MANUFACTURE OF STRAIN GAUGES & TRANSDUCERS

- **We produce sensors fitted with semiconductor or metal strain gauges for measuring forces, mass, pressure, torque, acceleration.**

- **We supply semiconductor silicon strain gauges, which have the highest known efficiency of the transfer of mechanical quantities to electrical signal.**

- **When designing and manufacturing sensors and transducers, we apply experience well-proved in the aerospace industry.**

www.vtsz.cz

CONTENT OF CATALOG

Our company was established at the beginning of 1990 in order to ensure the flexible development of semiconductor strain gauges and their applications under new economic conditions. It associated experts who had developed manufacturing technology at the The Aeronautical Research and Test Institute in Prague as well as specialists who had run the production of gauges since its start at OPS, Zlín. This manufacture, established there in 1974 for the aerospace industry, had to be increased eightfold for other industries by 1978, and twentyfold by 1989 for export needs.

CONTACTS

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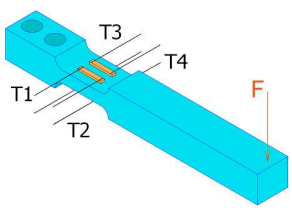
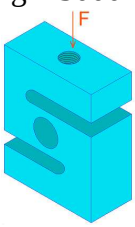
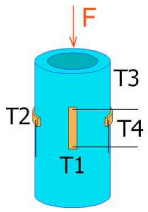
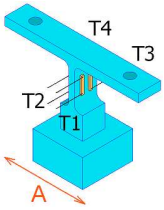
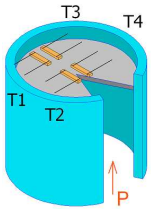
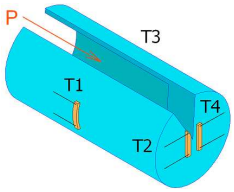
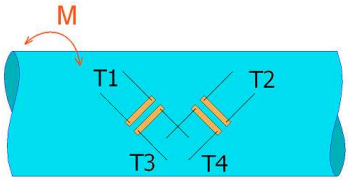
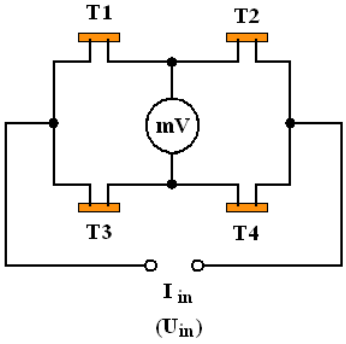
The function of a semiconductor strain gauge essentially consists in a very considerable and accurate change in its electrical resistance with applied mechanical strain. Senzors with these elements give to all mechanisms the ability to respond sensitively to mechanic impulses. They are usually used for force, mass, pressure, torque, acceleration and deformation electric measurements.

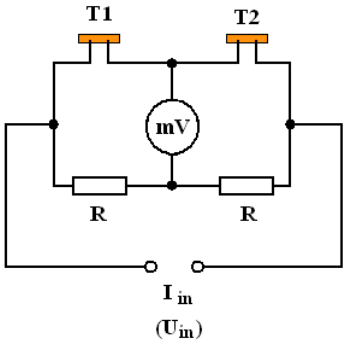
Basic principles:

<table>
<tr><th colspan="3">FORCE AND MASS</th><th>ACCELERATION</th></tr>
<tr><td>0.1 g – 200 kg</td><td>1 kg – 5000 kg</td><td>500 kg – 500 t</td><td>10^{-5} m/s^2 – 100 m/ s^2</td></tr>
<tr><td> 
</td><td> 
</td><td> 
</td><td> 
</td></tr>
<tr><th colspan="2">PRESSURE</th><th colspan="2">TORQUE</th></tr>
<tr><td>0.01 MPa – 5 MPa</td><td>5 Mpa – 100 MPa</td><td colspan="2">0.01 N.m – 100 N.m</td></tr>
<tr><td> 
</td><td> 
</td><td colspan="2"> 
</td></tr>
</table>

The most common use of strain gauges is for half-bridge or full-bridge, because during statical measurements it compensates the temperature effects. Measurement of electric resistance of one strain gauge can be used only there, where we don‘t need to compensate the temperature effects.



Full-bridge circuit



Half-bridge circuit

Technical merits of semiconductor as compared with wire and foil strain gauges:

- ✓ 60x higher strain sensitivity allowing measurement without amplifiers, with standard ohmmeters and voltmeters (input current 10mA , output voltage tens mV).
- ✓ 60x higher threshold sensitivity making possible measurement of strain in metals beginning with a value as low as a millionth of one millimetre per metre.
- ✓ Small width of strain gauges enabling the design of small and light sensors.
- ✓ Results of stress analysis of parts that can be subjected to controlled heating are absolutely reliable.
- ✓ Up to 300°C, monocrystalline silicon strain is without measurable hysteresis Strain gauges made of silicon and gold possess outstanding corrosion resistance.

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TRANSDUCERS

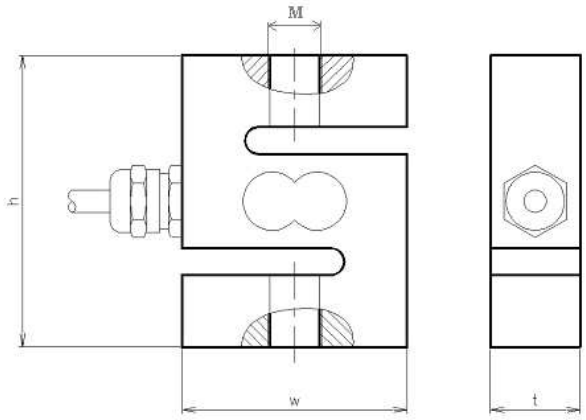
We produce sensors according to customer requirements.

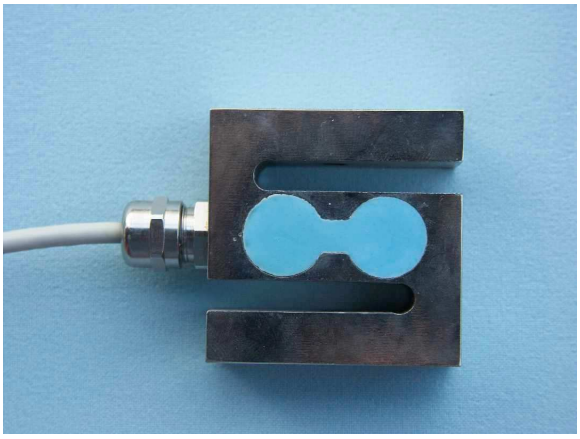
- **Our sensors are suitable for measuring forces, mass, pressure, torque, acceleration.**
- **Accuracy of sensors (non-linearity + hysteresis) with semiconductor strain gauges we guaranteed to ± 0.5% of the nominal range.**
- **Safe overload sensor is to 200% nominal range.**
- **We can use foil strain gauges from other company in sensors.**

