

## Experimental Testing for Aerospace Structures

Laboratory Activity n° 1 — October 24<sup>th</sup> – 28<sup>th</sup>, 2022

Name

Surname

Consider the cantilever beam loaded with a calibrated weight at its free end and equipped with four strain gauges. These are distributed along the beam span both on the upper and lower surfaces, see Fig. 1. The test setup also includes one strain measuring system (properties reported in Fig. 2 and Tab. 1), a digital multi-meter, a thermocouple (to check both the resistance and the operational temperature of the strain gauges), a calibration weight (nameplate accuracy is 1%), a vernier scale, a ruler, and connecting cables. By using the so called “zero” and “deflection” methods, estimate:

- The strain distribution over the beam span. Also assess the elastic “linear” behavior hypothesis
- The Young modulus of the material of the test article and its comparison with properties available in literature

For this purpose:

- evaluate the strain gauge resistances
- evaluate the thermal compensation induced by the current configuration
- statistically characterize the recorded data
- evaluate the uncertainties associated to both the strain and the Young modulus estimates<sup>1</sup>

Write a report, saved in pdf format and named as “L1\_GX\_FAMILYNAME.pdf” detailing the performed analysis and discussing the achieved results.

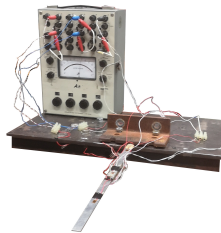


Figura 1: Test setup layout.

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<sup>1</sup>The total uncertainty of a derived variable  $R = f(x_1, x_2, \dots, x_n)$ , that is function of  $n$  direct measures,  $x_i$ ,  $i = 1, 2, \dots, n$ , can be achieved from the uncertainties of all the measures,  $\varepsilon_{x_i}$ , as

$$\varepsilon_R = \sqrt{\sum_{i=1}^n \left( \frac{\partial f}{\partial x_i} \varepsilon_{x_i} \right)^2}$$

# Typ3/120LY41

Stückzahl  
 Quantity  
 10 mit / with  ohne / without  Applikationshilfe  
 Application aid / Support d'aide à l'application

Widerstand / Resistance: 120.00 [Ω] ± 0.30 [%]  
 c-Faktor / Factor k: 1.99 ± 1 [%]

Querempfindlichkeit / Transverse Sensitivity: 0.2 [%]

Temperaturkompensation: Angepaßt für / Temperature Compensation: Compensated for:  $\alpha = 10.8 [10^{-6} / ^\circ\text{C}]$

Stahl / Steel  Aluminium  Sonstige / Other  Acier

Temperaturkoeffizient / Temperature coefficient of gauge factor: 104.0 ± 10 [10<sup>-6</sup> / °C]  
 Coefficient de température du facteur k: (-10. .... +45 °C)

Artikel Nr. / Part No.: 1-LY41-3/120  
 Follenlos / Lot: A261/06  
 Herstellungslos / Batch: EV3830800/1  
 Lot de fabrication

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 Herstellerangabe - Los an.

All technical data in accordance with OIML IR 62, also compliant with 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.

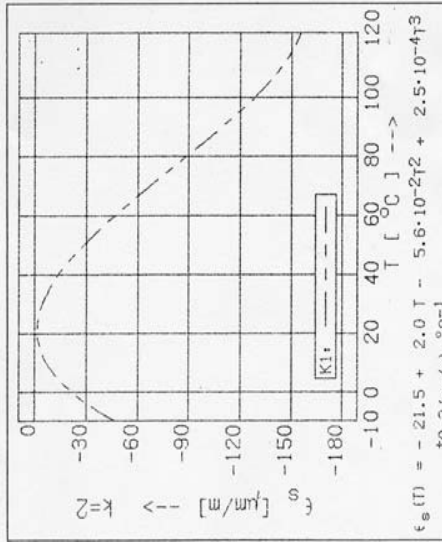


Fig. 2: Strain gauge characteristics

Measuring range	50 000 $\mu\text{s}$ in four dial direct digital display
Compensation bridge	100000 $\mu\text{s}$
Accuracy	0.05% of measured value $\pm 0.5 \mu\text{s}$ (120 $\Omega$ bridge, gauge factor 2.00, zero method of measurement)
Linearity	0.01% of full range $\pm 0.5 \mu\text{s}$
Repeatability	$\pm 0.2 \mu\text{s}$
Stability	0.025 $\mu\text{s}/^\circ\text{C}$ (zero method); 0.125% / °C (deflection method). Temperature range 0 - 40°C, full bridge at the input
Input	Five independent input circuits, switch selected. Each input can be used for full, half or 120 $\Omega$ quarter bridge circuits. Quarter bridge 120 $\Omega$ also in three-wire system. Input channel one has extra R and C balance controls.
R-C balancing	R $\pm 500 \mu\text{s}$ C $\pm 1000 \text{ pF}$
Gauge Resistance	50- 1000 $\Omega$
Gauge Factor	Calibrated from 1.75 to 2.25 in increments of 0.05. Continuously variable 1-10
Bridge Voltage	1.25 and 2.5 V (r.m.s.) Sinewave 1000 Hz
Lead wire capacitance	Typically less than 1 $\mu\text{s}$ additional error for 10 000 pF on one arm of 120 $\Omega$ bridge
Null-indicator sensitivity	$\pm 50, \pm 200, \pm 500, \pm 2000, \pm 5000 \mu\text{s}$ sensitivity f.s.d. Accuracy $\pm 1\%$
Output (for recorder or oscilloscope)	a) $\pm 100 \text{ mV}$ DC or peak AC at full scale deflection of null indicator. Remains linear up to 1 Volt (within 2%). Output load $> 100\Omega$ . Carrierfrequency suppression is approx. 45 db. b) Modulated carrier output 125 mV load $> 10\text{k}\Omega$
Frequency range for dynamic strain	0 - 100 Hz within 1%. 0 - 200 Hz - 3 dB
Operating temperatures	-10°C - + 60°C
Batteries	8 flash-light cells 1.5 V batteries like Berec LPU 2 Witte Kat LP 52
Battery life	approx. 40 hours
Dimensions	30(h) x 21.5 (w) x 13.5 (d) cm. 11 7/8 x 8 1/2 x 5 3/8 inches
Weight	7 kg. 15.4 lbs.

Tab. 1: Acquisition system characteristics