,1	5,0	6,0	20,0	15,0		10
	T24-MA- 2-120-(11,16,23)	120	2,0	2,0	2,5	8,0	6,0		10
	T24-MA- 5-120-(11,16,23)	120	2,1	5,0	6,0	20,0	15,0		10
	T24-MA- 5-350-11	350	2,1	5,0	6,0	20,0	15,0		10

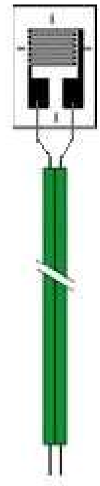
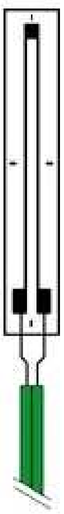
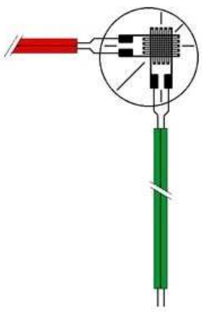
Strain gauge pattern	Type	Nominal resistance (Ohm Ω)	Approx. gauge factor	Dimensions (mm) Grid Length	Grid Width	Base Length	Base Width	Remarks	Gauges per packet
	U11-FA- 1-120-(11,16,23)	120	2,0	1,0	1,2	5,5	3,0	Uniaxial 90° leads at both ends	10
	U11-FA- 2-120-(11,16,23)	120	2,1	2,0	1,8	8,0	4,0		10
	U11-FA- 5-120-(11,16,23)	120	2,1	5,0	5,6	20,0	10,0		10
	U11-MA- 1-120-(11,16,23)	120	2,0	1,0	1,2	5,5	3,0		10
	U11-MA- 2-120-(11,16,23)	120	2,1	2,0	1,8	8,0	4,0		10
	U11-MA- 5-120-(11,16,23)	120	2,1	5,0	5,6	20,0	10,0		10
	Q44-FA-10-350-(11,16)	350			Φ9,5		Φ10,0	For pressure sensor	10
	Q44-FA-14-350-(11,16)	350			Φ13,0		Φ14,0		10
	Q44-MA-10-350-(11,16)	350			Φ9,5		Φ10,0		10
	Q44-MA-14-350-(11,16)	350			Φ13,0		Φ14,0		10
	Z11-FA- 1-120-(11,16,23)	120	2,0	1,0	3,9	5,0	2,5	Uniaxial 45° for shearing strain	10
	Z11-FA- 2-120-(11,16,23)	120	2,0	2,0	4,0	13,0	5,0		10
	Z11-FA- 5-120-11	120	2,0	5,0	2,6	15,0	10,0		10
	Z11-FA-10-120-11	120	2,1	10,0	5,0	26,0	16,0		10
	Z11-MA- 1-120-(11,16,23)	120	2,0	1,0	3,9	5,0	2,5		10
	Z11-MA- 2-120-(11,16,23)	120	2,0	2,0	4,0	13,0	5,0		10
	Z11-MA- 5-120-11	120	2,0	5,0	2,6	15,0	10,0		10
	Z11-MA-10-120-11	120	2,1	10,0	5,0	26,0	16,0		10
	Z23-FA- 2-120-(11,16,23)	120	2,0	2,0		13,0	7,0	Uniaxial 45° for shearing strain	10
	Z23-FA- 2-350-(11,16,23)	350	2,0	2,0		13,0	7,0		10
	Z23-FA- 5-120-11	120	2,1	5,0		15,0	14,0		10
	Z23-FA- 5-350-11	350	2,1	5,0		16,0	14,0		10
	Z23-FA-10-120-11	120	2,1	10,0		26,0	25,0		10
	Z23-MA- 2-120-(11,16,23)	120	2,0	2,0		13,0	7,0		10
	Z23-MA- 2-350-(11,16,23)	350	2,0	2,0		13,0	7,0		10
	Z23-MA- 5-120-11	120	2,1	5,0		15,0	14,0		10
	Z23-MA- 5-350-11	350	2,1	5,0		16,0	14,0		10
	Z23-MA-10-120-11	120	2,1	10,0		26,0	25,0		10
	C11-FA-5-1	1				5,0	27,0	For crack analysis	10
	C11-FA-14-1	1				6,0	36,0		10

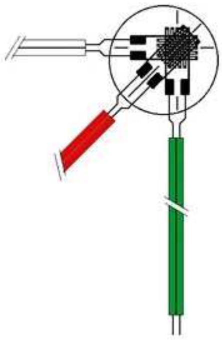
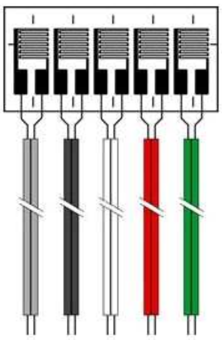
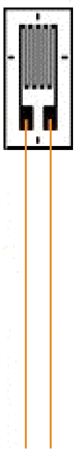
Strain gauge pattern	Type	Nominal resistance (Ohm Ω)	Approx. gauge factor	Dimensions (mm)				Remarks	Gauges per packet
				Grid		Base			
				Length	Width	Length	Width		
	X11-FA- 5-120	120		5,0	1,7	11,0	4,0	For crack propagation detection	10
	X11-FA-10-120	120		10,0	0,25	14,0	3,0		10
	X11-FA-30-120	120		30,0	0,7	35,0	4,0		10
	X11-FA-50-120	120		50,0	1,2	55,5	4,0		10
	X11-FA-90-120	120		90,0	2,0	95,0	6,0		10
	Y11-FA- 2-120	120	2,0	2,0	1,7	7,5	3,5	Uniaxial for yield strain	10
	Y11-FA- 5-120	120	2,0	5,0	1,6	11,0	3,5		10
	Y11-FA- 8-120	120	2,0	8,0	2,1	14,0	5,0		10
	P11-FA-05-120-11	120	1,9	0,5		Φ1,0*3,5		Pipe gauges for bolt spindle power measurement	25
	P11-FA- 2-120-11	120	2,1	2,0		Φ1,4*8,0			25
	P11-FA- 3-120-11-S	120	2,1	3,0		Φ1,9*11,0			25
	P11-MA- 3-120-11-S	120	2,1	3,0		Φ1,9*11,0			25

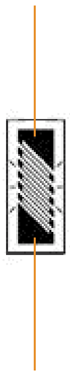
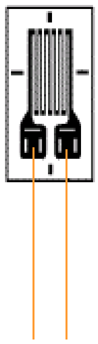
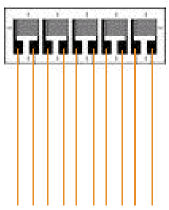
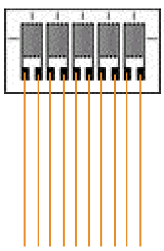
Specifications – Patterns – Models with lead wires

