

# Quartz Longitudinal Measuring Pin

## for Indirect Measurement of Forces in Machinery and Tools

Type 9243B

Piezoelectric sensor for monitoring forces and strains in machines and tools. This compact, longitudinally sensitive pin is used for indirect measurement of dynamic and quasistatic forces. It is particularly suitable for sensing very large forces where installation space is limited.

- Indirect measurement of very large forces
- Preloaded mounting allows measurement of compressive and tensile forces
- Can be mounted at virtually any depth in the structure
- Suitable for mounting in structures subject to heavy vibration
- Ground-isolated version available as option

### Description

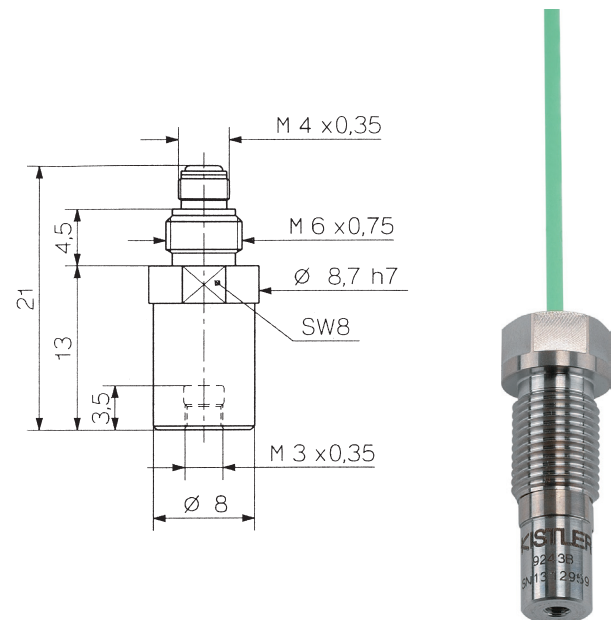
The measuring pin is mounted with a precisely defined preload. The strain in the surrounding material is transferred via the end of the sensor to the quartz sensing element.

The electrical charge output is proportional to the change in mechanical strain. A charge amplifier converts the charge into a voltage signal that can be processed as required.

After being mounted in the structure as prescribed, the strain sensor must be calibrated by comparison measurement against a force calibration sensor, for example.

### Application

The sensor could easily be mounted with a preloading bolt and allows measurement of the forces within a machine component or tool. It is used mainly for industrial monitoring of machinery forces (e.g. machine and tool monitoring) and tie bar forces in injection molding machines.



### Technical Data

Range	$\mu\epsilon$	-1,500 ... 1,500
Overload	$\mu\epsilon$	2,000
Axial preloading force	kN	$\approx 16$ ( $\approx 40,000$ pC)
Sensitivity (in test object)	pC/ $\mu\epsilon$	$\approx -15$
Sensitivity to force (for preload)	pC/N	$\approx -2.5$
Reproducibility of sensitivity when dismounting and remounting	%	$< \pm 1$
Linearity	%FSO	$\leq \pm 1$
Hysteresis	%FSO	$\leq 2$
Natural frequency	kHz	$> 110$
Acceleration sensitivity	pC/g	$< 0.15$
Operating temperature range	$^{\circ}\text{C}$	-40 ... 200
Insulation resistance at 20 $^{\circ}\text{C}$	$\Omega$	$\geq 10^{13}$
Degree of protection (with connected cable)		IP64
Weight (without cable and preloading bolt)	g	4.8

**Mounting**

There are basically three different methods of mounting:

**1. Standard: Mounting Hole with Flat Bottom**

- Prepare the mounting hole as shown in Figure 1; the 9 mm  $\varnothing$  end bearing surface for the sensor must be machined clean and flat (and if necessary finished with Type 1300A21 tool and blown out with clean compressed air).

- Grease (included in accessories) end and thread of the hollow preloading bolt sparingly.
- Mount and carefully preload the sensor to the stipulated value of 40,000 pC ( $\approx$ 16 kN) with the aid of the M10x1 hollow preloading bolt with the included accessories, using a suitable 8 mm tubular socket wrench such as the Type 1385B200.
- Check preloading force with the aid of a charge amplifier and an evaluation unit.

