KISTLER

measure. analyze. innovate.

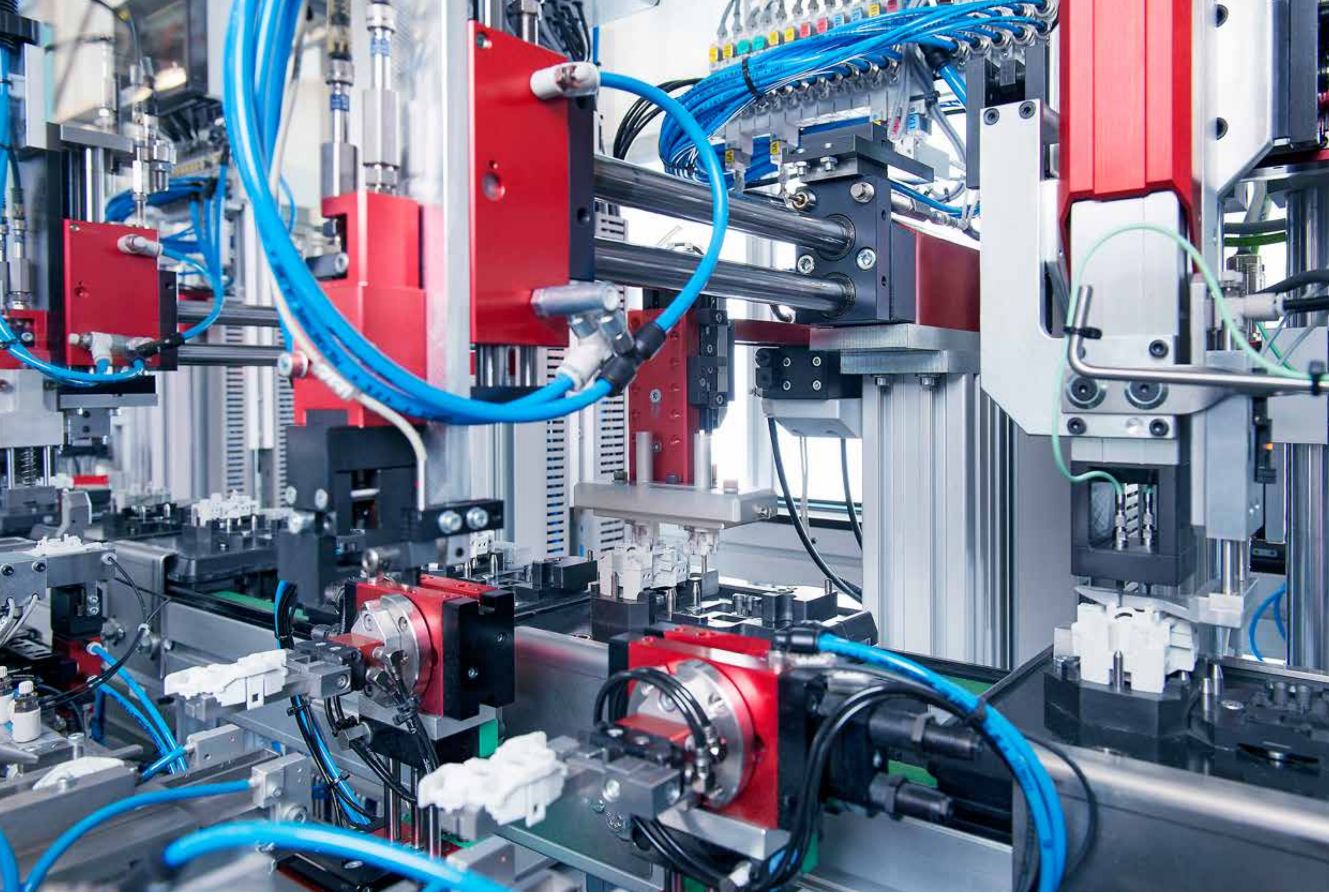
Force sensors

Transparent manufacturing processes
ensure quality and reduce costs.

Kistler – Your partner for process efficiency and cost effectiveness

The Kistler Group is one of the world's leading manufacturers of sensors and systems to measure pressure, force, torque and acceleration. Kistler systems are used to analyze and evaluate measuring signals. The results of these evaluations help to improve process efficiency, ensuring a sustainable increase in companies' overall success.