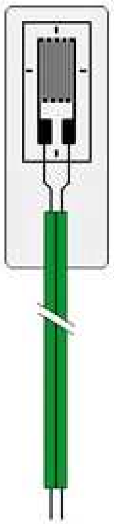
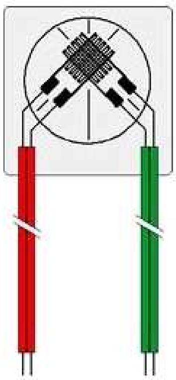
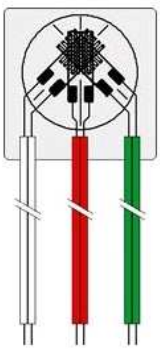
Strain gauge pattern	Type	Nominal resistance (Ohm Ω)	Approx. gauge factor	Dimensions (mm)				Wires length (m)	Remarks	Gauges per packet
				Grid		Base				
				Length	Width	Length	Width			
	N11-FA-03-120-11-VSE1	120	1,9	0,3	1,8	3,5	2,5	1,0	Parallel vinyl-coated leadwire A = Base-Trim	10
	N11-FA-03-120-23-VSE3	120	1,9	0,3	1,8	3,5	2,5	3,0		10
	N11-FA- 1-120-11-P4-VSE1	120	2,0	1,0	1,0	4,0	2,0	1,0		10
	N11-FA- 1-120-23-P4-VSE1	120	2,0	1,0	1,0	4,0	2,0	1,0		10
	N11-FA- 1-120-11-P4-VSE3	120	2,0	1,0	1,0	4,0	2,0	3,0		10
	N11-FA- 1-120-11-P4-VSE3-A	120	2,0	1,0	1,0	3,4	1,3	3,0		10
	N11-FA- 1-120-23-P4-VSE3	120	2,0	1,0	1,0	4,0	2,0	3,0		10
	N11-FA- 1-120-23-P4-VSE3-A	120	2,0	1,0	1,0	3,4	1,3	3,0		10
	N11-FA- 2-120-11-VSE1	120	2,0	2,0	1,6	6,0	2,5	1,0		10
	N11-FA- 2-120-23-VSE1	120	2,0	2,0	1,6	6,0	2,5	1,0		10
	N11-FA- 2-120-11-VSE3	120	2,0	2,0	1,6	6,0	2,5	3,0		10
	N11-FA- 2-120-11-VSE3-A	120	2,0	2,0	1,6	5,6	1,9	3,0		10
	N11-FA- 2-120-23-VSE3	120	2,0	2,0	1,6	6,0	2,5	3,0		10
	N11-FA- 2-120-23-VSE3-A	120	2,0	2,0	1,6	5,6	1,9	3,0		10
	N11-FA- 5-120-11-VSE1	120	2,1	5,0	1,8	9,5	3,5	1,0		10
	N11-FA- 5-120-11-VSE3	120	2,1	5,0	1,8	9,5	3,5	3,0		10
	N11-FA- 5-120-11-VSE5	120	2,1	5,0	1,8	9,5	3,5	5,0		10

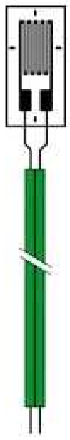
	N11-MA-03-120-11-FE1	120	1,9	0,3	1,8	3,5	2,5	3,0	Useable up to 180°C, Teflon-coated leadwire	10
	N11-MA-03-120-23-FE3	120	1,9	0,3	1,8	3,5	2,5	3,0		10
	N11-MA- 1-120-11-P4-FE3	120	2,0	1,0	1,0	4,0	2,0	3,0		10
	N11-MA- 1-120-23-P4-FE3	120	2,0	1,0	1,0	4,0	2,0	3,0		10
	N11-MA- 2-120-11-FE3	120	2,0	2,0	1,6	6,0	2,5	3,0		10
	N11-MA- 2-120-23-FE3	120	2,0	2,0	1,6	6,0	2,5	3,0		10

Strain gauge pattern	Type	Nominal resistance (Ohm Ω)	Approx. gauge factor	Dimensions (mm) Grid Length	Grid Width	Base Length	Base Width	Wires length (m)	Remarks	Gauges per packet
	R11-FA-1-120-11-VSE3-A	120	2,0	1,0	2,2	5,0	2,3	3,0	Uniaxial 90°, parallel vinyl -coated leadwire A = Base-Trim	10
	R11-FA-1-120-23-VSE3-A	120	2,0	1,0	2,2	5,0	2,3	3,0		10
	X11-FA-5-120-VSE3	120		5,0	1,7	11,0	4,0	3,0	For crack propagation detection parallel vinyl-coated leadwire	10
	X11-FA-10-120-VS3	120		10,0	0,25	14,0	3,0	3,0		10
	X11-FA-30-120-VSE3	120		30,0	0,7	35,0	4,0	3,0		10
	X11-FA-30-120-VS3	120		30,0	0,7	35,0	4,0	3,0		10
	N22-FA- 1-120-11-VS3	120	2,0	1,0	1,5	Φ6,0		3,0	Biaxial 0°90°, stacked rosette, parallel vinyl-coated leadwire	10
	N22-FA- 1-120-23-VS3	120	2,0	1,0	1,5	Φ6,0		3,0		10
	N22-FA- 2-120-11-VS3	120	2,0	2,0	1,6	Φ8,0		3,0		10
	N22-FA- 2-120-23-VS3	120	2,0	2,0	1,6	Φ8,0		3,0		10
	N22-FA- 5-120-11-VS3	120	2,1	5,0	1,8	Φ11,0		3,0		10

Strain gauge pattern	Type	Nominal resistance (Ohm Ω)	Approx. gauge factor	Dimensions (mm) Grid Length	Grid Width	Base Length	Base Width	Wires length (m)	Remarks	Gauges per packet
	N32-FA- 1-120-11-VS3	120	2,0	1,0	1,5	Φ6,0		3,0	Triaxial 0°/45°/90°, stacked rosette, parallel vinyl-coated leadwire	10
	N32-FA- 1-120-23-VS3	120	2,0	1,0	1,5	Φ6,0		3,0		10
	N32-FA- 2-120-11-VS3	120	2,0	2,0	1,6	Φ8,0		3,0		10
	N32-FA- 2-120-23-VS3	120	2,0	2,0	1,6	Φ8,0		3,0		10
	N32-FA- 5-120-11-VS3	120	2,1	5,0	1,8	Φ11,0		3,0		10
	R51-FA- 1-120-11-VM3	120	2,0	1,0	0,5	11,0	4,0	3,0	5-Element 90° parallel vinyl-coated leadwire	10
	R51-MA- 1-120-11-VM3	120	2,0	1,0	0,5	11,0	4,0	3,0		10
	N11-FA- 1-120-11-P4-L05	120	2,0	1,0	1,0	4,0	2,0	0,5	Uniaxial, polyester-coated leadwire	10
	N11-FA- 2-120-11-L05	120	2,0	2,0	1,6	6,0	2,5	0,5		10