Typical characteristics of our transducers:

	UNIT	VALUE
Input current	mA	10 – 30
Rated unloaded signal (the difference between output signal of 100% loaded and free sensor) at power Iin=10mA	mV	50 ± 0.2
Output signal of free sensor at power Iin=10mA	mV	0 ± 0.2
Output signal of loaded sensor at the nominal value at input current 10mA	mV	50 ± 0.2
Combining error (non-linearity + hysteresis) – in % of the nominal range sensor	%	< ±0.5
Safe overload	%	200
Long-term stability (in% of the nominal sensor range)	%	< ±0.1
Temperature coefficient of unloaded sensor signal	%/°C	< 0.01
Temperature coefficient of the output signal	%/°C	< 0.03
Operating temperature range	°C	-10 až +40
Life in terms of number of cycles of the nominal load		$> 10^7$

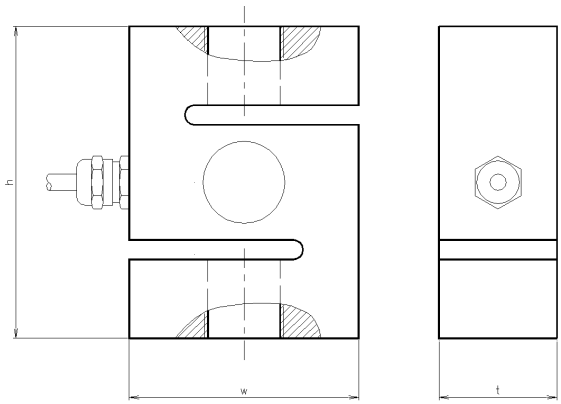
Sensors for measuring tensile forces and pressure – type „S“

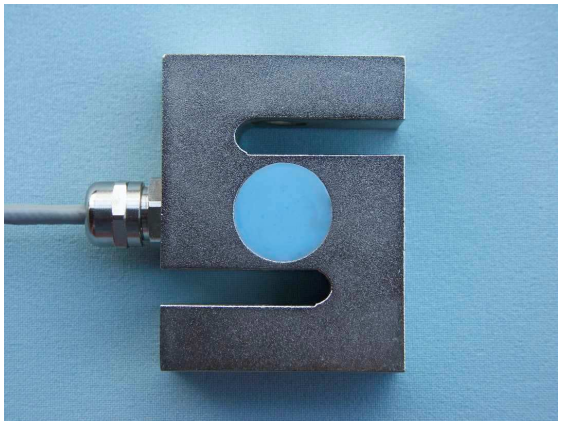




Type	Range [kg]	Height h [mm]	Weight w [mm]	Thickness t [mm]	Screw M [mm]
F025	0 - 10	50	50	20	5
F026	0 - 20	50	50	20	5
F027	0 - 50	50	50	20	8
F028	0 - 100	50	50	20	8
F029	0 - 250	65	50	20	12

*** All parameters can be consulted and adjusted according to customer requirements.**



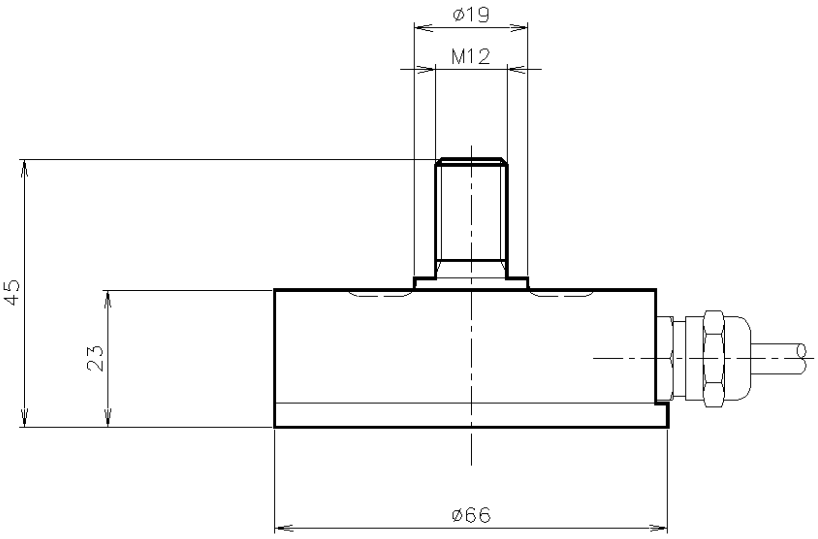


Type	Range [kg]	Height h [mm]	Weight w [mm]	Thickness t [mm]	Screw M [mm]
F030	0 - 500	65	50	20	12
F031	0 - 1000	65	50	20	12
F032	0 - 2500	95	70	36	24
F033	0 - 5000	95	70	36	24

*** All parameters can be consulted and adjusted according to customer requirements.**

* This type of sensor is suitable for measuring tensile forces and pressure.

Sensors for measuring tensile forces and pressure - membrane

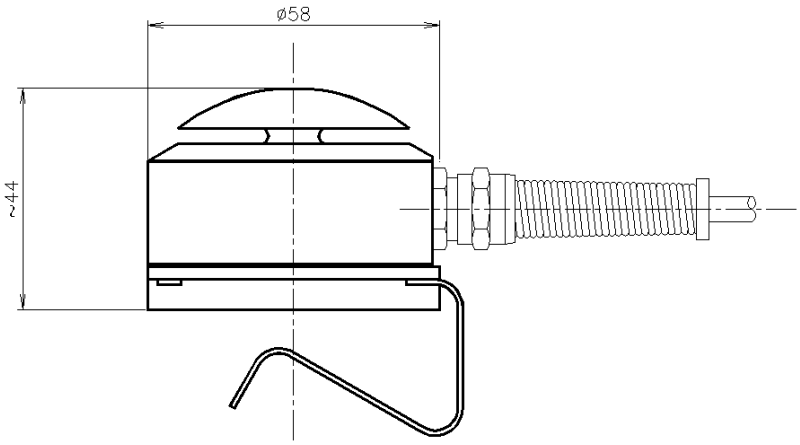


Sensor is provided with a screw also on the underside for measuring tensile force.