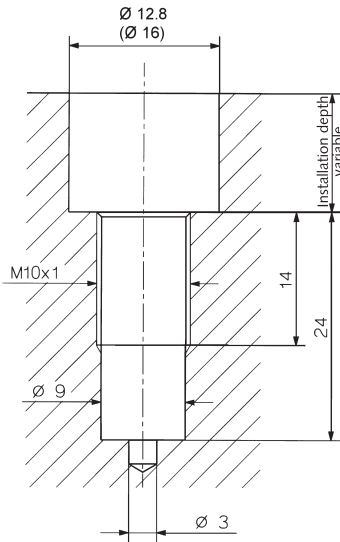


Fig. 1: Mounting hole with flat bottom

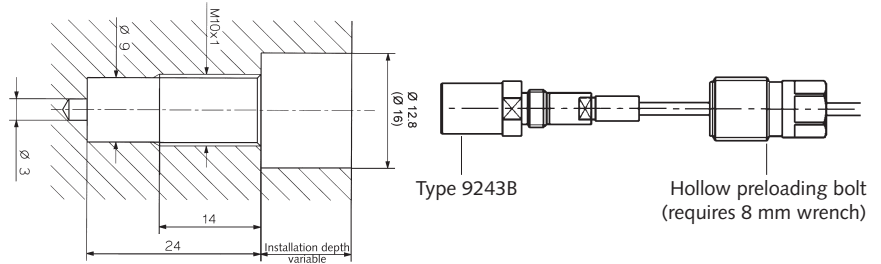


Fig. 2: Standard method of mounting the Type 9243B measuring pin

**2. Option: Mounting Hole with Conical (120°) Bottom**

- Prepare the mounting hole as shown in Figure 3; the 9 mm  $\varnothing$  end bearing surface for the sensor must be machined clean and flat (and if necessary finished with Type 1300A21 tool and blown out with clean compressed air).
- Grease (included in accessories) end and thread of the hollow preloading bolt sparingly.
- Screw the Type 9481 domed thrust piece available as an option onto the head of the sensor to improve force introduction.

- Mount and carefully preload the sensor to the stipulated value of 40,000 pC ( $\approx$ 16 kN) with the aid of the M10x1 hollow preloading bolt with the included accessories, using a suitable 8 mm tubular socket wrench such as the Type 1385B200.
- Check preloading force with the aid of a charge amplifier and an evaluation unit.
- Please note that with this method of mounting the strain sensitivity is approximately 15% lower than the calibrated value (see page 1).

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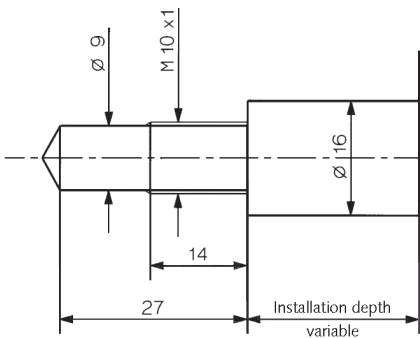


Fig. 3: Mounting hole with conical bottom

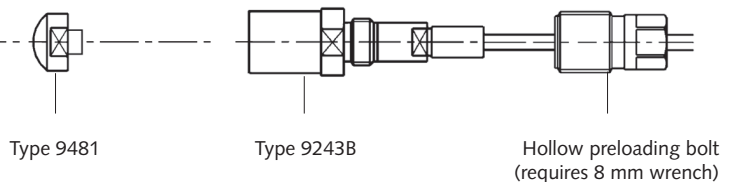


Fig. 4: Mounting the Type 9243B measuring pin with domed thrust piece

### 3. Option: Mounting with Type 9487A Ground Isolation Kit (only for Mounting Hole with Flat Bottom)

The Type 9487A ground isolation mounting kit available as an option prevents electrical faults due to earth loops.

- Prepare the mounting hole as shown in Figure 1; the 9 mm  $\varnothing$  end bearing surface for the sensor must be machined clean and flat (and if necessary finished with Type 1300A21 tool and blown out with clean compressed air).
- Grease (included in accessories) end and thread of the hollow preloading bolt sparingly.
- Put the specially coated thrust piece included in the the Type 9487A mounting kit on the sensor head.

- Mount and carefully preload the sensor to the stipulated value of 40,000 pC ( $\approx 16$  kN) with the aid of the specially coated type 9487A hollow preloading bolt included in the Type 9487A mounting kit, using a suitable 8 mm tubular socket wrench such as the Type 1385B200 as shown in Figure 5.
- Check preloading force with the aid of a charge amplifier and an evaluation unit.
- Please note that with this method of mounting the strain sensitivity is approximately 11% lower than the calibrated value (see page 1).