Strain gauge pattern	Type	Nominal resistance (Ohm Ω)	Approx. gauge factor	Dimensions (mm) Grid Length	Grid Width	Base Length	Base Width	Wires length (m)	Remarks	Gauges per packet
	Z11-FA- 1-120-11-L05	120	2,0	1,0	3,9	5,0	2,5	0,5	Uniaxial 45°for shearing strain polyester-coated leadwire	10
	Z11-FA- 1-120-11-L08	120	2,0	1,0	3,9	5,0	2,5	0,8		10
	Z11-FA- 1-120-11-L1	120	2,0	1,0	3,9	5,0	2,5	1,0		10
	Y11-FA-2-120-11-L05	120	2,0	2,0	1,7	7,5	3,5	0,5	For yield strain polyester-coated leadwire	10
	R51-FA-1-120-11-L03	120	2,0	1,0	0,5	11,0	4,0	0,3	5-Element 90° polyester-coated leadwire	10
	N51-FA-1-120-11-L03	120	2,0	1,0	1,5	12,0	4,0	0,3	5-Element 0° polyester-coated leadwire	10

Strain gauge pattern	Type	Nominal resistance (Ohm Ω)	Approx. gauge factor	Dimensions (mm) Grid		Base		Wires length (m)	Remarks	Gauges per packet
				Length	Width	Length	Width			
Waterproof Moulded Type with special Epoxy resine										
	N11-FA- 1-120-11-P4-W1	120	2,0	1,0	1,5	25,0	10,0	1,0	Uniaxial , waterproof moulded, parallel vinyl-coated leadwire	10
	N11-FA- 1-120-11-P4-W3	120	2,0	1,0	1,5	25,0	10,0	3,0		10
	N11-FA- 2-120-11-W1	120	2,0	2,0	1,6	25,0	20,0	1,0		10
	N11-FA- 2-120-11-W3	120	2,0	2,0	1,6	25,0	20,0	3,0		10
	N11-FA- 5-120-11-W1	120	2,1	5,0	1,8	25,0	20,0	1,0		10
	N11-FA- 5-120-11-W1	120	2,1	5,0	1,8	25,0	20,0	3,0		10
	N22-FA- 1-120-11-P4-W1	120	2,0	1,0	1,5	25,0	20,0	1,0	Biaxial , waterproof moulded, parallel vinyl-coated leadwire	10
	N22-FA- 1-120-11-P4-W3	120	2,0	1,0	1,5	25,0	20,0	3,0		10
	N22-FA- 2-120-11-W1	120	2,0	2,0	1,6	25,0	20,0	1,0		10
	N22-FA- 2-120-11-W3	120	2,0	2,0	1,6	25,0	20,0	3,0		10
	N22-FA- 5-120-11-W1	120	2,1	5,0	1,8	25,0	20,0	1,0		10
	N22-FA- 5-120-11-W1	120	2,1	5,0	1,8	25,0	20,0	3,0		10
	N32-FA- 1-120-11-W1	120	2,0	1,0	1,5	25,0	20,0	1,0	Triaxial , waterproof moulded, parallel vinyl-coated leadwire	10
	N32-FA- 1-120-11-W3	120	2,0	1,0	1,5	25,0	20,0	3,0		10
	N32-FA- 2-120-11-W1	120	2,0	2,0	1,6	25,0	20,0	1,0		10
	N32-FA- 2-120-11-W3	120	2,0	2,0	1,6	25,0	20,0	3,0		10
	N32-FA- 5-120-11-W1	120	2,1	5,0	1,8	25,0	20,0	1,0		10
	N32-FA- 5-120-11-W3	120	2,1	5,0	1,8	25,0	20,0	3,0		10

Strain gauge pattern	Type	Nominal resistance (Ohm Ω)	Approx. gauge factor	Dimensions (mm) Grid Length	Grid Width	Base Length	Base Width	Wires length (m)	Remarks	Gauges per packet
Combination of five color cable(Leadwire Type : VM) #The minimum ordering lot will be per packet of 100 strain gages.										
	N11-FA- 1-120-11-P4-VM3	120	2,0	1,0	1,0	4,0	2,0	3,0	Parallel vinyl-coated leadwire	
	N11-FA- 1-120-23-P4-VM3	120	2,0	1,0	1,0	4,0	2,0	3,0		
	N11-FA- 2-120-11-VM3	120	2,0	2,0	1,6	6,0	2,5	3,0		
	N11-FA- 2-120-23-VM3	120	2,0	2,0	1,6	6,0	2,5	3,0		
	N11-FA- 3-120-11-VM3	120	2,0	3,0	1,6	7,0	2,8	3,0		
	N11-FA- 3-120-23-VM3	120	2,0	3,0	1,6	7,0	2,8	3,0		
	N11-FA- 6-120-11-VM3	120	2,0	6,0	2,0	11,0	3,5	3,0		
	N11-FA- 6-120-11-VM3	120	2,0	6,0	2,0	11,0	3,5	3,0		
	N11-FA- 1-120-11-P4-VM3-A	120	2,0	1,0	1,0	3,4	1,3	3,0	A = Base-Trim	
	N11-FA- 1-120-23-P4-VM3-A	120	2,0	1,0	1,0	3,4	1,3	3,0		

Installation instructions by Showa

In order to obtain the best possible results from a strain gauge installation it is important that care and attention is given to the preparation of the gauge, the surface of the specimen, and bonding techniques.
Whilst circumstances may call for variations in technique for particular installations, the following instructions based on extensive experience, should ensure the complete success of the bonding of Showa foil strain gauges. In applications where it is considered there may be special problems, we will be pleased to give any advice and assistance we can.

1. Specimen Surface Preparation.
An area larger than the installation shou1d be cleared of all paint, rust etc., and finally smoothed with a fine grade emery paper or fine sand blasting to provide a sound bonding surface. The area should now be degreased with a solvent such as trichlorethylene and finally neutralised with a weak detergent solution. One should use tissue for this operation, wetting the surface and wiping off with clean tissues until the final tissue used is stain free. Care must be taken not to wipe grease from a surrounding area onto the prepared area or to touch the surface with the fingers.
This final cleaning should take place immediately prior to installing the strain gauges.