Type	Range [kg]	Note
F079	0 – 500	tensile + pressure
F088	0 – 1000	tensile + pressure
F123	0 – 2000	pressure

*** All parameters can be consulted and adjusted according to customer requirements.**

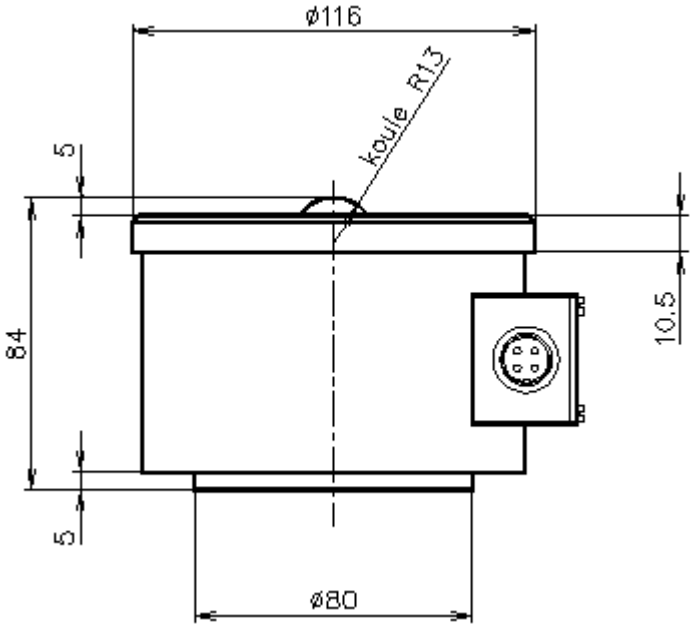
Sensors for small pressure



Type	Range [kg]	Connection
SRK1-V	0 – 100	bushing and cable
SRK1-K	0 – 100	connector

*** All parameters can be consulted and adjusted according to customer requirements.**

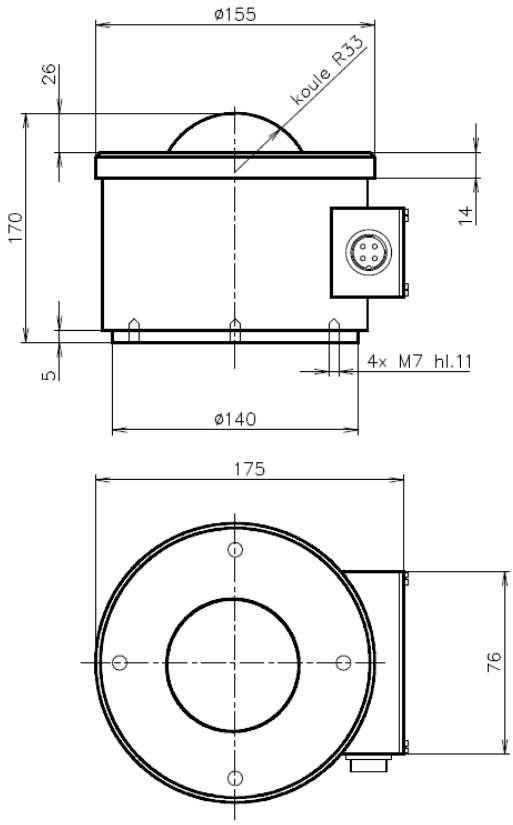
Robust sensors



Type	Range [kg]
SG16-5	0 – 500
SG16-10	0 – 1 000
SG16-20	0 – 2 000

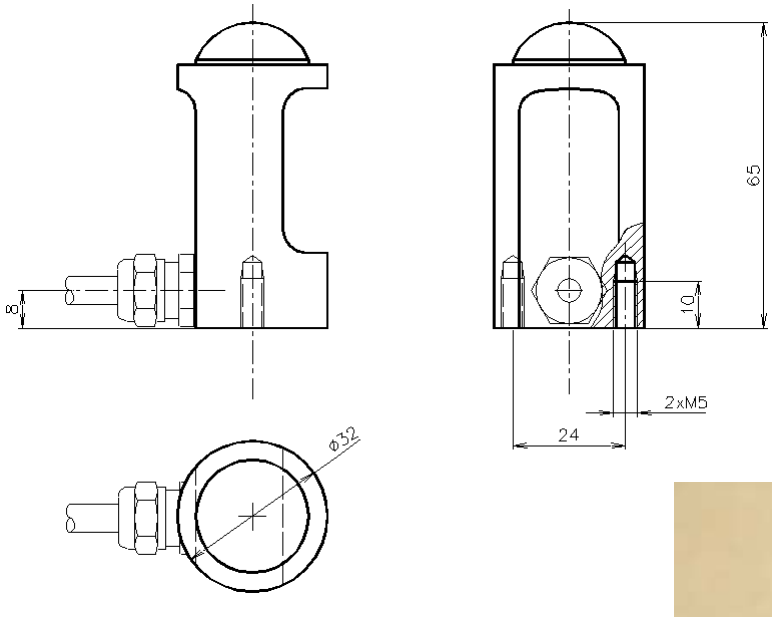
Type	Range [kg]
SG16-30	0 – 3 000
SG16-50	0 – 5 000
SG16-100	0 – 10 000

*** All parameters can be consulted and adjusted according to customer requirements.**



Type	Range [kg]
SG-20	0 – 20 000
SG-30	0 – 30 000
SG-40	0 – 40 000

Sensors for pressure - cylinder with a hemisphere

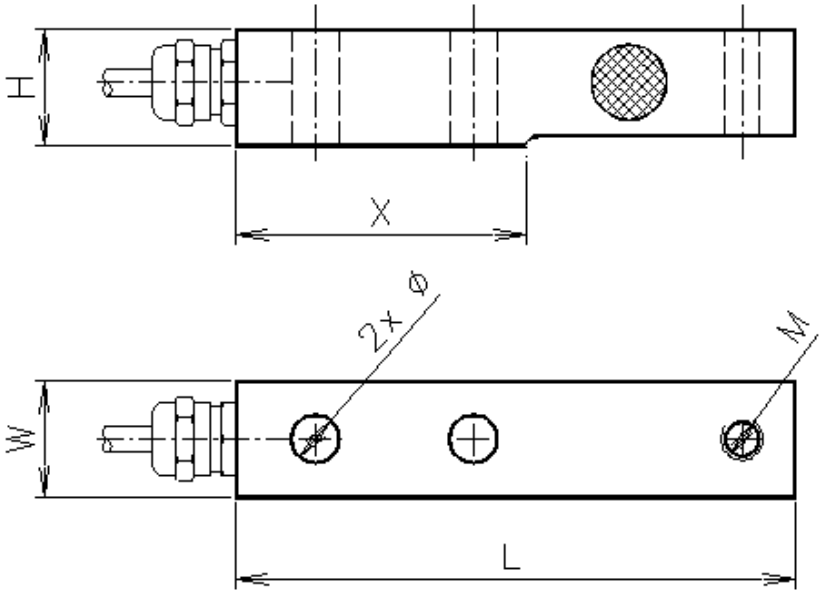


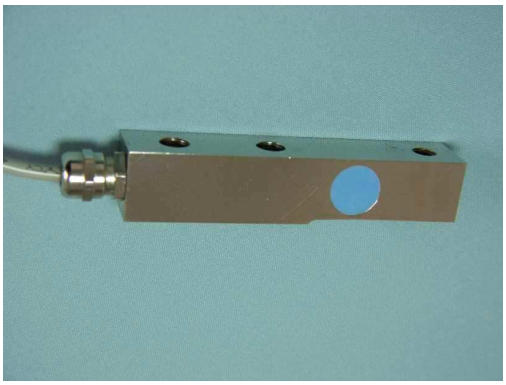
Type	Range [kg]
F095	0 – 500
F096	0 – 1000