Content



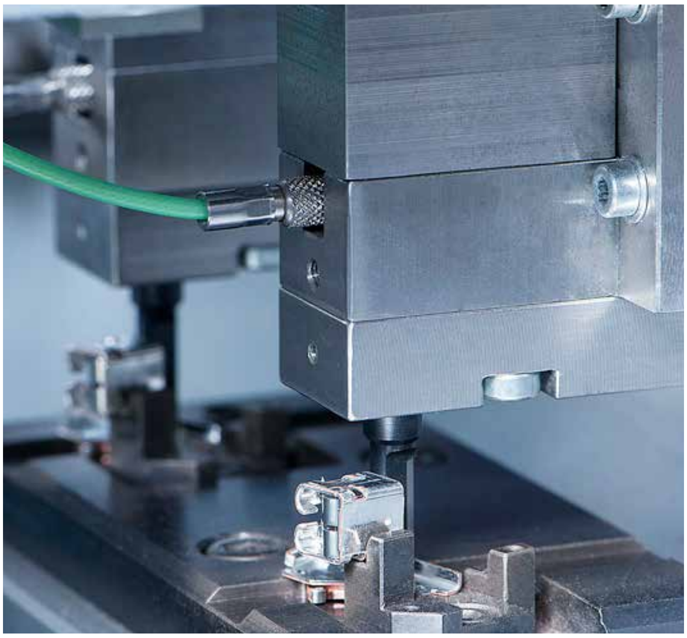
Assembly processes and product testing are just two of the many industrial activities where sensors from Kistler are used

Focus on quality and cost-effectiveness

Quality and precision standards in industrial manufacturing are continually increasing while competition is becoming even more fierce, thereby making it essential to optimize and monitor the entire production chain. Kistler's measurement and system technology can help meet these requirements, laying the foundations for zero-defect industrial production.

Ensuring the quality of the end product is always the top priority in the automotive industry and the medical technology or electrical engineering sectors (to mention only a few examples); and this is why strict standards are specified for this purpose. Especially if many individual components are assembled to form one single product, each component must already have been tested by the suppliers: this is the only way to guarantee the quality of the end product. In many such cases, the only solution is to integrate monitoring systems into the production process.

- Force measurement is integrated in the production process
- Process monitoring ensures zero-defect production
- Quality costs are cut because deviations are detected at an early stage
- Process efficiency is optimized due to the flexibility of the measuring equipment



Optimized process efficiency thanks to technology from Kistler
The objective: to implement zero-defect industrial production at the lowest possible cost. Kistler's response: integrated process monitoring, which means direct verification during each process step. This concept is underpinned by sensor technology based on the piezoelectric principle – an approach that is outstandingly suitable for monitoring and optimizing production processes.

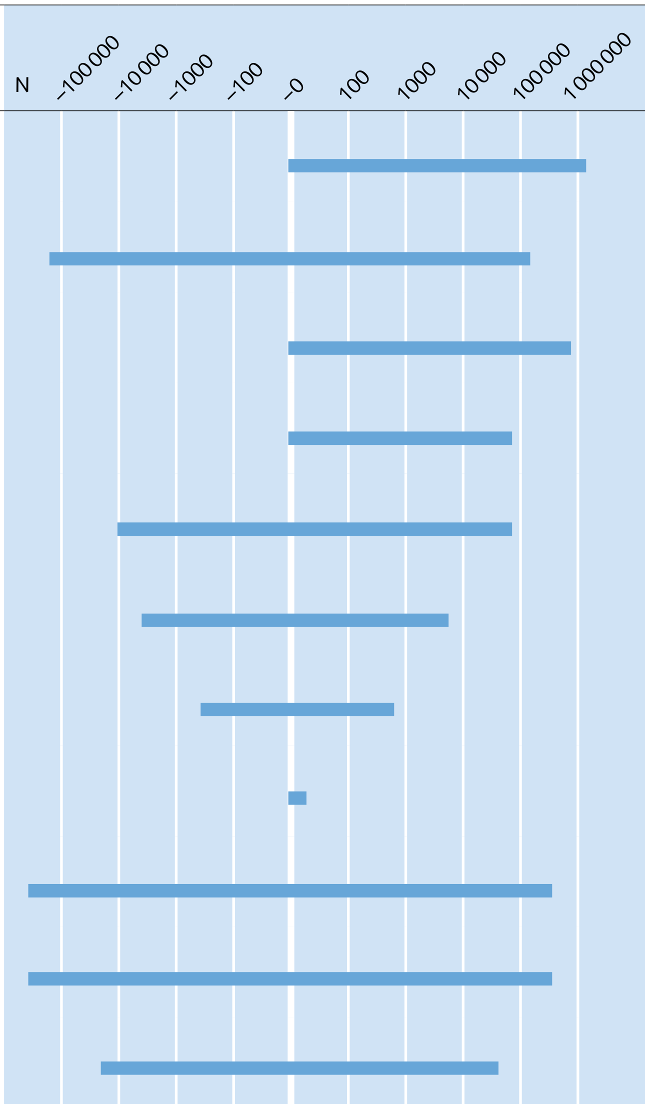
Lower quality assurance costs for plant operators
Process-integrated monitoring cuts the costs of quality assurance. This cost-effective solution protects plant operators against the possibility of faulty parts reaching the customer; it also ensures that there is no disruption to any downstream assembly operations.