2. Strain Gauge Preparation.
Normally the gauge is ready for applying as soon as it is removed from the packet but, experience shows that some engineers prefer to roughen the back off the gauge before applying it. Extreme care should be taken and the area under the tags should be avoided. One method is to sprinkle pumice powder onto a piece of blotting paper and with one finger tip lightly rub the back of the gauge over the powder. Remove all products of the abrasion and wipe back of gauge with a tissue.
Note: It is advisable not to mix the adhesive until all the gauges to be installed have been prepared to this stage.

3. Strain Gauge Installation.
By sticking a short length of sellotape lengthways along the upper face of the gauge it may be picked up from a flat clean surface. Holding both ends of the tape, orientate the gauge in the desired location and stick the end of the tape furthermost from the tags, to the specimen. Bend the other end of the tape back on itself thereby exposing the back of the gauge.

Adhesives
Three basic types of adhesives are recommended: (1) Epoxy resin, (2) Phenol-Epoxy resin and (3) pressure sensitive (Cyanoacrylate series) adhesive.

The single component pressure sensitive adhesive is recommended where fast bond and thin glue are optimum requirements as this adhesive reacts immediately upon water contained in the atmospheric air.

For an installation where long term stability under adverse atmospheric conditions is the main requirement one should use Epoxy or Phenol-Epoxy system. F3 cement is simple to use and may be cured at ambient room temperature, whilst F1 cement has excellent heat resistance quality. PR7781(E110) is most suitable for use with MA Series (Polyimide backing) gauges for high temperature application.

i) Epoxy Adhesives F1 and F3.
Coat the exposed back of the gauge with adhesive and gently push the gauge down into position, at the same time wiping excessive adhesive to the two outside edges of the gauge. Stick the whole length of the sellotape to hold the gauge in position, cover the area with the piece of polyethylene provided and apply a light weight or clamp as required. Care should be taken that there is an even layer of adhesive and no air bubbles are left under the grid. The installation is now ready for curing. After curing remove the tape as per para. 4.

F1	10 parts resin : 2 parts hardener	2 hrs. at 100ºC
F3	10 parts resin : 6 parts hardener	24 hrs. at room temp.

Of this two pack adhesive, the base material (A) is inert, and this should be harmless when in contact with human tissue.

The hardener (B) is slightly toxic and can possibly be harmful if allowed in contact with human tissue.

Warning:
1. **Do not allow the mixed or unmixed materials to contact skin. Protective gloves should be worn. Should skin be inadvertently contaminated it must be washed off immediately and thoroughly, with soap or detergent and water.**
2. **If heat is applied to accelerate the cure time of the adhesive then adequate ventilation is necessary to avoid inhalation of resulting fumes.**

ii) Phenol-Epoxy Adhesive PR7781(E110).

The cement is spread by brush or by spatula on both the specimen surface and strain gauges and these must then be left in this condition and dried in a clean atmosphere for 1 to 3 hours in order to allow evaporation of solvents from the cement. If cement is applied by spraygun, the cement should be diluted before it is applied, by methyl-ethyl-keton until its solidity rate reaches to 20%. After drying, both the strain gauges and the specimen surface are contacted face to face and clamped and heated in an oven for 30 minutes at 140ºC to complete bonding.

iii) Pressure Sensitive Adhesive 4000(101).

Follow strain gauge installation instructions as above sticking one end of the tape down to the specimen completely up to the gauge. Drop a fillit of adhesive in the 'hinge' formed by the gauge and the specimen.

Starting at the fixed end with one finger push the gauge down at the same time pushing the adhesive along the gauge in a single wiping motion until the whole gauge is stuck down. Apply pressure with the finger over the whole length of the gauge for one minute. Extra attention may need to be given to the tag and lead wire area.

4. Removing the tape.
Remove the tape by slowly and very carefully pulling it back over itself starting at the end furthermost from the tags. Do not pull upwards.

5. Wiring.
Showa strain gauges are fitted with short leads and it is standard practice to wire these to small stick-on or self adhesive terminals placed adjacent to the gauges. These serve as a bridge-completion point and a change-over point to the heavier wire required for the run to measuring or recording instruments.
The lead out wires from the gauges are fragile, and should be handled with care. Preparatory tinning of the ends of the lead out wires, connecting cables and terminals is recommended. Be sure to remove all traces of flux or soldering paste with trichlorethylene.

6. Installation Protection.
Showa strain gauges are encapsulated and therefore are protected from dust and draughts, etc. This encapsulation serves to make any required form of protection all the more efficient. In choosing a protective coating one should study completely the environment in wich the installation is to function and the length of time the installation will be required to function in such environment. One should also pay special attention to the wiring especially if the installation is required to be immersed in water.
There are numerous forms of protection available and we will be pleased to advise you on your particular installation.

High Elongation (Yielding) Strain Gauges
Generally speaking the foregoing instructions apply also for the bonding of high elongation gauges but there are some specific aspects of the technique which should be followed.

a. F3 or 4000(101) cement is recommended, but in each case the layer of cement between the gauge and specimen surface must be as thin and uniform as possible.
b. It is desirable not to apply any coating material to the installation. Silicone rubber, however, may be thinly applied if necessary.
c. Lead-out wires should be raised and looped in order to keep them free from strains taking place in the test object.
d. Terminals should be used and an excessive amount of solder on the terminals should be avoided.

“P” Series Gauge ("pipe" Gauge)
This series is intended, for measurement, to be inserted into the test object. Care should be exercised for the handling and installation of this gauge especially when carrying the gauge into the hole prepared on the test object. Removal of air bubbles from the adhesive mixture is also very important in order to prevent any damages from taking place on the gauge or to attain the better measuring results.
Brief instructions:-

a. Prepare a hole of 2.3 mm dia. on the test object.
b. F1 or F3 cement is used for "P" Series gauge. Apply a well mixed adhesive eliminating any air bubbles to the internal surface of that hole. Insert the gauge gently into the hole.
c. After having applied adhesive to the hole and placed the gauge in position, the adhesive is left cured as per para. 3.i.
d. Wire the strain gauge leads to terminals placed adjacent to the hole. Care should be given to the fact that the leads, if covered with splashes of adhesive, are likely to be broken.

Measurements - What is strain gage measuring?

The strain gage is really a unique sensor with which one can easily measure a variation of physical amount in terms of the "length" in the level of 1/1,000,000. The strain gage was worked out for the first time by Simmons & Ruge in USA in 1938. In Japan, Showa Measuring Instruments Company started production in the form of foil based strain gages in 1962. It has accordingly elapsed around 45 years since this initiation of operation. These strain gages are utilized for the evaluation through analysis and measurement of stress and strain of various materials including metals, rubber, plastics, ceramics and so on which are not so widely familiar especially among ordinary non-technical persons. We believe the strain gage technique can be utilized as one of the simplest and handiest means for the solution of surrounding problems even in case when one does not have a professional knowledge on the measuring principle with strain gages.