*** All parameters can be consulted and adjusted according to customer requirements.**

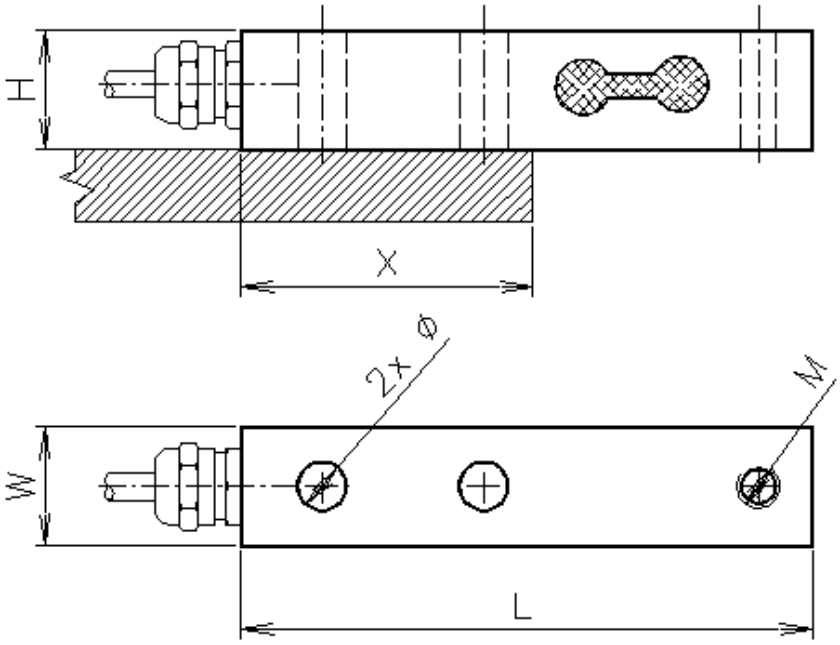
Bending beam

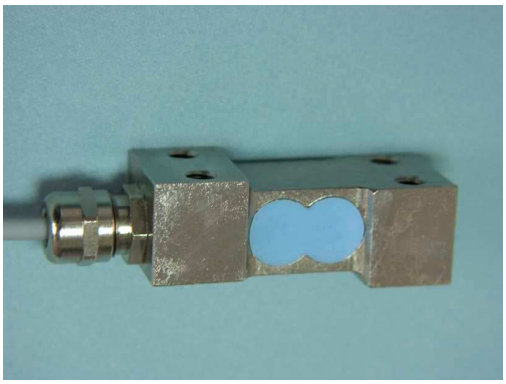
Option A:





Option B:

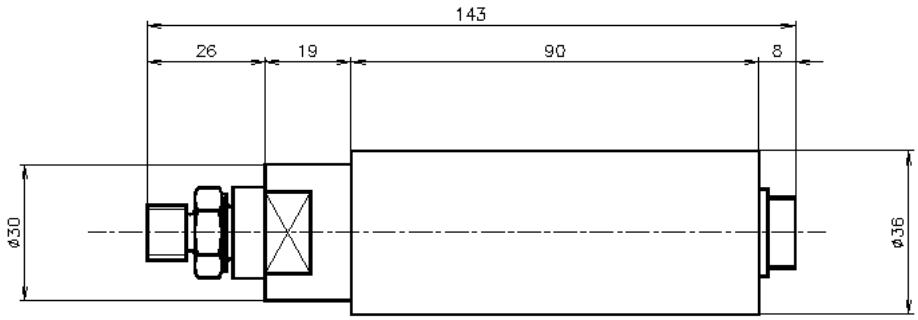


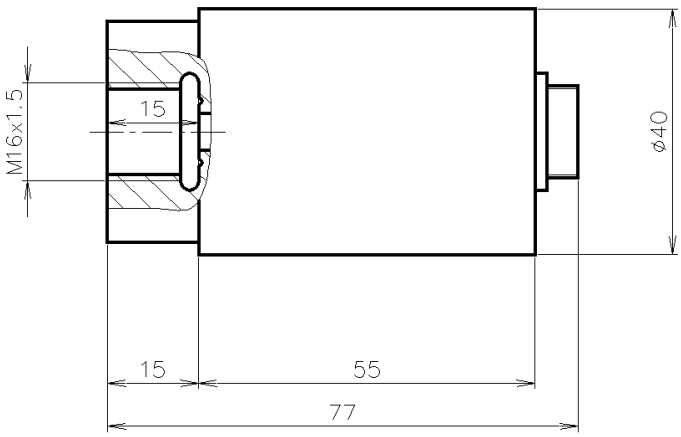


The design, shape and size of these sensors are variable. The sensors are designed and manufactured according to customer requirements. Sensors can be made from steel or alloy, in a different class of IP, etc.