Increased process efficiency with Kistler – now online!
View our animation to experience convincing, first-class Kistler solutions – the sure way to optimize process efficiency:
www.kistler.com/maxymos

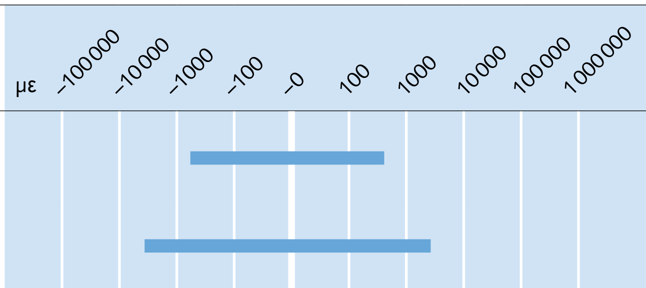
Product overview: force sensors

Piezoelectric sensors

Direct force measurement		Measurement Type	Preloaded	Ready for Measurement	Pages
	Force Sensor	Fz			8–9
	Force Link	Fz	•	•	10–11
	Press Force	Fz	•	•	12–13
	SlimLine	Fz			14–17
	SlimLine Force Link	Fz	•	•	18–19
	SlimLine Shear Force	Fy			20–21
	Low Force	Fz	•	•	22–23
	Miniature Sensor	Fz		•	24–25
	3-Component Force Sensor	Fx, Fy, Fz			28–29
	3-Component Force Link	Fx, Fy, Fz	•	•	30–31
	Dynamometers	Fx, Fy, Fz, Mz	•	•	32–33

