Wydział Elektryczny,
Katedra Maszyn, Napędów i Pomiarów Elektrycznych
Laboratorium Przetwarzania i Analizy Sygnałów Elektrycznych
(bud A5, sala 310)

Instrukcja dla studentów kierunku Automatyka i Robotyka do zajęć laboratoryjnych

Pomiary przemysłowe

Ćwiczenie 7 (seria II)

Badanie wpływu temperatury na czujniki tensometryczne

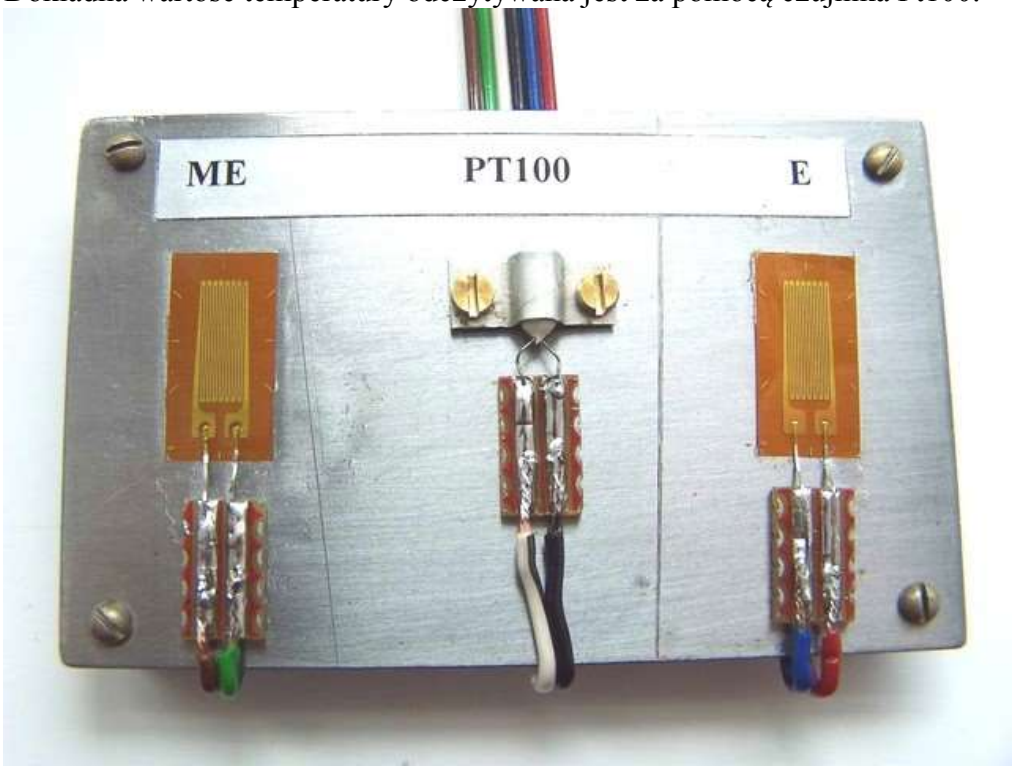
Program ćwiczenia

1. Wyznaczyć charakterystyki temperaturowe dla dwóch tensometrów umieszczonych w termostacie
   a) tensometr drutowy typ RL Ro~122 Ω, baza pomiarowa – 10mm, czułość 2.18,
   b) tensometr foliowy typ LY-11-10/120 Ro~120 Ω, baza pomiarowa – 10mm, czułość 2.07

   Temperaturę mierzyć czujnikiem Pt100 umieszczonym na płytce
2. Sporządzić wykresy $\Delta R/R_o = f(T)$.
3. Wyznaczyć współczynniki temperaturowe dla tensometrów $\alpha = \frac{\Delta R}{R\,\Delta T}$ i porównać z pracą czujników tensometrycznych w ćwiczeniu z serii I.