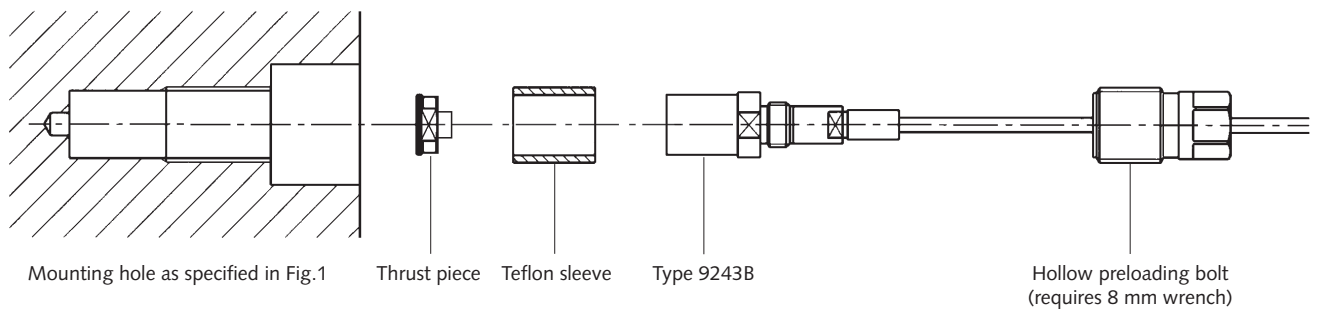


Fig. 5: Ground-isolated mounting of the longitudinal measuring pin (Type 9243B) with mounting kit (Type 9487A)

### Mounting Examples

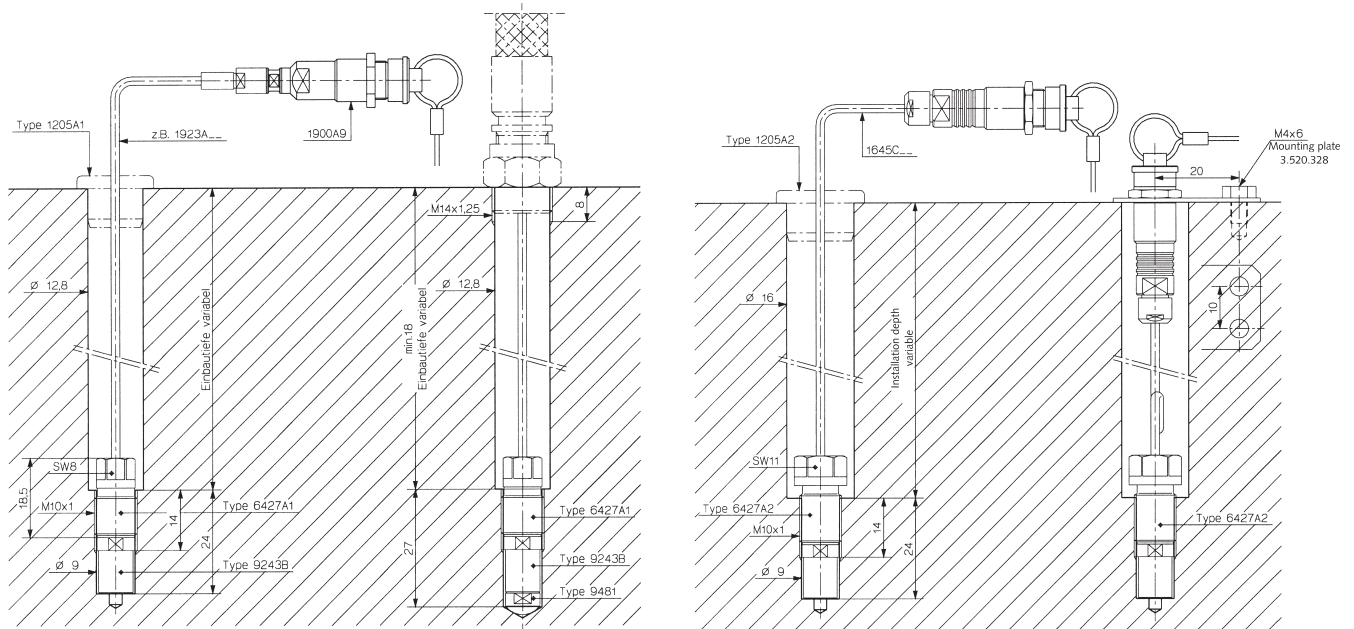


Fig. 6: Examples of different methods of mounting Type 9243B longitudinal measuring pin

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**Example of Calculation** (Estimation of Sensitivity)

**Exercise**

A steel cylinder with a cross-sectional area of 1,134 mm<sup>2</sup> (≈∅ 38 mm) is loaded with a compression force F of 300 kN. A quartz longitudinal measuring pin M10 Type 9243B is installed in the axis.