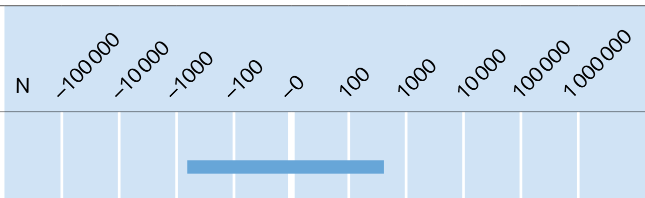


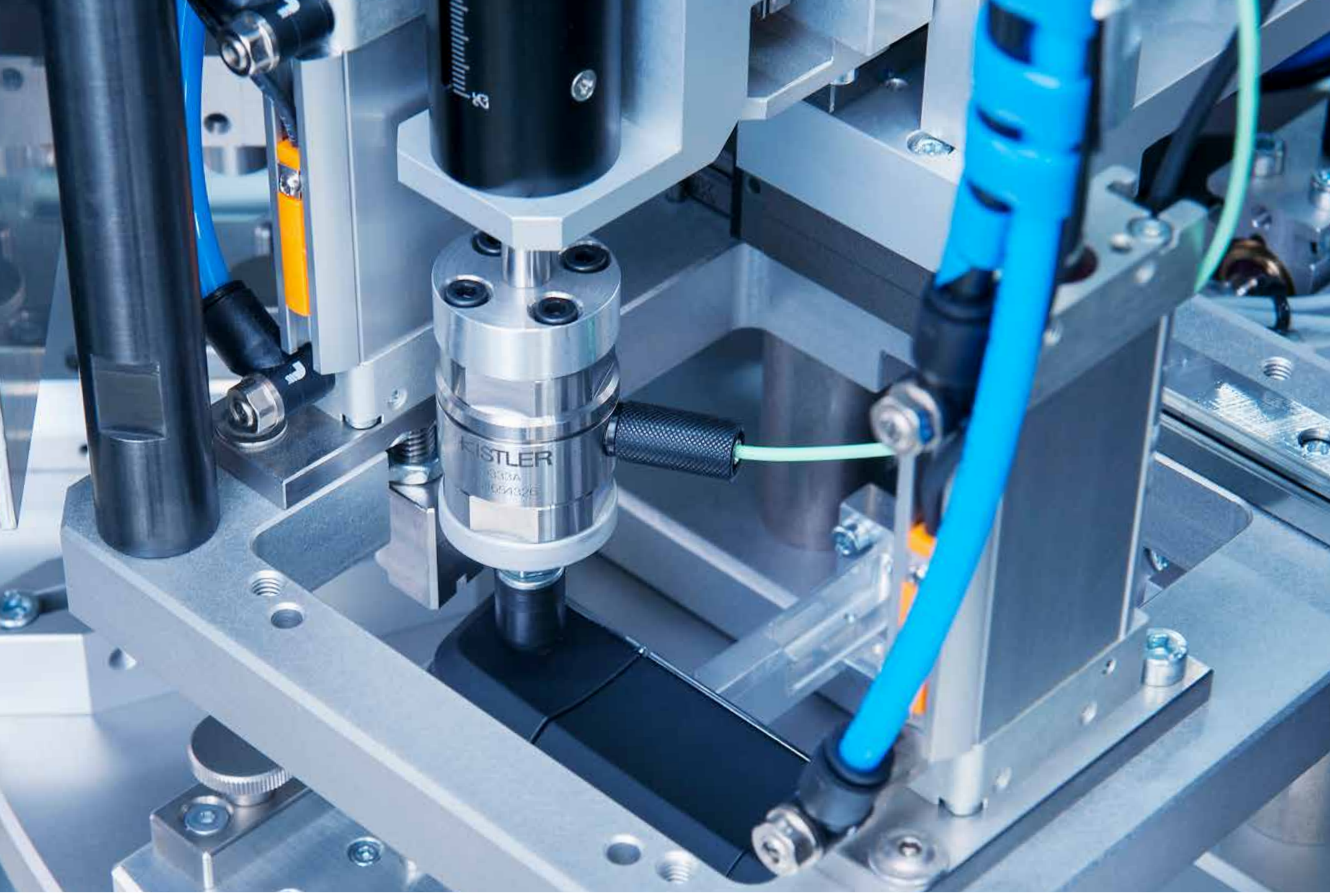
Indirect force measurement		Measurement Type	Preloaded	Ready for Measurement	Pages
	Surface Strain Sensor	με		•	35
	Strain Measuring Pin	με		•	36–37



Strain gage sensors

Direct force measurement		Measurement Type	Preloaded	Ready for Measurement	Pages
	Strain Gage Force Sensors	Fz		•	38–41





1-Component force sensors

The force sensors in our portfolio utilize the outstanding properties of piezo crystals and quartzes, providing the basis for our sensor technology.

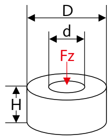
The load washer is the standard piezoelectric measuring element. The sensor elements themselves are only slightly preloaded. They are typically integrated into the existing structure at the measuring point, where they are installed with the required preload. This preload corresponds to a load offset.

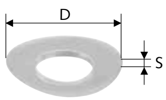
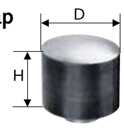
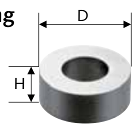
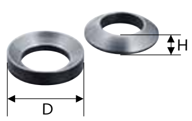
Our force links and press force sensors can be used directly by customers for immediate measurements. These preloaded quartz force links are calibrated in the factory, and are suitable for measuring compression and tensile forces.

Our low level force sensors are designed for extremely small forces. Thanks to their internal structure, these sensors are up to 30 times more sensitive so that even the smallest forces can be measured reliably.

Benefits
- Extremely rigid, so that high natural frequencies can be attained
- High loading capacity
- Durable
- Compact design
- Broad measuring range
- Direct measurements in the force flux
- Measurements without deflection are possible
- Extensive range