Measurements by means of strain gages are in the world of 1/1,000,000

It is stated in the last paragraph that one can easily measure with strain a variation of physical amount in terms of the "length" in the level of 1/1,000,000. We can say it may be extremely difficult with an ordinary measuring system to measure the length of for example 100 meters in the exactitude of 0.1mm. In the measurement with strain gages, however, a resistance variation of ΔR in the formula of $\Delta L / L \ \alpha \ \Delta R / R$ can seize the world of 1/1,000,000 through the Wheatstone Bridge because the resistance wire in the length of "0.3 to 5mm"is receiving an external force in the strain gages.

Purpose of measurements by means of strain gages

Although the strain gage is usually detecting the local linear variation in ΔL, it may be a general practice to replace the amount of variation into the stress, external force, pressure and so on which are the physical amounts led from the above-mentioned amount of linear variation. In view of the fact that almost all strain gages being put on sale in the market are self-temperature compensated ones, it is expected to divert these strain gages into the use including the assessment of unknown linear expansion coefficients of a variety of materials.

Terminology and expressions worthy to know of in relation with strain gages

1. Definition of strain: $\varepsilon=\Delta L/L$, Gage Factor: $\Delta R/R=K*\varepsilon$
2. Expression of relations of perpendicular stress and strain: $\sigma=E*\varepsilon$
3. Expression of relations of shearing stress and shearing strain: $\tau=G*\gamma$
4. Calculation formula of perpendicular stress: $\sigma=P/A$
5. Calculation formula of bending stress: $\sigma=M/Z=6M/bh^2$ (Z : modulus of section)
6. Calculation formula of shearing stress by the torsional moment of the round bar : $\tau=T/Zp=$ (Zp: polar modulus of section)
   - Circular cross-section "Zp"): $\pi*d^3/16$
   - Hollow circular cross-section "Zp": $\pi*(d2^4-d1^4)/16*d2$)
7. Expression of relations of Young's modulus "E" and modulus of rigidity "G": $G=E/2(1+\nu)$
8. Strain Gage Factor "K": The product of strain and the quotient of change in strain gage resistance and unstrained resistance of strain gage.
9. Poisson's ratio "ν": The ratio of transverse contraction strain "εb" to longitudinal extension strain "ε" in the direction of stretching force.
10. Perpendicular stress "σ": Expression of the internal distribution of force per unit area, $\sigma = F/A$, it's called engineering stress or nominal stress.
11. Elastic limit / Yield point: Maximum stress in the linear region of stress-strain curve.

12. Young's modulus / Modulus of elasticity "E": The constant ratio of tensile stress "σ" to tensile strain "ε", within the elastic limit.
13. Modulus of rigidity / Modulus of trasverse elasticity "G": The constant ratio of shearing stress "τ" to shearing strain "γ", within the elastic limit.

Self-temperature compensated strain gages

When the resistance value of a strain gage, one of the resistance elements, has made a relative change per one degree C, this change can be expressed by the equation of $\Delta R/R=\alpha+K(\beta s-\beta g)$. Therefore, it might be concluded that any effects from the temperature change may be negated if an equation of $0=\alpha+K(\beta s-\beta g)$ can be brought into existence. In these circumstances, because of the fact that the resistance temperature coefficient "α" of the strain gage material of ADVANCE (Cu54, Ni45, Mn1) can be controlled through the thermal treatment applied to this material, it can finally come into a conclusion that one can produce a strain gage which is less in an "apparent strain" and which can match with the linear expansion factor of the materials to be measured. For your information, strain gages being generally on sale are principally self temperature compensated strain gages whose applicable materials are mild steel, stainless steel and aluminium.

- α : Temperature coefficient of strain gage resistance materials
- K : Gage Factor
- βs: Thermal expansion coefficient of specimen
- βg: Thermal expansion coefficient of strain gage resistance materials

Thermal Output Characteristics(Fig.1 / Sample strain gage : N11-MA-5-120-11)

Fig.1 Thermal Output Characteristics

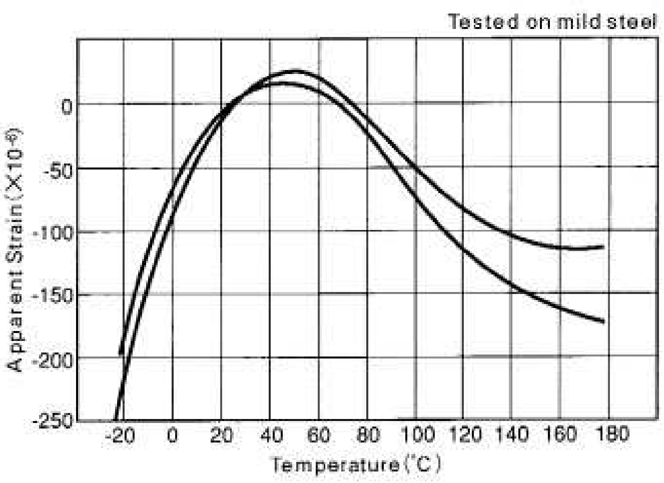


Fig.1 shows the traveling curve of an apparent output of Showa self temperature compensation strain gages caused by the temperature variation extending to these strain gages. There is a considerable variation in the distance between two curves appearing on the graph and this variation in the distance represents the dispersion of outputs of the strain gages. Showa strain gages are compensated to be within ±2ε strain per degree C in the dispersion of output strain curve without employing any dummy gages in the bridge but in the neighborhood of normal temperatures.