Pressure sensors

PP-20



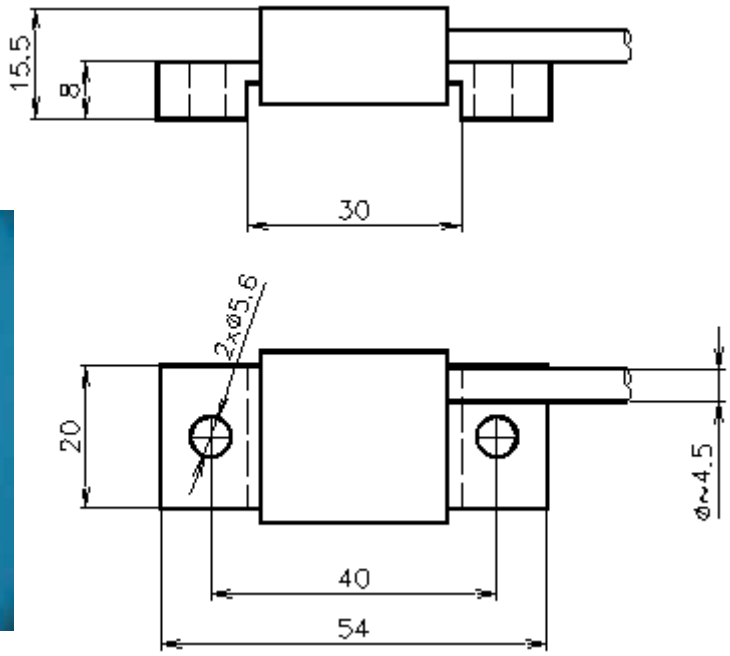


PP-1

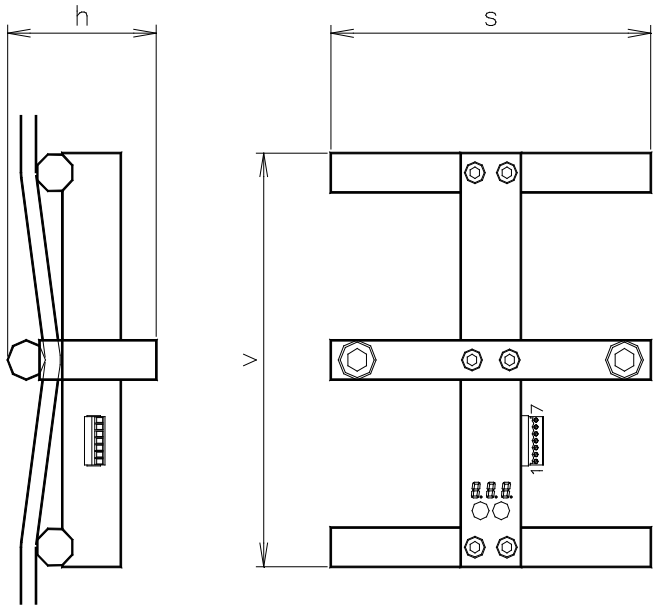
Type	Range [Mpa]	Height [mm]	Diameter [mm]
PP-1	1.0	77.0	40.0
PP-2	2.0	77.0	40.0
PP-20	20.0	143.0	36.0
PP-30	30.0	103.0	36.0

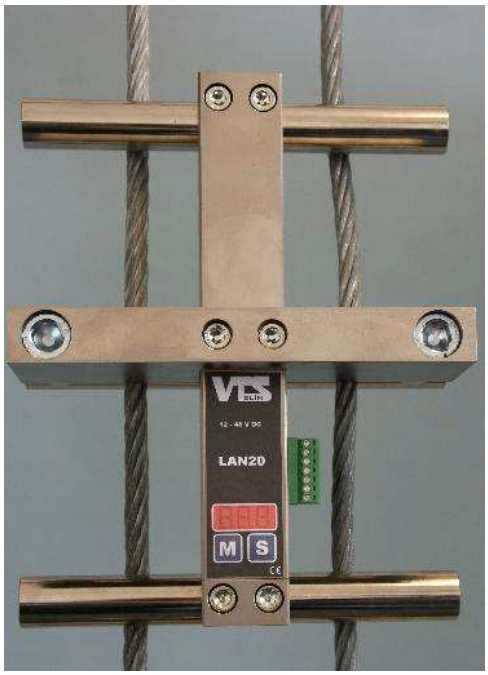
Sensors for measuring the relative deformation of the material

TYP: **E001**
Rozsah: **0 - 500µm**



Rope tension sensors





Type	Range [kg]	v [mm]	h [mm]	s [mm]
L016-2k	2 000	210	67 + thick rope	117 – for 3 ropes
L019-3k5	3 500	228	83 + thick rope	170 – for 6 ropes

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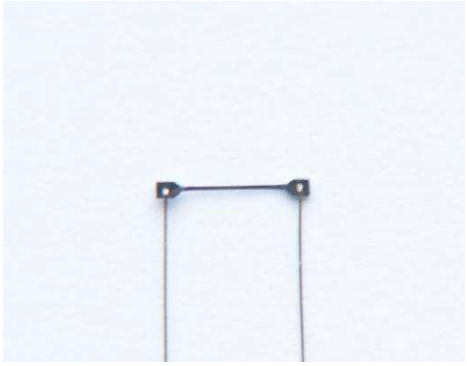
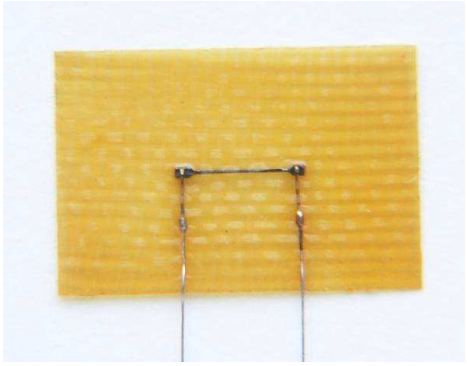
SEMICONDUCTOR STRAIN GAUGES



without support



with support

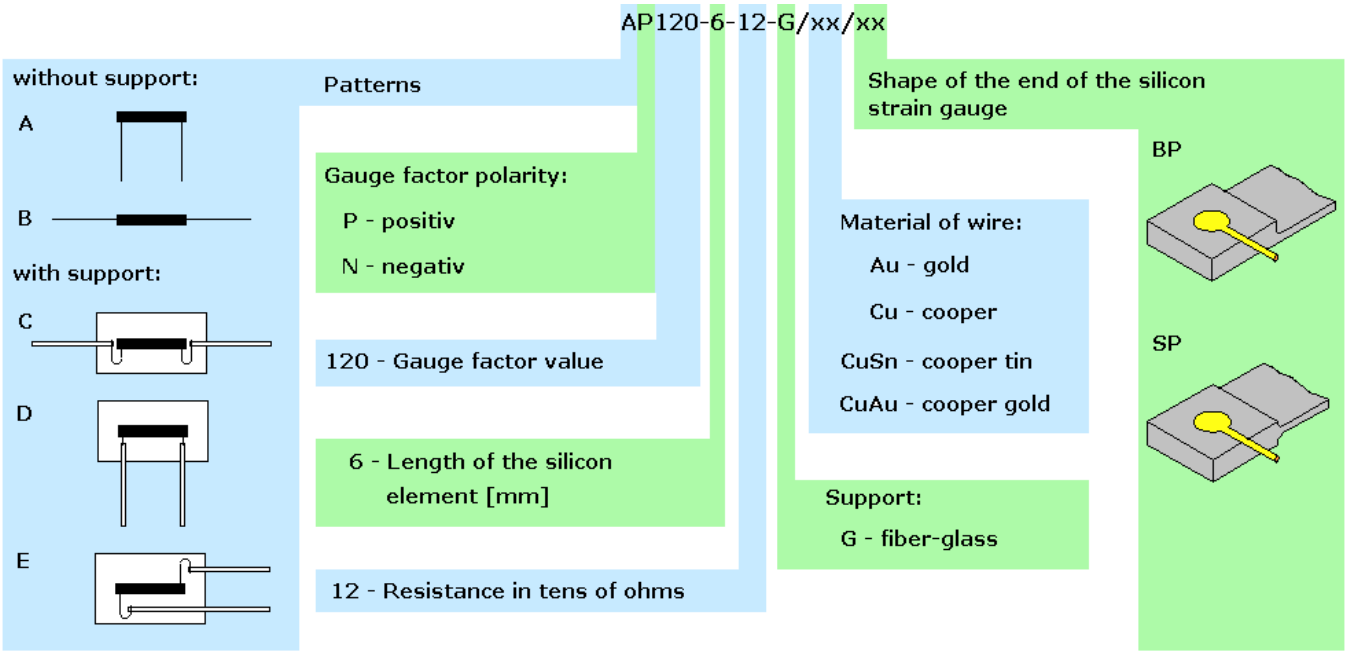
At present, we have these types of strain gauges store: Type „Positive“, length 3mm and 6mm, with gauge factor C1 = 120 - 150 and with electrical resistance 120 , 350 and 1000 Ohm. Of course, we are able to produce strain gauges with parameters according to customer's requirements.