1-Component force sensors

Technical data		Type	9001A	9011A	9021A	9031A
						
Measuring range	Fz [1]	kN	0 ... 7,5	0 ... 15	0 ... 35	0 ... 60
Calibrated meas. ranges	Fz Fz	kN kN	0 ... 6 [2] 0 ... 0,6 [2]	0 ... 12 [2] 0 ... 1,2 [2]	0 ... 28 [2] 0 ... 2,8 [2]	0 ... 48 [2] 0 ... 4,8 [2]
Sensitivity	Fz [1]	pC/N	≈ –4,0	≈ –4,3	≈ –4,3	≈ –4,3
Dimensions	D d H	mm mm mm	10,3 4,1 6,5	14,5 6,5 8	22,5 10,5 10	28,5 13 11
Rigidity	$c_{A,z}$	kN/μm	≈ 1,1	≈ 1,6	≈ 3,4	≈ 5,4
Weight		g	3	7	20	36
Operating temp. range [3]		°C	–196 ... 200	–196 ... 200	–196 ... 200	–196 ... 200
Connector			KIAG 10–32 neg.	KIAG 10–32 neg.	KIAG 10–32 neg.	KIAG 10–32 neg.
Deg. of protection to IEC/EN 60529 screwed with cable (e.g. 1631C...) welded with cable (e.g. 1983AD...)		 IP65 IP67	 • •	 • •	 • •	 • •

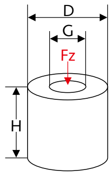
Accessories						
Preloading screw [4] Thread × pitch/ length Preloading force		Type Fv (kN)	**9422A01** M3 × 0,5 / 19,5 2,5	**9422A11** M5 × 0,8 / 26 5	**9422A21** M8 × 1,25 / 39 10	**9422A31** M10 × 1,5 / 46 20
Preloading element Thread × pitch/ length Preloading force		Type Fv (kN)	**9420A01** M3 × 0,5 / 22 4	**9420A11** M5 × 0,5 / 28 7	**9420A21** M8 × 1 / 40 18	**9420A31** M10 × 1 / 46 30
Insulating washer Dimensions		Type D (mm) S (mm)		**9517** 14 0,125	**9527** 22 0,125	**9537** 28 0,125
Force distributing cap Dimensions		Type D (mm) H (mm)	**9509** 10 10	**9519** 14 15	**9529** 22 20	**9539** 28 25
Force distributing ring Dimensions		Type D (mm) H (mm)	**9505** 10 6	**9515** 14 8	**9525** 22 10	**9535** 28 11
Spherical washer Dimensions		Type D (mm) H (mm)		**9513** 12 4	**9523** 21 6	**9533** 24 7

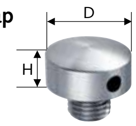
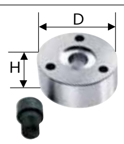
[1] without preloading
[2] with a preload of 20 % of the measuring range
[3] operating temperature range depends on the cable used
[4] included in delivery

9041A	9051A	9061A	9071A	9081B	9091B
					
0 ... 90	0 ... 120	0 ... 200	0 ... 400	0 ... 650	0 ... 1200
0 ... 72[2)] 0 ... 7,2[2)]	0 ... 96[2)] 0 ... 9,6[2)]	0 ... 160[2)] 0 ... 16[2)]	0 ... 320[2)] 0 ... 32[2)]	0 ... 650 0 ... 65	0 ... 1200 0 ... 120
≈–4,3	≈–4,3	≈–4,3	≈–4,3	≈–2,2	≈–2,2
34,5 17 12	40,5 21 13	52,5 26,5 15	75,5 40,5 17	100 40,5 22	145 72 28
≈6,9	≈9,8	≈15	≈29	30	65
70	80	157	370	910	2180
–196 ... 200	–196 ... 200	–196 ... 200	–196 ... 200	–40 ... 200	–40 ... 200
KIAG 10–32 neg.	KIAG 10–32 neg.	KIAG 10–32 neg.	KIAG 10–32 neg.	KIAG 10–32 neg.	KIAG 10–32 neg.
• •	• •	• •	• •	• •	• •

9422A41 M12×1,75/53 30	**9422A51** M14×2/60 40				
9420A41 M12×1/60 45	**9420A51** M14×1,5/62 60	**9420A61** M20×1,5/80 100	**9420A71** M27×2/102 200	**9455** M40×2 450	**9456** M64×3 600 (hydraulic)
9547 34 0,125	**9557** 40 0,125	**9567** 52 0,125	**9577** 75 0,125		
9549 34 30	**9559** 40 40	**9569** 52 50	**9579** 75 60		
9545 34 12	**9555** 40 13	**9565** 52 15	**9575** 75 17		
9543 30 8	**9553** 36 10	**9563** 52 14	**9573** 75 20		