Badanie temperaturowe tensometrów

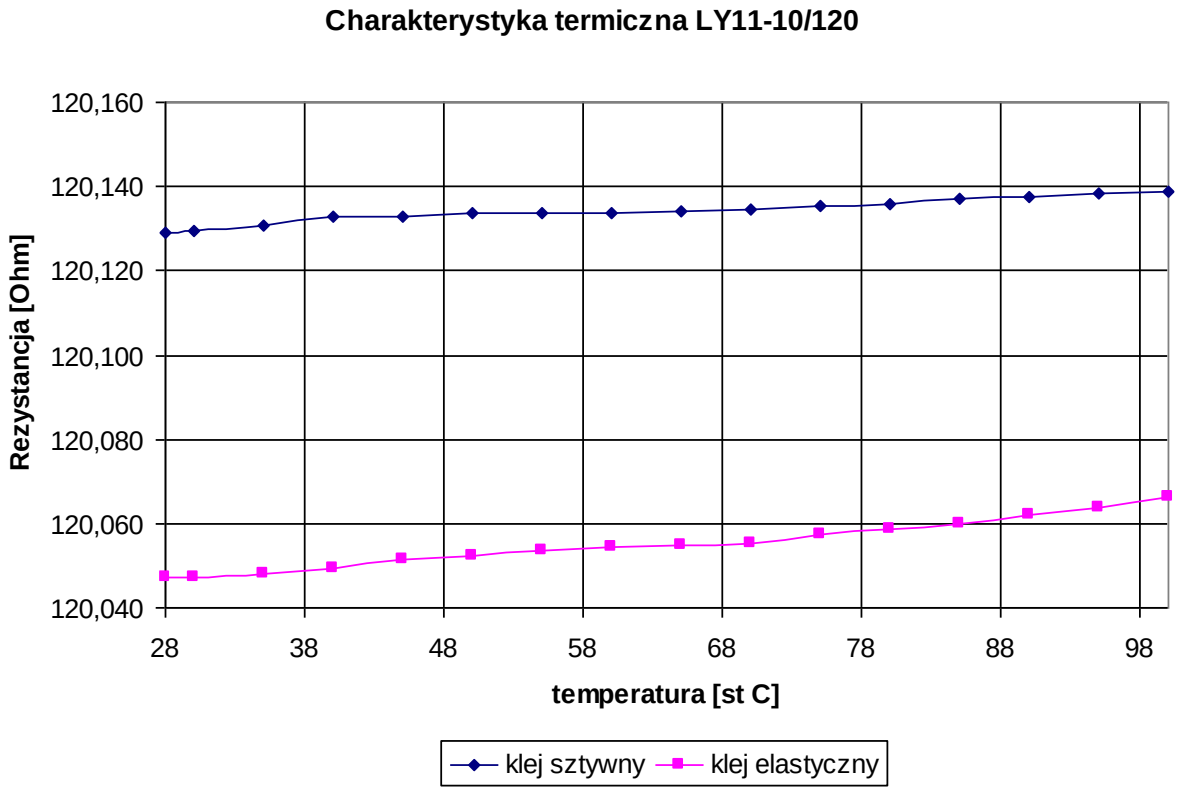
Na element o wymiarach 8x5 cm wykonany z tej samej stali co belka naklejono dwa tensometry **LY-11-10/120** oraz utwierdzono czujnik Pt100. Jeden tensometr naklejono klejem Cyjanopan ME do połączeń sztywnych natomiast drugi klejem Cyjanopan E do połączeń elastycznych. Cały element badany umieszcza się w piecu, w którym bada się wpływ temperatury na zmianę rezystancji obu tensometrów przy narastaniu temperatury. Dokładna wartość temperatury odczytywana jest za pomocą czujnika Pt100.