We deliver semicoductor strain gauges in two sorts of tolerance at pack, specified by assurance of their tolerance characteristics. For dynamic measurement and stable temperatures are suitable strain gauges marked as **N-sort**. For statical measurements, sensors and strain gauges for temperature fluctuation are suitable ones marked as **T-sort**.

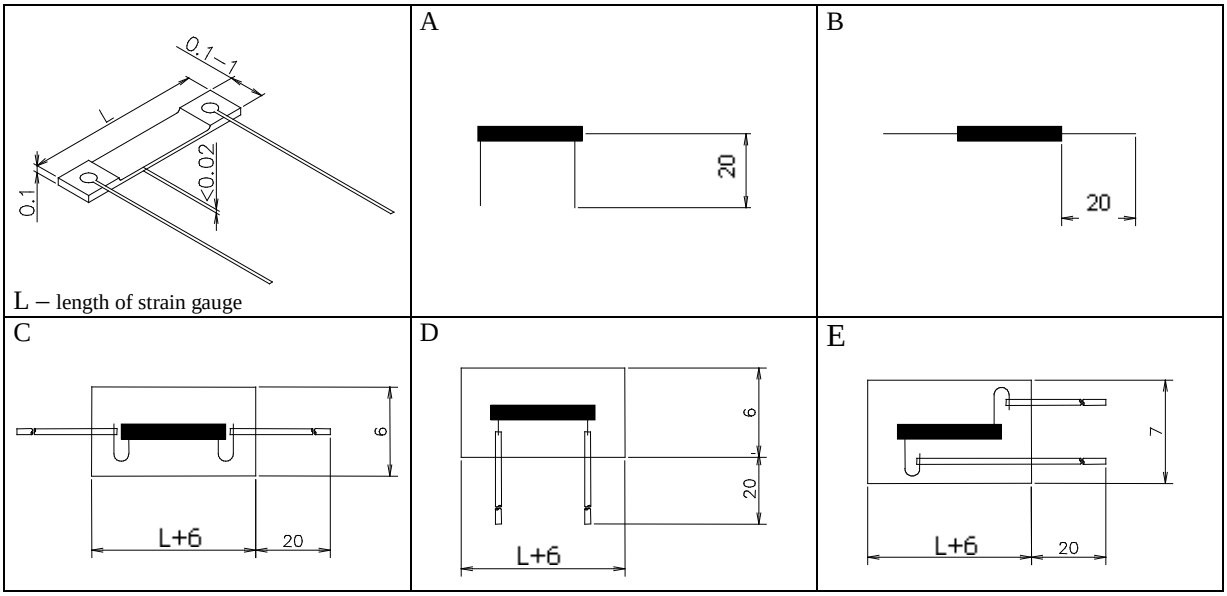
		Tolerance at pack (standard is 5 pieces)		**Tolerance of type**	
		N-sort	**T-sort**	**N-sort**	**T-sort**
R_0 – Electrical resistance of the free gauge		± 0.4%	± 0.25%	± 5%	± 3%
R_B - Electrical resistance of the free gauge with support		± 1%	± 0.50%	± 10%	± 5%
Strain sensitivity constants	**C_1 (Gauge factor)**	± 2%	± 2%	± 5%	± 5%
	C_2	± 8%	± 8%	*	*
α - Temperature resistance coefficient of the free gauge		------	±0.02%/°C	------	*
Limit static positiv tensile strain		0.3%	0.3%	0.3%	0.3%

* according to contract

Code designation of strain gauges

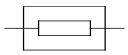
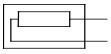


Dimensions of strain gauges



The range of semiconductor strain gauges

Implementation	Type	Nominal resistance [Ohm]	K-factor	Length of strai gauge L [mm]
	AP95-3-3	30	+95	3
	AP105-5-3	30	+105	5
	AP120-1.5-12	120	+120	1.5
	AP120-3-12	120	+120	3
	AP120-6-12	120	+120	6
	AP120-6-25	250	+120	6
	AP120-10-12	120	+120	10
	AP120-10-35	350	+120	10
	AP125-2-12	120	+120	2
	AP130-1.5-12	120	+130	1.5
	AP130-3-12	120	+130	3
	AP130-6-12	120	+130	6
	AP130-6-35	350	+130	6
	AP130-10-60	600	+130	10
	AP130-20-35	350	+130	20
	AP140-2-12	120	+140	2
	AP140-3-35	350	+140	3
	AP140-6-35	350	+140	6
	AP140-10-100	1000	+140	10
	AP150-1.5-35	350	+150	1.5
	AP150-2-12	120	+150	2
	AP150-3-55	550	+150	3
	AP150-3-100	1000	+145	3
	AP150-6-35	350	+150	6
	AP160-1.5-35	350	+160	1.5
	AP160-6-100	1000	+160	6
	AP160-10-170	1700	+160	10
	AN20-6-65	650	-20	6
	AN120-3-12	120	-120	3
	AN120-3-35	350	-120	3
	AN120-6-30	300	-120	6
	BP120-3-12	120	+120	3
	BP120-6-12	120	+120	6
	BP120-10-35	350	+120	10
	BP130-1.5-12	120	+130	1.5
	BP130-3-12	120	+130	3
	BP130-6-35	350	+130	6
	BP130-10-60	600	+130	10
	BP140-3-35	350	+140	3
	BP140-10-100	1000	+140	10
	BP150-1.5-35	350	+150	1.5
	BP150-3-100	1000	+150	3
	BP150-6-100	1000	+150	6