1-Component quartz force links redundant

Technical data		Type	9301B	9311B	9321B
					
Measuring range	Fz	kN	–2,5 … 2,5	–5 … 5	–10 … 10
Calibrated meas. ranges	Fz Fz Fz	kN kN kN	0 … 2,5 0 … –2,5 0 … 0,025	0 … 5 0 … –5 0 … 0,05	0 … 10 0 … –10 0 … 0,1
Sensitivity	Fz	pC/N	≈–3,2	≈–4	≈–4
Dimensions	D H G	mm mm	11 25 M5	15 30 M6	23 45 M10
Rigidity	$c_{A,z}$	kN/µm	≈0,44	≈0,73	≈1,1
Natural frequency	$f_n(z)$	kHz	≈90	≈70	≈55
Weight		g	14	28	90
Operating temp. range [1]		°C	–40 … 120	–40 … 120	–40 … 120
Connector			KIAG 10–32 neg.	KIAG 10–32 neg.	KIAG 10–32 neg.
Deg. of protection to IEC/EN 60529 screwed with cable (e.g. 1631C…) welded with cable (e.g. 1983AD…)		 IP65 IP67	 • •	 • •	 • •
With basic insulation			•	•	•
Preloaded			•	•	•
Ready for measurement			•	•	•
Datasheet: see www.kistler.com			**9301B (000-107)**	**9301B (000-107)**	**9301B (000-107)**

Accessories					
Force distributing cap Dimensions		**Type** D (mm) H (mm)	**9500A0** 8,5 4	**9500A1** 12,5 6	**9500A2** 18 9
Flange Dimensions		**Type** D (mm) H (mm)	**9501A0** 25 8	**9501A1** 34 9	**9501A2** 44 16

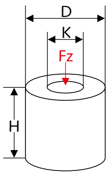
Note:
These sensors are also available as reference sensors with excellent linearity (up to ± ≤ 0,1 % FSO) and SCS calibration, with type designation 93×1BK. They are especially well-suited for calibrations (e.g. as factory reference sensors).

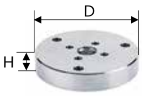
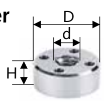
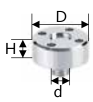
[1] operating temperature range depends on the cable used

9331B	9341B	9351B	9361B	9371B
				
–20 … 20	–30 … 30	–40 … 40	–60 … 60	–120 … 120
0 … 20 0 … –20 0 … 0,2	0 … 30 0 … –30 0 … 0,3	0 … 40 0 … –40 0 … 0,4	0 … 60 0 … –60 0 … 0,6	0 … 120 0 … –120 0 … 1,2
≈–4	≈–4	≈–4	≈–4	≈–4
29 52 M12	35 62 M16	41 72 M20	53 88 M24	76 108 M30
≈1,6	≈2,1	≈2,4	≈3,1	≈6,1
≈45	≈40	≈33	≈28	≈22
170	330	480	1020	2500
–40 … 120	–40 … 120	–40 … 120	–40 … 120	–40 … 120
KIAG 10–32 neg.	KIAG 10–32 neg.	KIAG 10–32 neg.	KIAG 10–32 neg.	KIAG 10–32 neg.
• •	• •	• •	• •	• •
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
9301B (000-107)	**9301B (000-107)**	**9301B (000-107)**	**9301B (000-107)**	**9301B (000-107)**

9500A3 23 12	**9500A4** 31 15	**9500A5** 35 18	**9500A6** 45 22	**9500A7** 64 32
9501A3 56 20	**9501A4** 70 27	**9501A5** 84 35	**9501A6** 102 42	**9501A7** 136 51

1-Component quartz force links, press force

Technical data		Type	9313AA1	9313AA2	9323AA	9323A
						
Measuring range	Fz	kN	0 ... 5	0 ... 20	0 ... 10	0 ... 20
Permissible tensile force	Fz	kN	0 ... −0,5	0 ... −2	0 ... −1	0 ... −2
Calibrated meas. ranges	Fz Fz Fz	kN kN kN	0 ... 0,05 0 ... 0,5 0 ... 5	0 ... 0,2 0 ... 2 0 ... 20	0 ... 0,1 0 ... 1 0 ...	0 ... 0,2 0 ... 2 0 ... 20
Sensitivity	Fz	pC/N	≈−10	≈−10	≈−9,6	≈−3,9
Output signal		V				
Dimensions	D K H	mm mm mm	13 M2,5 10	19 M4 14	20 M5 × 0,5 26	20 M5 × 0,5 26
Rigidity	$c_{A,z}$	kN/µm	≈0,56	≈1,50	≈1,30	≈1,20
Natural frequency	$f_n(z)$	kHz	>38	>35	>74,5	>72
Weight		g	10	25	50	47
Operating temp. range [1]		°C	−40 ... 120	−40 ... 120	−40 ... 120	−40 ... 120
Connector			KIAG 10−32 neg.	KIAG 10−32 neg.	KIAG 10−32 neg	KIAG 10−32 neg
Deg. of protection to IEC/EN 60529 screwed with cable (e.g. 1631C...) welded with cable (e.g. 1983AD...) screwed with cable (e.g. 1787A...)		 IP65 IP67 IP67	 • •	 • •	 • •	 • •
Preloaded			•	•	•	•
Ready for measurement			•	•	•	•
Datasheet: see www.kistler.com			**9313 (000-705)**	**9313 (000-705)**	**9323 (000-704)**	**9323 (000-704)**