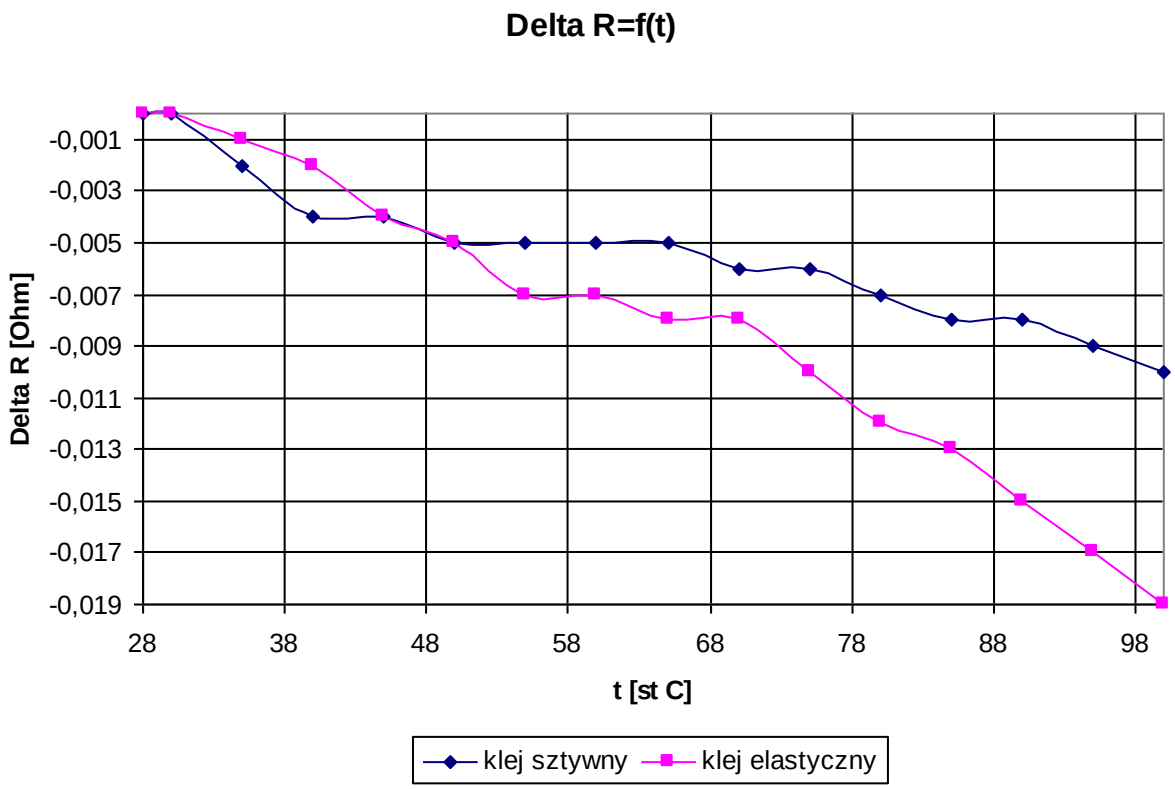
Rys. 1 Stanowisko do wyznaczania charakterystyk temperaturowych

Lp	PT100	temperatura	tensometr foliowy	ΔR	ΔR/Ro	tensometr drutowy	ΔR	ΔR/Ro
	Ω	ºC	Ω	Ω		Ω	Ω	
1	110,950	28	120,129			120,047	0,000	
2	111,670	30						
3	113,610	35						
4	115,540	40						

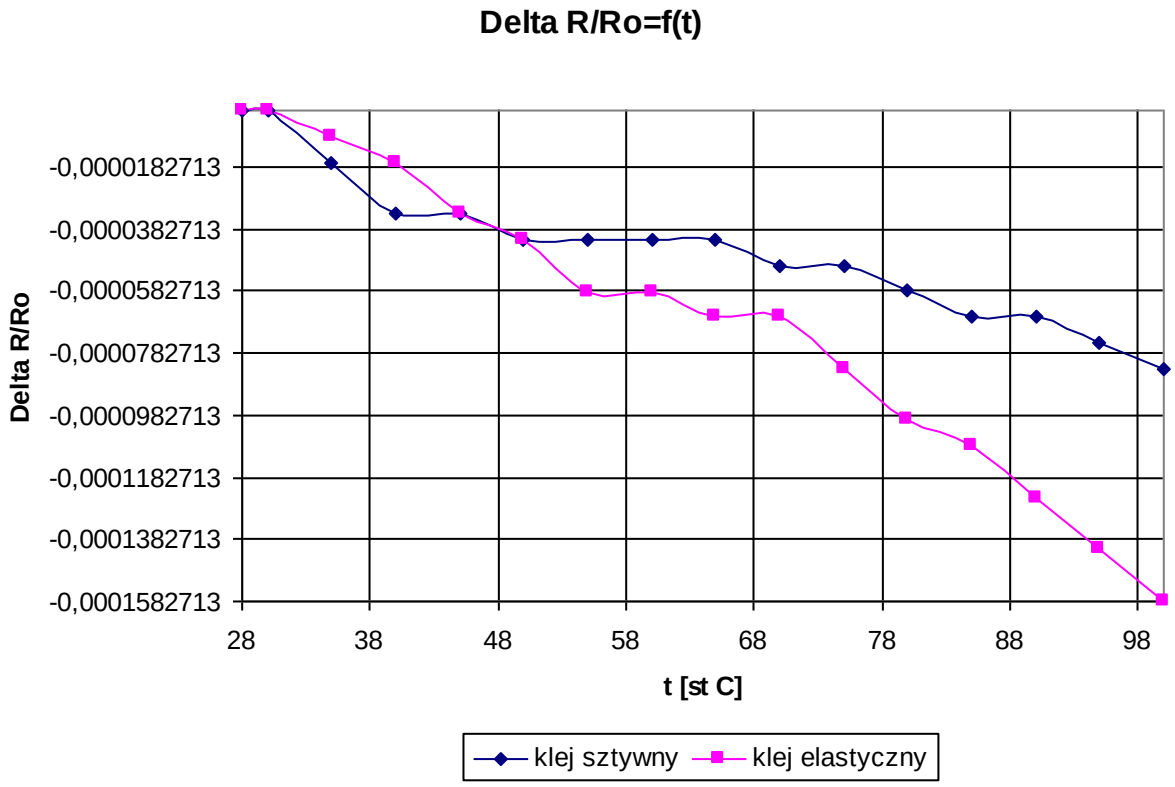
5	117,470	45						
6	119,400	50						
7	121,320	55						
8	123,240	60						
9	125,160	65						
10	127,080	70						
11	128,990	75						
12	130,900	80						
13	132,800	85						
14	134,710	90						
15	136,610	95						
16	138,510	100	120,139	-0,010	-0,0000832438	120,066	-0,019	-0,0001582713