Implementation	Type	Nominal resistance [Ohm]	K-factor	Length of strai gauge L [mm]
	CP120-3-12-G	120	+120	3
	CP120-6-12-G	120	+120	6
	CP120-10-35-G	350	+120	10
	CP130-1.5-12-G	120	+130	1.5
	CP130-3-12-G	120	+130	3
	CP130- 6 -35-G	350	+130	6
	CP130-10 -60-G	600	+130	10
	CP140- 3 -35-G	350	+140	3
	CP140-10-100-G	1000	+140	10
	CP150-1.5-35-G	350	+150	1.5
	CP150-3-100-G	1000	+150	3
	CP150-6-100-G	1000	+150	6
	DP120-3-12-G	120	+120	3
	DP120-6-12-G	120	+120	6
	DP120-10-35-G	350	+120	10
	DP130-1.5-12-G	120	+130	1.5
	DP130-3-12-G	120	+130	3
	DP130-6-35-G	350	+130	6
	DP130-10-60-G	600	+130	10
	DP140- 3 -35-G	350	+140	3
	DP140-10-100-G	1000	+140	10
	DP150-1.5-35-G	350	+150	1.5
	DP150-3-100-G	1000	+150	3
	DP150-6-100-G	1000	+150	6
	EP120-3-12-G	120	+120	3
	EP120-6-12-G	120	+120	6
	EP120-10-35-G	350	+120	10
	EP130-1.5-12-G	120	+130	1.5
	EP130-3-12-G	120	+130	3
	EP130-6-35-G	350	+130	6
	EP130-10-60-G	600	+130	10
	EP140-3-35-G	350	+140	3
	EP140-6-35-G	350	+140	6
	EP140-10-100-G	1000	+140	10
	EP150-1.5-35-G	350	+150	1.5
	EP150-3-100-G	1000	+150	3
	EP150-6-100-G	1000	+150	6

MANUFACTURE OF STRAIN GAUGES & TRANSDUCERS
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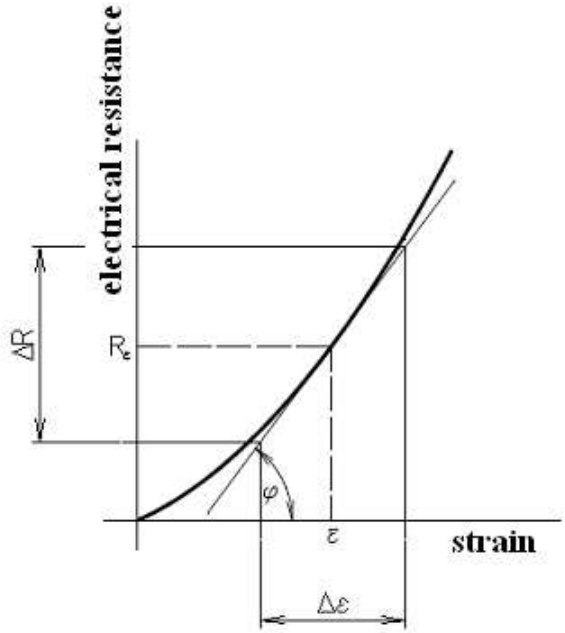
BASIC MATHEMATICAL EQUATIONS



For free gages (without support):

Dependence of resistance to deformation:

$$R_{\varepsilon,25} = R_{0,25} \cdot \left(1 + C_1 \cdot \varepsilon + C_2 \cdot \varepsilon^2\right) \quad (1)$$

Dependence of resistance to temperature:

$$R_{0,t} = R_{0,25} \cdot \left(1 + a(t-25) + b(t-25)^2\right) \quad (2)$$

Dependence of resistance to deformation and temperature:

$$R_{\varepsilon,t} = R_{0,t} + R_{0,25}\left[C_1\left(\varepsilon + (\alpha_{mat} - \alpha_{Si})(t-25)\right) + C_2\left(\varepsilon + (\alpha_{mat} - \alpha_{Si})(t-25)\right)^2\right] \quad (3)$$

The coefficient of strain sensitivity at 25°C:

$$K_{\varepsilon,25} = C_1 + 2C_2 \cdot \varepsilon = \frac{\Delta R}{\Delta \varepsilon} \quad (4)$$

Dependence of coefficient of strain sensitivity to temperature:

$$K_{0,t} = C_1 \cdot \left(1 + \frac{B}{100} \cdot (t-25)\right) \quad (5)$$

$$K_{\varepsilon,t} = K_{\varepsilon,25} \cdot \left(1 + \frac{B}{100} \cdot (t-25)\right) \quad (6)$$

For gages with support:

Dependence of resistance to deformation:

$$R_{B\varepsilon,25} = R_{0,25} \cdot \left(1 + C_1 \cdot \varepsilon + C_2 \cdot \varepsilon^2\right) \tag{7}$$

Dependence of resistance to temperature for free gages does not state because semiconductor element is already glued on the support. For free semiconductor element applies the same formula as for the free gauge without support.

Dependence of resistance to deformation and temperature:

$$R_{\varepsilon,t} = R_{0,t} + R_{B0,25}\left[C_1\left(\varepsilon + \left(\alpha_{mat} - \alpha_{Si}\right)\left(t - 25\right)\right) + C_2\left(\varepsilon + \left(\alpha_{mat} - \alpha_{Si}\right)\left(t - 25\right)\right)^2\right] \tag{8}$$

The coefficient of strain sensitivity at 25°C:

$$\mathrm{K}_{\varepsilon,25} = \mathrm{C}_1 + 2\mathrm{C}_2 \cdot \varepsilon = \frac{\Delta \mathrm{R}}{\Delta \varepsilon} \tag{9}$$

Dependence of coefficient of strain sensitivity to temperature:

$$\mathrm{K}_{0,\mathrm{t}} = \mathrm{C}_1 \cdot \left(1 + \frac{\mathrm{B}}{100} \cdot \left(\mathrm{t} - 25\right)\right) \tag{10}$$

$$\mathrm{K}_{\varepsilon,\mathrm{t}} = \mathrm{K}_{\varepsilon,25} \cdot \left(1 + \frac{\mathrm{B}}{100} \cdot \left(\mathrm{t} - 25\right)\right) \tag{11}$$

$R_{0,25}$ ….Electrical resistance of the free gauge (without support) at 25°C [Ω]
$R_{B0,25}$…Electrical resistance of the free gauge glued on the support at 25°C [Ω]
$R_{\varepsilon,25.}$….Electrical resistance of the deformed free gauge at 25°C [Ω]
$R_{B\varepsilon,25}$…Electrical resistance of the deformed gauge glued on the underlay at 25°C [Ω]
$K_{\varepsilon,25}$ ….The coefficient of strain sensitivity at 25°C
$K_{\varepsilon,t}$ ……The coefficient of strain sensitivity at temperature t and deformation ε
C_1.....…Linear coefficient of deformation rate equation *)
C_2.....…Quadratic coefficient of deformation rate equation *)
a,b.....…Temperature coefficients of resistance free strain gauges
B.....…Temperature coefficient of strain sensitivity specified by the manufacturer [%/°C]
ε.....…Strain [m/m]
t .....…Temperature [°C]
α_{mat} ..…Coefficient of thermal expansion material in which the strain gauge glued [1/°C]
α_{Si} .....…Coefficient of thermal expansion of silicon - 2.8×10^{-6} [1/°C]