How high is its force sensitivity?

**Solution**

$$\sigma \text{ [N/mm}^2\text{]} = \frac{F}{A} = \frac{300,000 \text{ N}}{1,134 \text{ mm}^2} = 265 \text{ N/mm}^2$$

$$E \text{ [N/mm}^2\text{]} = \text{Modulus of elasticity of steel} = 200,000 \text{ N/mm}^2$$

$$e \text{ [}\mu\epsilon\text{]} = \frac{\Delta l}{l_0} = \frac{\sigma}{E} = \frac{265 \text{ N/mm}^2}{200,000 \text{ N/mm}^2} = 1.32 \cdot 10^{-3} \text{ m/m} = 1,320 \mu\epsilon$$

$$1 \text{ [}\mu\epsilon\text{]} = 1 \mu\text{m/m} = 10^{-6} \text{ Strain } (\Delta l/l_0)$$

**Check**

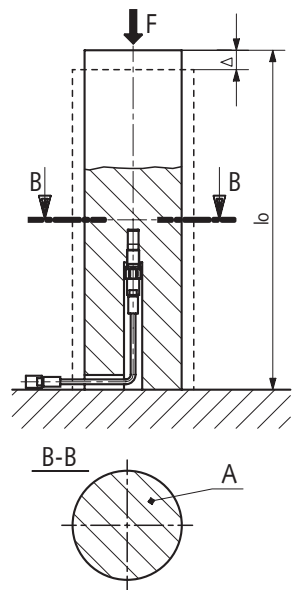
Is the calculated strain e within the measuring range?  
→ Yes, the measuring range is (see Technical Data) = ±1,500 με

**Calculation of the Force Sensitivity of the Built-In Sensor**

$$S_e = \text{Sensitivity of the sensor (see Technical Data)} = -15 \text{ pC}/\mu\epsilon$$

$$Q = e \cdot S_e = 1,320 \mu\text{m/m} \cdot (-15 \text{ pC}/\mu\epsilon) = -19,800 \text{ pC}$$

$$S_F = \frac{Q}{F} = \frac{-19,800 \text{ pC}}{300,000 \text{ N}} = -0.066 \text{ pC/N} = \underline{\underline{-66 \text{ pC/kN}}}$$



**Legend**

Symbol	Meaning	Unit
F	Axial force	N
A	Cross-sectional area at the mounting point	mm <sup>2</sup>
σ	Average mechanical stress at the mounting point	N/mm <sup>2</sup>
E	Modulus of elasticity of the structural material	N/mm <sup>2</sup>
e	Strain	με
l <sub>0</sub>	Length of the unloaded cylinder	m
Δl	Change in length due to load F	m
S <sub>e</sub>	Strain sensitivity of the sensor	pC/με
Q	Electric charge	pC
S <sub>F</sub>	Force sensitivity of the built-in sensor for forces acting in the cylinder axis	pC/N

**Note**

This calculation produces an approximation. The exact force sensitivity of the built-in sensor can only be determined by direct calibration on the object measured.