Rys. 2 Charakterystyka R=f(t) badanego tensometru



Rys. 3 Charakterystyka ΔR=f(t) badanego tensometru



Rys. 4 Charakterystyka $\Delta R/R_0=f(t)$ badanego tensometru

LITERATURA

[1] E. Romer – Miernictwo przemysłowe, PWN, Warszawa 1972.

[2] W. Styburski – Przetworniki tensometryczne, WNT, Warszawa 1976.

[3] K. Hoffmann – Ann Introduction to Measurements using Strain Ganges, HBM GmbH 1989

[4] W. Orłowski, L. Słowiański – Wytrzymałość materiałów, przykłady obliczeń, „Arkady", Warszawa 1978.

Dokumentacja techniczna – strony internetowe firm

Vibrometer,

CARBOAUTOMATYKA S.A,

Avery Berkel,

Hottinger-Baldwin Messtechnik. (www.hbm.com)

Cardinal,

Elmaks,

Alitech, (www.alitech.com.pl)

Althen,

CAS,

Tecsis,

[5] Polska Norma PN-59/M-53852

Tabela oporności czujników Pt100

(fragment Polskiej Normy PN-59/M-53852)

°C	0	1	2	3	4	5	6	7	8	9	°C
10.00	103.90	104.29	104.68	105.07	105.46	105.85	106.24	106.63	107.02	107.40	10.00
20.00	107.79	108.18	108.57	108.96	109.35	109.73	110.12	110.51	110.90	111.29	20.00
30.00	111.67	112.06	112.45	112.83	113.22	113.61	114.00	114.38	114.77	115.15	30.00
40.00	115.54	115.93	116.31	116.70	117.08	117.47	117.86	118.24	118.63	119.01	40.00
50.00	119.40	119.78	120.17	120.55	120.94	121.32	121.71	122.09	122.47	122.86	50.00
60.00	123.24	123.63	124.01	124.39	124.78	125.16	125.54	125.93	126.31	126.69	60.00
70.00	127.08	127.46	127.84	128.22	128.61	128.99	129.37	129.75	130.13	130.52	70.00
80.00	130.90	131.28	131.66	132.04	132.42	132.80	133.18	133.57	133.95	134.33	80.00
90.00	134.71	135.09	135.47	135.85	136.23	136.61	136.99	137.37	137.75	138.13	90.00
100.00	138.51	138.88	139.26	139.64	140.02	140.40	140.78	141.16	141.54	141.91	100.00