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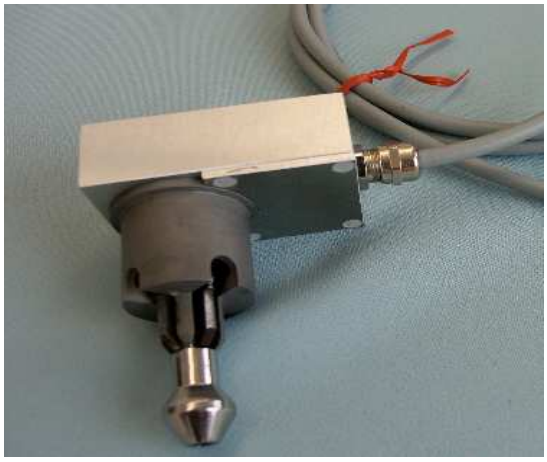
*) Constants C1, C2 are derived from changes in resistance strain gauges glued Cyanoacrylate glue. Epoxy glue hardened above 100°C transferred to the deformation strain gauge with higher efficiency. This increases C1 average value of 5% and the value of C2 average of 50%. The exact values are determined experimentally.

SAMPLES OF SOME TRANSDUCERS



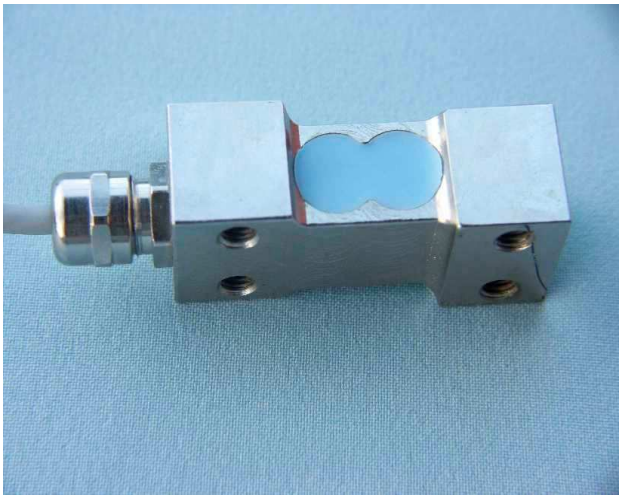
F098 – Force sensor

L024 - Rope tension sonsor

TQ051 – Calibrator torque

TQ045 – Torque sensor

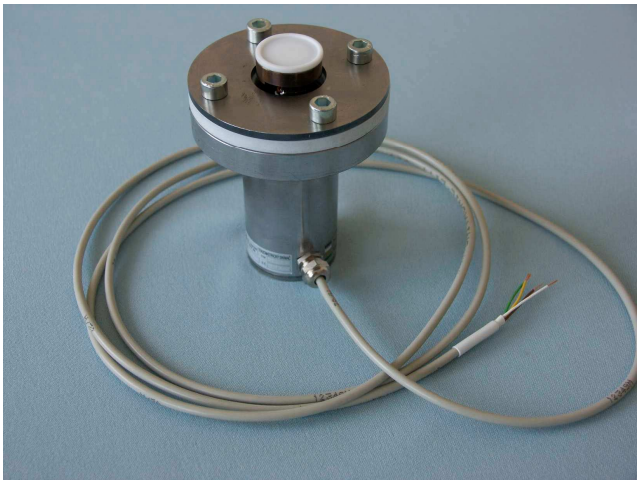
C033 – Bending beam



F062 – Bending beam

M016 – Tensile sensor

M014 – Tensile sensor



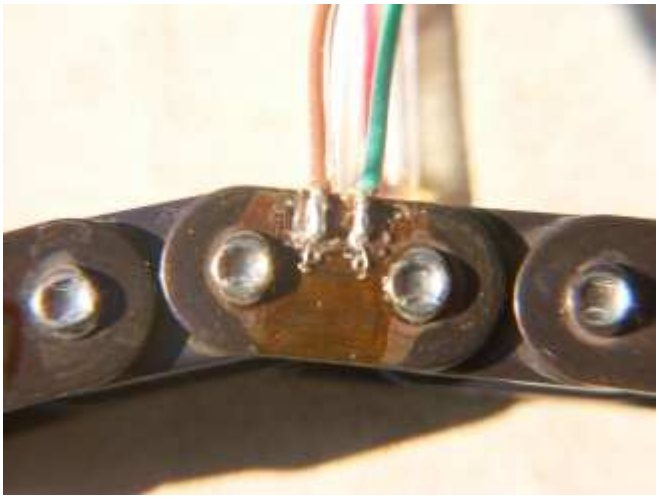
F139 – Sensor memrane stress

F140 – Pressure sensor

F135, F136 – Adjustable pressure sensor

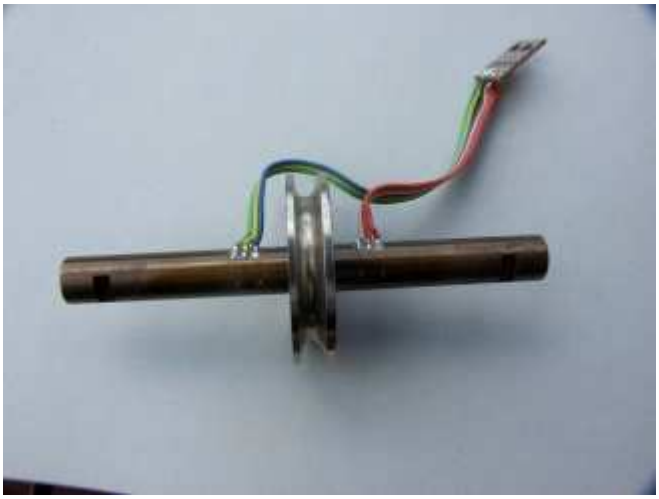
C020 – Pressure sensor

INDIVIDUAL APPLICATION OF STRAIN GAUGES



Tension in the chain

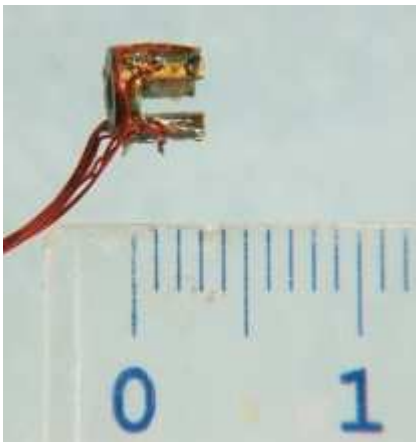
Test automotive lock



Loading rollers

Stress in the pressure cylinder

Shifter



Measuring of biting force