Gage Factor variation temperature(Fig.2 / Sample strain gage : N11-MA-5-120-11)

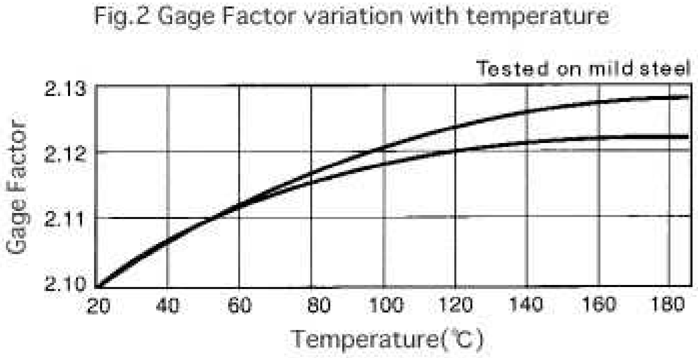
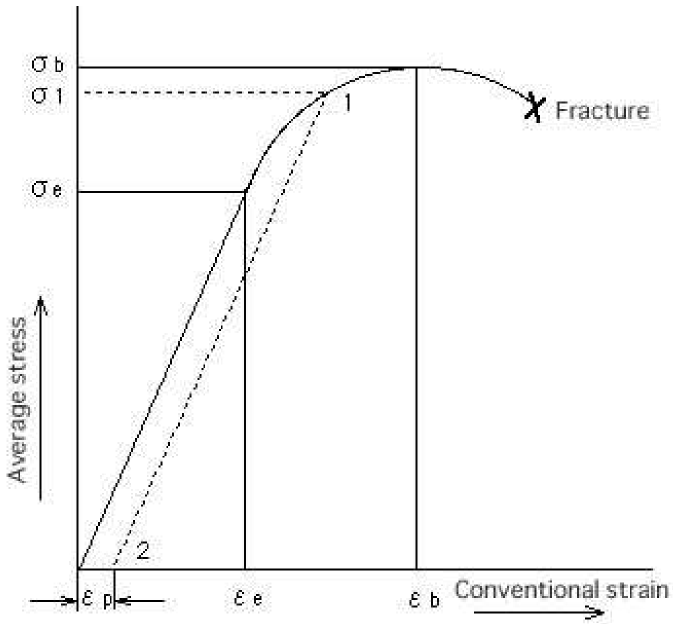


Fig.2 shows a curve representing strain gage sensitivity variation got when the strain gage is bonded on a mild steel specimen to which a constant strain of +1000μstrain at 20°C is applied and when changing the temperature applied to this strain gage.
Remarks: Movements of this curve include variations of the Young's modulus of "mild steel".

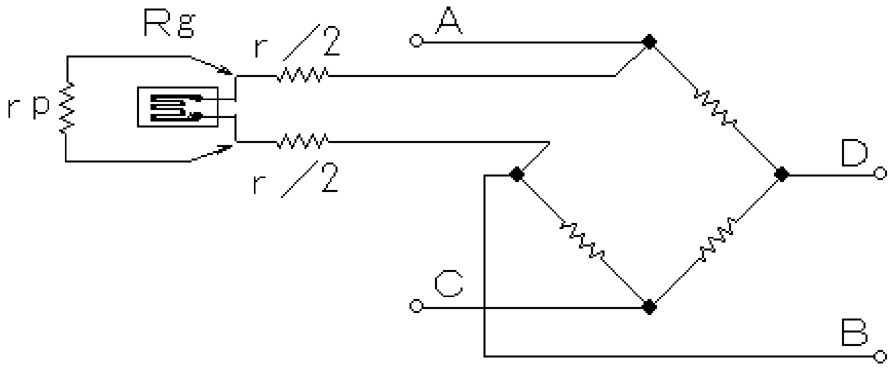
Stress-strain curves



σe: Elastic limit / Yield point
σb: Ultimate stress
*In the case of tensile stress, it's called "tensile strength".
εp: Permanent set
E : Young's modulus / Modulus of elasticity

Remarks:
Increased load newly in the state that a permanent set was left , and become a new yield point "σ1" with following curve "2~1", that is to say, A new yield point varies by doing plastic deformation and become a hard-brittle materials.

Simple method for generating equivalent strain by inserting a parallel resistor into one side of the strain gage bridge



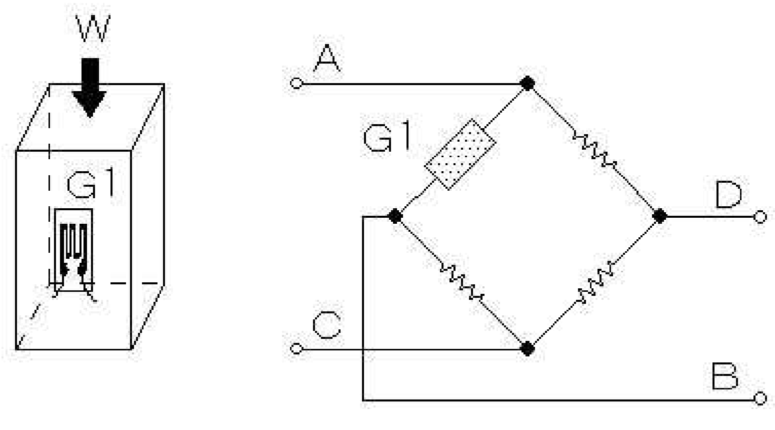
It should be noted that, in case when the length of lead wires of strain gages or that of the cable combining the bridge box with the amplifier is considerably longer than usual, say several 10 meters or longer, effects to be brought about by the sensitivity change due to resistance of longer lead wires may become extremely large that cannot be disregarded. In order to prevent these difficulties from taking place by generating a correct calibration value (an equivalent strain), a parallel resistor (rp) is inserted into one side of the strain gage bridge as shown in the figure given above. For your information, the relations of the gage resistance (Rg) with the calibrated strain (ε) and with the inserted resistor (rp) are shown in the following equations.

Rg/(rp+Rg)=K*ε
rp = Rg/(K*ε)

Example:
Resistance value to generate CAL-strain / 2,000*10-6 on Bridge resistance / Rg: 120Ω, Gage Factor / K: 2.00,
rp = 120/(2*2000^-6)=30(kΩ)

Therefore, it should be prepared for outside CAL resistance depending on the strain measurement range.

Calculation of tension and compression stress (1-Gage Method)



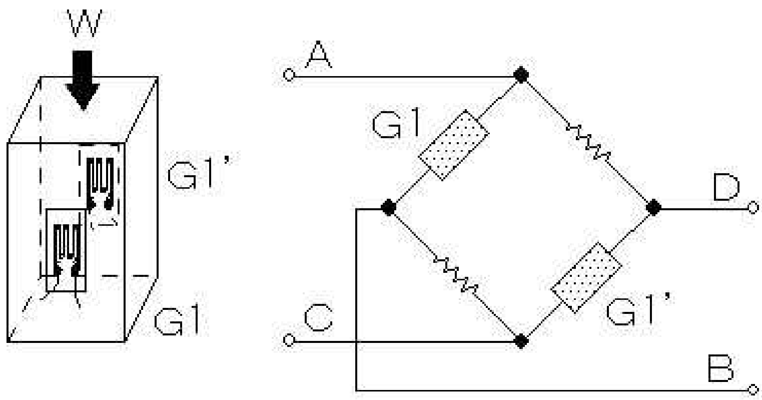
1-Gage Method for tension / compression stress measuring