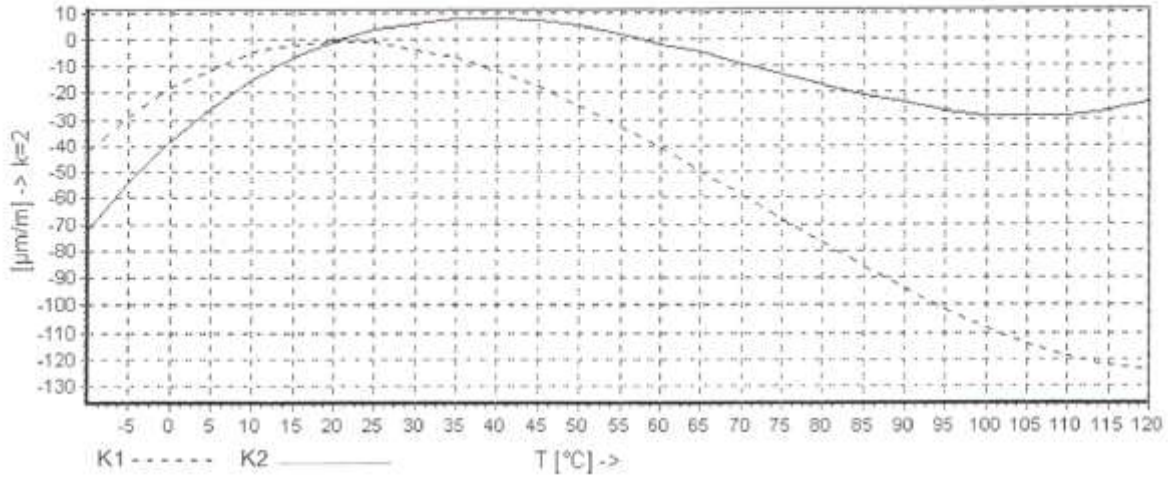
Dehnungsmeßstreifen
Strain Gauges
Jauges d'extensometrie

Bestellnummer Order No. No. de référence			**1-LY11-10/120**
Typ Type Type			10/120LY11
Widerstand Resistance Resistance	120 Ω	± 0.35 %	
Stückzahl Contents Quantité			10
k-Faktor Gauge factor Facteur k	2.07	± 1 %	
Temperaturkoeffizient des k-Faktors Temperature coefficient of gauge factor Coefficient de température du facteur k			104 ±10 [10^{-6} / °C] (-10...+45°C)
Querempfindlichkeit Transverse Sensitivity Sensibilité transverse	-0.3 %		
Folienlos Lot Lot de la feuille			A377/13
Herstellungslos Batch Lot de fabrication			812020181

Temperaturkompensation: Angepaßt für
Temperature Compensation: Compensated for
Compensation de température: Compensation pour

Ferritischen Stahl mit
Steel with
Acier avec

α = 10.8 [10^{-6} / °C]



$$\varepsilon_S(T) = -18.5 + 1.79 * T - 5.02 * 10^{-2} * T^2 + 2.33 * 10^{-4} * T^3 + 0.0333 * L * (T-20)\ \mu m/m \pm 0.3\ (\mu m/m)\ ^{\circ}C^{-1}$$

Alle technischen Daten nach OIML IR 62, bei Beachtung der abweichenden Toleranzangaben auch nach VDI/VDE 2635. Geben Sie bei Rückfragen bitte DMS-Typ und Herstellungs-Los an.

All technical data in accordance with OIML IR 62, also compliant with C VDI/VDE 2635 if deviating tolerances are observed. In case of further inquiries please indicate gauge type and batch number.

Toutes caractéristiques techniques selon OIML IR 62 et VDI/VDE 2635 pour les indications différentes de tolérance. Pour toutes questions, indiquer le type de la jauge ainsi que le lot de fabrication.

Temperaturgang der Dehnungsmeßstreifen bei Applikationen mit umseitig angegebenen Wärmeausdehnungskoeffizienten α. Gemessen bei kontinuierlicher Temperaturänderung.

Kennlinie 1: DMS ohne Anschlußbändchen

Kennlinie 2: DMS mit Anschlußbändchen (30mm einfache Bändchenlänge). Bei gekürzten Bändchen liegt der Temperaturgang zwischen Kennlinie 1 und 2. Die numerische Darstellung erlaubt den Temperaturgang für jede Bändchenlänge exakt zu errechnen.
T = Temperatur in °C L = einfache Bändchenlänge in mm

Comportement en température des jauges d'extensométrie appliquées sur des matériaux dont les coefficients de dilatation termique α sont indiqués au verso. Mesuré au d'une variation continue de la température.