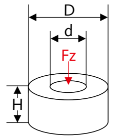
Accessories					
Flange Dimensions 	**Type** D (mm) H (mm)	**9580A7** 27 7	**9580A8** 35 8	**9580A9** 40 8	**9580A9** 40 8
Force distributing cap Dimensions 	**Type** D (mm) H (mm)	**9500A00** 6 3	**9500A01** 10,5 5	**9582A9** 20 8,5	**9582A9** 20 8,5
Spigot Dimensions	**Type** D (mm) L (mm)	**9590A7** 5 12,5	**9590A8** 10 20,5		
Female thread adapter Dimensions 	**Type** D (mm) H (mm)			**9584A9** 20 8	**9584A9** 20 8
Male thread adapter Dimensions 	**Type** D (mm) H (mm)			**9586A9** 20 8	**9586A9** 20 8

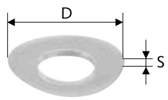
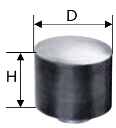
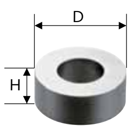
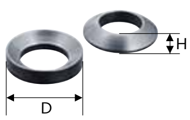
1) operating temperature range depends on the cable used

9333A	9343A	9363A	9383A	9393A	9337A40
					
0 ... 50	0 ... 70	0 ... 120	0 ... 300	0 ... 700	0 ... 70
0 ... –5	0 ... –10	0 ... –20	0 ... –50	0 ... –120	
0 ... 0,5 0 ... 5 0 ... 50	0 ... 0,7 0 ... 7 0 ... 70	0 ... 1,2 0 ... 12 0 ... 120	0 ... 3 0 ... 30 0 ... 300	0 ... 7 0 ... 70 0 ... 700	0 ... 5 0 ... 50
≈–3,9	≈–3,9	≈–3,8	≈–1,9	≈–1,9	
					0 ... 10
30 M9×0,5 34	36 M13×1 42	54 M20×1,5 60	100 S28×2 130	145 31 190	50 45
≈2,30	≈2,60	≈4,40	≈7,90	≈10,0	≈2,34
>55	>47	>35	>17	>11,3	>32
137	240	800	6490	18663	520
–40 ... 120	–40 ... 120	–40 ... 120	–40 ... 120	–40 ... 120	–10 ... 70
KIAG 10–32 neg	KIAG 10–32 neg	KIAG 10–32 neg	KIAG 10–32 neg	KIAG 10–32 neg	M12×1 8-pole, shielded
• •	• •	• •	• •	• •	 •
•	•	•	•	•	•
•	•	•	•	•	•
9323 (000-704)	**9323 (000-704)**	**9323 (000-704)**	**9323 (000-704)**	**9323 (000-704)**	**9337A (000-664)**

9580A0 62 11	**9580A1** 70 13	**9580A2** 100 22	**9580A4** 180 30	**9580A6** 220 48	**9594A1** 80 13
9582A0 30 11	**9582A1** 36,5 13	**9582A2** 56 22	**9582A4** 100 50	**9582A6** 145 80	**9582A1** 36,5 13
9584A0 30 11	**9584A1** 36,5 14	**9584A2** 56 21	**9584A4** 100 30	**9584A6** 150 48	**9584A1** 36,5 14
9586A0 30 11	**9586A1** 36,5 14	**9586A2** 56 21	**9586A4** 100 30	**9586A6** 150 48	**9586A1** 36,5 14