Amounts of stress (σ) and force (W) to be got when one piece of strain gage is bonded, in parallel with the direction of force applied, on the surface of a column which is receiving a uniform force from one certain direction, as shown in the sketch given below, both surfaces are expressed by the following equations:

$\sigma=\varepsilon o*E$
where,
σ : Stress
E: Young's modulus / Modulus of elasticity
εo: Indicated strain

$W=A*\sigma=A*\varepsilon o*E$
where,
W: Force
A: Cross-section area of column

Calculation of tension and compression stress (2-Gage Method A)



2-Gage Method for tension / compression stress measuring

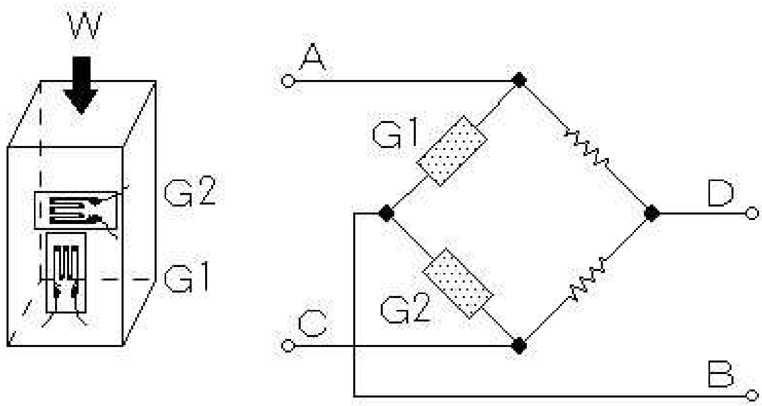
Amounts of stress (σ) and force (W) to be got when 2 pieces of strain gage are bonded on both surfaces of a column in right angle with the direction of force applied as shown in the sketch given below, are expressed by the following equations:

$\sigma=(1/2)*\varepsilon o*E$
$W=A*\sigma=A*(1/2)*\varepsilon o*E$

$W=A*\sigma=A*\varepsilon o*E$
where,
W: Force
A: Cross-section area of column

*Apparent strain by the bending is denied, and it is it with the double output made the average of the axis strain(ε).

Calculation of tension and compression stress (2-Gage Method B)



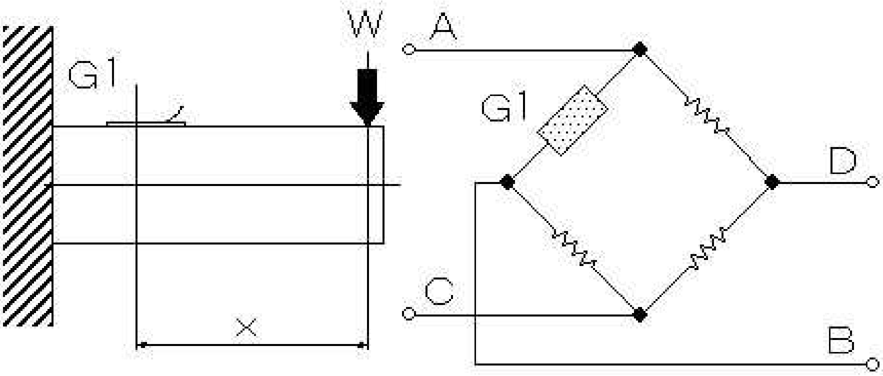
2-Gage Method for tension / compression stress measuring

Amounts of stress (σ) and force (W) that the column is suffering when 2 pieces of strain gage are bonded to the direction of forth and to the right angle to the force direction, and when connections are made through the bridge as shown in the sketch given below, are expressed by the following equations:

$\sigma=\varepsilon o*E/(1+\nu)$
where,
$W=A*\sigma=A*\varepsilon o*E/(1+\nu)$
ν: Poisson's ratio

*Indicated strain "εo" is output as ε1 and absolute value of ε2(=-νε1).

Calculation of bending stress (1-Gage Method)



1-Gage Method for bending stress measuring

An amount of surface stress (σ) in accordance with bonding positions of the strain gage when one piece of strain gage is bonded on the surface of a beam with a rectangular cross section whose one-side is being locked and the other side is being applied to a force, is expressed by the following equations:

$\sigma=\varepsilon o*E$
$M=W*X$

where,
X: Distance from the position "W" to the strain gage center.

The surface stress "σ" of the beam due to the moment "M" can be calculated using a next formula.

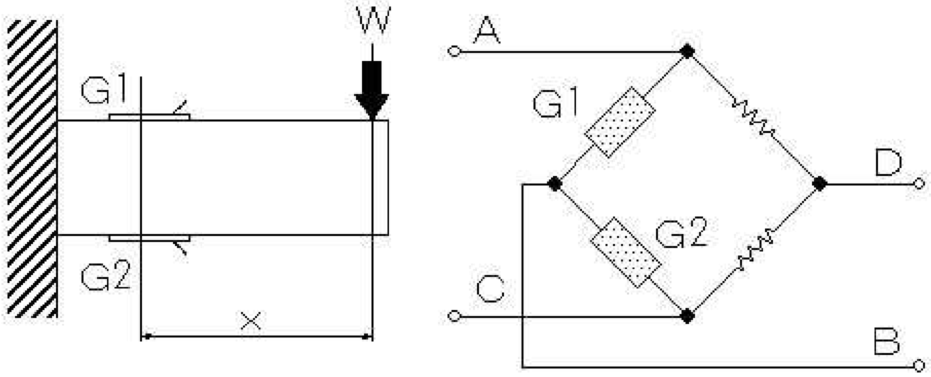
$\sigma=M/Z$
$M=Z*\varepsilon o*E$
where,
Z: Modulus of section

Modulus of section of rectangular section is calculated to

$Z=b*h^2/6$, therefore

$W=b*h^2*E*\varepsilon o/6*X$
where,
b: width of beam
h: height of beam

Calculation of bending stress (2-Gage Method)



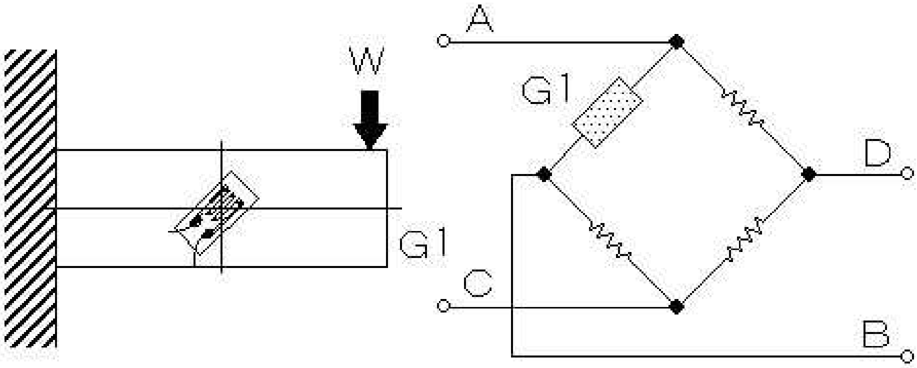
2-Gage Method for bending stress measuring

Two strain gages bonded at the contrasting positions of the front and rear surfaces of a beam are equal in their absolute values and the mark of (+) or (-) will come reverse. If the strain gages are bonded on a beam in such a manner that they may be neighboring ones each other, their bending strain will become double and the strains caused by the force to the axial direction may be negated.