Courbe 1: Jauges sans fils de sorbe

Coube 2: Jauges avec fils de sorbe (longuer unitaire du fil de 30 mm). Lorsque les fils sont plus courts, le comportement en température se trouvera entre les deux courbes 1 et 2. Le dernier terme de l'équation détermine avec exactitude l'influence des fils de sorbe.
T = température en °C L = longueur unitaire des fils en mm

The **Thermal output** refers to strain gauges when bonded to materials with coefficient of thermal expansion α given overleaf. Values are measured at a continous temperature progression.

Curve 1: Gauges without connecting leads

Curve2: Gauges with connecting leads (simple lead length of 30mm). If the leads are shorter, then the thermal output lies between curve 1 and 2. The numeric approximation allows the calculation of the thermal output for any lead length.
T = temperature in °C L = simple lead length in mm

Technical Data

strain gage construction		foil strain gage complete with embedded measuring grid
measuring grid		
material		Constantan foil
thickness	µm	3.8 or 5, depending on strain gage type
carrier		
material		polyimide
base thickness	µm	45 ± 10
cover thickness	µm	25 ± 5
connections		nickel plated Cu leads, approx. 30mm in length, integrated solder tabs, approx. 1.5mm in length, approx. 1.6 ... 2.2mm wide
for strain gages without leads		
nominal resistance	Ω	120, 350, 700, or 1000, depending on strain gage type
resistance tolerance	%	± 0.3 without; ± 0.35 with leads[1]
except for KY types, per chain	%	± 0.5
gage factor		approx. 2
nominal factor of gage factors		specified on each package
gage factor tolerance for 0.6mm and 1.5mm measuring grid length	%	± 1.5
for ≧ 3 mm measuring grid length	%	± 1
temperature coefficient of the gage factor	1/K	ca. (115 ± 10) · 10^{-6}
nominal value of temperature coefficient of gage factor		specified on each package
reference temperature	°C	23
operation temperature range		
for static, i.e. zero point related measurements	°C	- 70 ... + 200
for dynamic, i.e. not zero point related measurements	°C	-200 ... + 200
transverse sensitivity		
within reference temperature range using adhesive Z 70	%	- 0.1
on strain gage type LY 11-6/120		
temperature variation		specified on each package
temperature variation acc. to selection, adjusted to thermal expansion coefficient α		
α for ferritic steel	1/K	10.8 · 10^{-6}
α for aluminium	1/K	23 · 10^{-6}
α for plastic material	1/K	65 · 10^{-6}
α for austenitic steel	1/K	16 · 10^{-6}
α for titanium/ grey steel	1/K	9 · 10^{-6}
α for molybdenum	1/K	5.4 · 10^{-6}
α for quartz	1/K	0.5 · 10^{-6}
temperature variation tolerance	1/K	± 0.3 · 10^{-6}
adjustment of temperature variation within range	°C	-10 ... + 120
mechanical hysteresis[1]		
at reference temperature and strain ε = ± 1000 µm/m		
strain gage type LY 11-6/120		
at 1st load cycle and adhesive Z 70	µm/m	1
at 3rd load cycle and adhesive Z 70	µm/m	0.5
at 1st load cycle and adhesive X 60	µm/m	2.5
at 3rd load cycle and adhesive X 60	µm/m	1
at 1st load cycle and adhesive EP 250	µm/m	1
at 3rd load cycle and adhesive EP 250	µm/m	1
maximum elongation[1]		
at reference temperature using adhesive Z 70 on		
strain gage type LY 11-6/120		
strain limit ε for positive direction	µm/m	50 000 (≙ 5 %)
strain limit ε for negative direction	µm/m	50 000 (≙ 5 %)
fatigue life[1]		
at reference temperature using adhesive X 60 on		
strain gage type LY 11-6/120		
stress cycle value L_n at		
alternating strain ε_w = ± 1000 µm/m and zero point drift $\varepsilon_w \Delta \leq 300$ µm/m		>> 10^7 (test was interrupted at 10^7)
$\varepsilon_w \Delta \leq 30$ µm/m		> 10^7 (test was interrupted at 10^7)
minimum radius of curvature, longitudinal and transverse, at reference temperature		
for strain gages c/w leads	mm	0.3
for strain gages c/w integrated leads		
within the measuring grid area	mm	0.3
within the area of the solder tabs	mm	2
usable bonding materials		
cold curing adhesives		Z 70; X 60; X 280
hot curing adhesives		EP 250; EP 310

[1] The data depend on the various parameters of the specific application and are therefore stated for representative examples only.