**Cable Concept**

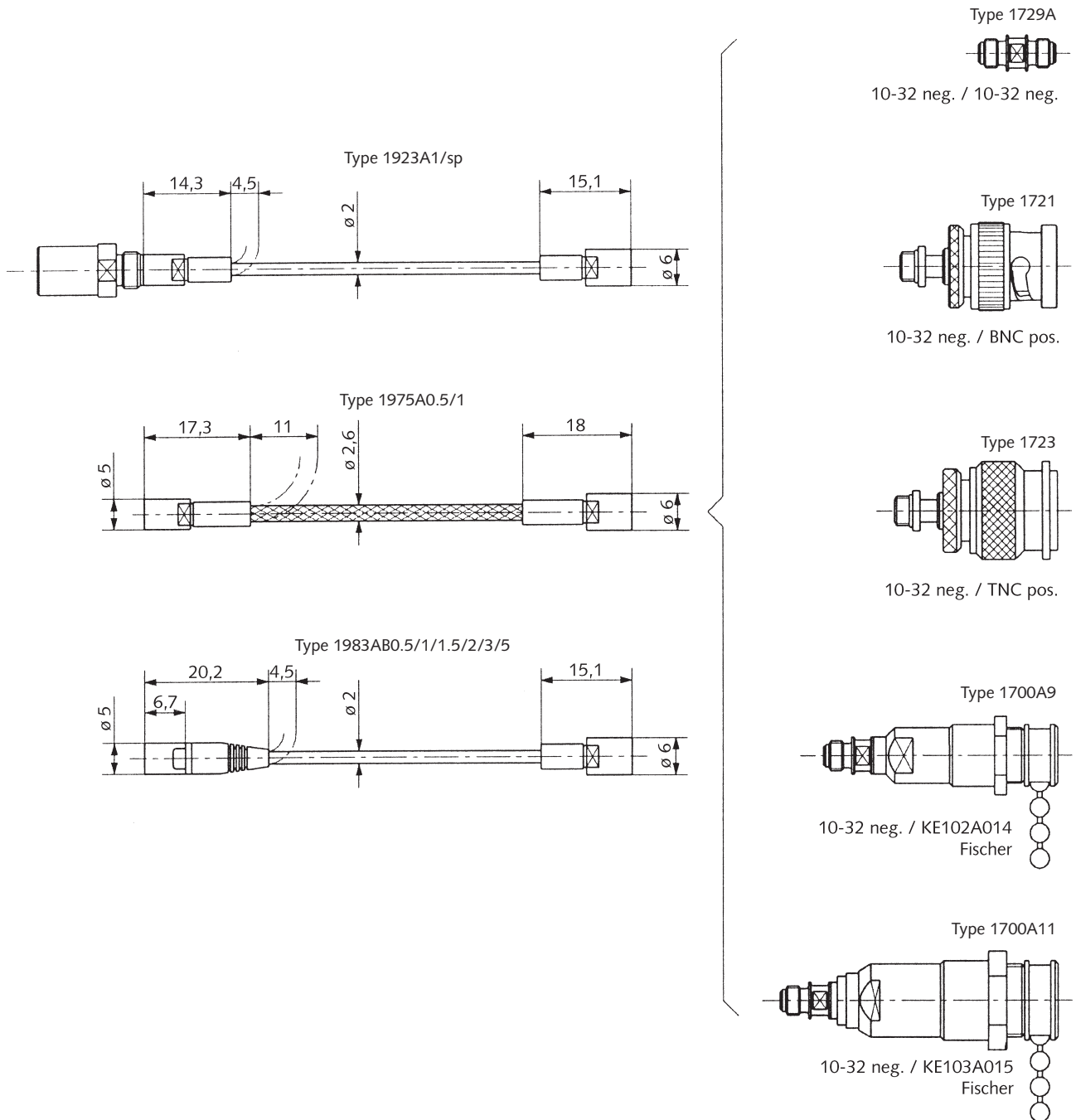


Fig. 7: Cable concept for longitudinal measuring pin Type 9243B

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## Accessories Included

	Type
• Hollow preloading bolt (requires 8 mm wrench)	6427A1
• Rubber plug, $\varnothing$ 12.8 mm	1205A1
• Grease	1063
• Calibration certificate	

## Ordering Key

	Type
• M10 Quartz Longitudinal Measuring Pin without Connecting Cable	9243B

## Optional Accessories

	Type/Art.No.
• Tubular socket wrench, 8 mm (for hollow preloading bolt requiring this size) length = 200 mm	1385B200
• Tubular socket wrench, 8 mm (for hollow preloading bolt requiring this size) with special length, please specify in mm ( $L_{\min}$ 100 mm/ $L_{\max}$ = 800 mm)	1385Bsp100-800
• Hollow preloading bolt, 11 mm	6427A2
• Tubular socket wrench, 11 mm (for hollow preloading bolt requiring this size) with special length, please specify in mm) ( $L_{\min}$ = 100 mm/ $L_{\max}$ = 800 mm)	1387sp100-800
• Rubber plug, $\varnothing$ 16 mm	1205A2
• Force introducing cap	9481
• Finishing tool	1300A21
• Preload tester	5991
• Ground isolation mounting kit	9487A
• For connecting cables see cable concept on page 4	