In this case, calculated to:

$\sigma=\varepsilon o*E/2$

Calculation of shearing stress



1-Gage Method for shearing stress measuring

The formula for shearing stress "τ" in a beam is :

$\tau=F/S$
where,
F: Shearing force
S: Cross-section area of beam

In this case, the shearing force of becomes "F = W", and the shearing stress "τ" due to the cross-section area of the beam can be calculated using a next formula.

$\tau=W/b*h$
where,
b: width of beam
h: height of beam

And, relations of shearing stress "τ" and shearing strain "γ" is :

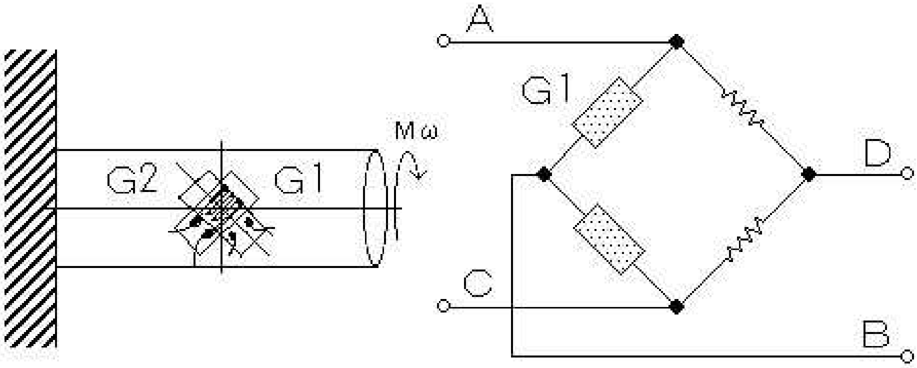
$\tau=G*\gamma$
where,
G: Modulus of rigidity, therefore

$\gamma=W/G*b*h$

Additionally, shearing stress "τ" and shearing force "W" can be calculated by strain "εo" of the 45 degrees direction because the shearing strain "γ" (rad) is equivalent to double of strain "εo".

$\gamma=2*\varepsilon o$
$\tau=2*G*\varepsilon o$
$W=2*G*b*h*\varepsilon o$

Calculation of torsional stress



2-Gage Method for torsional stress measuring

In the axle catching the torsional moment "Mω" like a figure, the shearing stress "τ" becomes greatest at the axis surface; the value is :

$\tau_{max}=M\omega/Zp$
where,
Zp: Polar modulus of section

The surface shearing strain "γ" is :

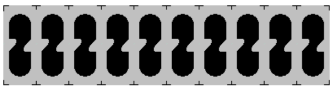
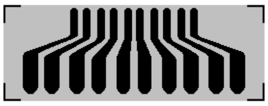
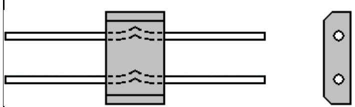
$\gamma=\tau_{max}/G=M\omega/G*Zp$

The indicated strain "εo'" becomes the value of the surface shearing strain "γ = 2*εo" when it's measured by 2-Gage Method, and the shearing stress "τ" be calculated using a next formula.

$\tau_{max}=G*\varepsilon o'$
$\varepsilon o'=\gamma=2*\varepsilon o$
$M\omega=G*Zp*\varepsilon o'$

Solder terminals

Patterns and specifications

Classifications	Appearances/Patterns	Type	Dimensions (mm)	Compatible gauge length (mm)	Number of pieces per packet	Remarks
Foil type		FG-5T	6x20x0.15	0.3 till 2	10	
		SFG-5T	6x20x1.0			Self-Adhesive type
		FG-7T	7x26x0.15	2 till 6	10	
		SFG-7T	7x26x1.0			Self-Adhesive type
		FG-10T	12x40x0.15	6 till 8	10	
		SFG-10T	12x40x1.0			Self-Adhesive type
		FG-15T	16x56x0.15	8 till 60	10	
		SFG-15T	16x56x1.0			Self-Adhesive type
		FGR-10T	10x25x0.15	2	10	
		SFGR-10T	10x25x1.0			Self-Adhesive type
		FGR-15T	15x38x0.15	5 till 8	10	
		SFGR-15T	15x38x1.0			Self-Adhesive type
		FGF-5T	15x40x0.15	0.3 till 2	10	
		SFGF-5T	15x40x1.0			Self-Adhesive type
Cubic type		CG-1	14x9x4	1 till 60	10	
		SCG-1	14x9x5			Self-Adhesive type

Explanations

The terminals are placed between strain gage lead and the heavier leads required for the run to measuring or recording instruments to protect strain gage leads from disconnections or inferior insulation which are likely to take place during strain gage installation and measurement.

Properties

* Small size
* Easy to solder because the Terminals are tinplated
* Very flexible Capable of bonding to flat, spherical or angled surfaces
* Soldering Heat Resistivity:102 to 2×102 seconds at 230°C
* Insulation:1×102 to 1×104MΩ
* Adhering Force:140 to 220kPa

Glue

Series	Type	Use	Thermal deformtion temperature (℃)	Hardening time	Mixing ratio by weigth (A : B)	Contents per set(g)	Pressure to be applied (kPa)
Epoxy	F1	For high temp use	130	2hrs at 100℃	100 : 20	100	50 till 150
	F3	For general use	80	24hrs at room temp	100 : 60	100	50 till 150
Phenol-Epoxy	PR7781	For high temp use	180	30min at 140℃	Single agent	50	500 till 1000
Cyanoacrylate	4000	For general use	70	30sek at room temp	Single agent	2g x 5	Finger pressure

Explanations

To obtain the best possible results from measurements, it is important that care and attention is given to the selection of the strain gages which may most meet the measuring purposes. At the same time, selection among two basic types of adhesive, Epoxy resin and pressure sensitive adhesive(Cyanoacrylate Series), is also as important as that for strain gages to the highest results in measurement.

Se also: Installation instructions by Showa on page 15.