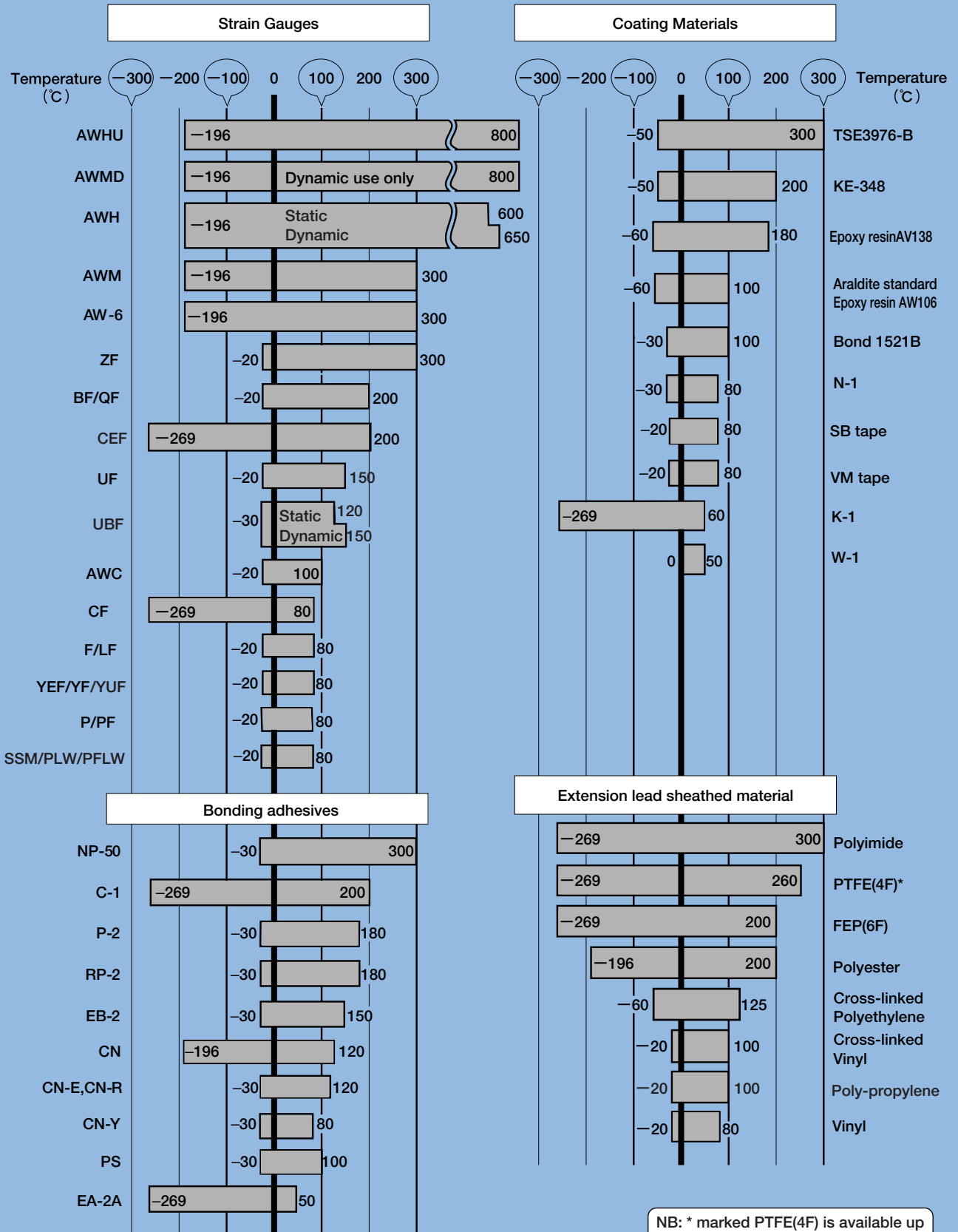


TML STRAIN GAUGES SELECTION

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

2. OPERATIONAL TEMPERATURES



TML STRAIN GAUGES SELECTION

3. Strain Gauge Characteristics

Gauge series	Applicable specimen	Applicable thermal expansion (ppm/°C)	Operational temperature (°C)		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-elasticity	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-elasticity	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, Poly- imide-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
	1×10 ⁶	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
	1×10 ⁶	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
	1×10 ⁶	This gauge includes temperature sensor to measure both strain and temperature simultaneously. The FLA-T identical to the F series has T thermocouple.	35
	1×10 ⁶	The operational temperature range of this general-purpose gauge series extends to 150°C. The gauges are temperature compensated for mild steel, stainless 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
	1×10 ⁶	The QF series have a polyimide carrier backing for excellent performance at high temperature of 200°C. 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
	1×10 ⁶	The ZF series have a polyimide carrier backing for excellent performance at high temperature of 300°C. 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
	1×10 ⁶	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
	◎1×10 ⁶	The CEF series have a polyimide-amide carrier backing for wide use in temperature range from cryogenic condition up to 200°C and configuration of single element.	42
	◎1×10 ⁶	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°C and in harsh environment for strain measurement.	44
	◎1×10 ⁶	The AWMd is a spot-weldable strain gauge withstand upto 800°C for only dynamic strain measurement. It has a standard high-pass filter with full bridge configuration to eliminate unexpected low frequency influence.	44
	◎1×10 ⁶	The AWH is a spot-weldable strain gauge withstand upto 600°C for static measurement or upto 650°C for dynamic measurement. The backing material is available in Inconel 600 or SUS321 which should be selected according to the test specimen.	45
	◎1×10 ⁶	The AWHU is a spot-weldable strain gauge withstand upto 800°C 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
	◎1×10 ⁶	The AW-6 with quarter bridge with 3-wire system is suited for strain measurement in high temperature upto 300°C for measurement of specimen to which adhesive is not applicable or for long term measurement.	46
	◎1×10 ⁶	The AWC-8B is fully encapsulated in a stainless steel tube with quarter bridge with 3-wire system. It enables a long term strain measurement in harsh environment.	46
	◎1×10 ⁵	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
	1×10 ⁶	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
	◎1×10 ⁵	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 moistureproofing 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 waterproofing. 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°C), while operating temperature is available during -20 to +60°C.	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
	1×10 ⁶	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/°C.	53
	1×10 ⁶	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
	1×10 ⁶	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/°C.	54
	◎1×10 ⁶	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
	1×10 ⁶	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 electromagnetic effects.	55
	YUF/YF : **** YEF: 5×10 ⁵	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. ±1500×10 ⁻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
	◎1×10 ⁵	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
	1×10 ⁶	The SF is a foil strain gauge with a polyimide backing and measures stress in the optional direction in a plane stress field. It detects stress in the gauge axial direction regarding the shearing strain.	60
	1×10 ⁶	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