1-Component force sensors

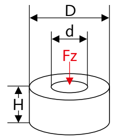
Technical data		Type	9101A	9102A
				
Measuring range	Fz [1]	kN	0 ... 20	0 ... 50
Calibrated meas. ranges	not calibrated			
Sensitivity	Fz [1]	pC/N	≈–4,3	≈–4,3
Dimensions	D d H	mm mm mm	14,5 6,5 8	22,5 10,5 10
Rigidity	$c_{A,z}$	kN/µm	≈1,6	≈3,4
Weight		g	7	20
Operating temp. range [2]		°C	–40 ... 120	–40 ... 120
Connector			KIAG 10–32 neg.	KIAG 10–32 neg.
Deg. of protection to IEC/EN 60529 screwed with cable (e.g. 1631C...) welded with cable (e.g. 1983AD...)		 IP65 IP67	 • •	 • •
Datasheet: see www.kistler.com			**9101A (000-108)**	**9101A (000-108)**

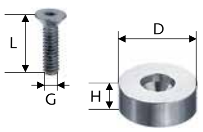
Accessories				
Preloading screw Thread × pitch/length Preloading force		**Type** Fv (kN)	**9422A11** M5 × 0,8 / 26 5	**9422A21** M8 × 1,25 / 39 10
Preloading element Thread × pitch/length Preloading force		**Type** Fv (kN)	**9420A11** M5 × 0,5 / 28 7	**9420A21** M8 × 1 / 40 18
Insulating washer Dimensions		**Type** D (mm) S (mm)	**9517** 14 0,125	**9527** 22 0,125
Force distributing cap Dimensions		**Type** D (mm) H (mm)	**9519** 14 15	**9529** 22 20
Force distributing ring Dimensions		**Type** D (mm) H (mm)	**9515** 14 8	**9525** 22 10
Spherical washer Dimensions		**Type** D (mm) H (mm) (total)	**9513** 12 4	**9523** 21 6

[1] without preloading
[2] operating temperature range depends on the cable used

9103A	**9104A**	**9105A**	**9106A**	**9107A**
				
0 … 100	0 … 140	0 … 190	0 … 330	0 … 700
≈ –4,3	≈ –4,3	≈ –4,3	≈ –4,3	≈ –4,3
28,5 13 11	34,5 17 12	40,5 21 13	52,5 26,5 15	75,5 40,5 17
≈ 5,4	≈ 6,9	≈ 9,8	≈ 15	≈ 29
36	70	80	157	370
–40 … 120	–40 … 120	–40 … 120	–40 … 120	–40 … 120
KIAG 10–32 neg.	KIAG 10–32 neg.	KIAG 10–32 neg.	KIAG 10–32 neg.	KIAG 10–32 neg.
 • •	 • •	 • •	 • •	 • •
9101A (000-108)	**9101A (000-108)**	**9101A (000-108)**	**9101A (000-108)**	**9101A (000-108)**
9422A31 M10 × 1,5 / 46 20	**9422A41** M12 × 1,75 / 53 30	**9422A51** M14 × 2 / 60 40		
9420A31 M10 × 1 / 46 30	**9420A41** M12 × 1 / 60 45	**9420A51** M14 × 1,5 / 62 60	**9420A61** M20 × 1,5 / 80 100	**9420A71** M27 × 2 / 102 200
9537 28 0,125	**9547** 34 0,125	**9557** 40 0,125	**9567** 52 0,125	**9577** 75 0,125
9539 28 25	**9549** 34 30	**9559** 40 40	**9569** 52 50	**9579** 75 60
9535 28 11	**9545** 34 12	**9555** 40 13	**9565** 52 15	**9575** 75 17
9533 24 7	**9543** 30 8	**9553** 36 10	**9563** 52 14	**9573** 75 20

1-Component force sensors, SlimLine

Technical data		Type	9130B...	9131B...	9132B...
					
Measuring range	Fz [1]	kN	0 ... 3	0 ... 2,5	0 ... 7
Calibrated meas. ranges	not calibrated				
Sensitivity	Fz [1]	pC/N	≈–3,5	≈–4	≈–3,8
Dimensions	D d H	mm mm mm	8 2,7 3	7 – 3	12 4,1 3
Rigidity	$c_{A,z}$	kN/µm	≈1	≈0,9	≈2,1
Weight (without cable)		g	1	1	2
Operating temperature range		°C	–20 ... 120	–20 ... 120	–20 ... 120
Connector (with integrated cable)			optional: KIAG 10–32 pos. int. or Mini-Coax neg.	optional: KIAG 10–32 pos. int. or Mini-Coax neg.	optional: KIAG 10–32 pos. int. or Mini-Coax neg.
Deg. of protection to IEC/EN 60529		IP65	•	•	•
Datasheet: see www.kistler.com			**9130B (000-110)**	**9130B (000-110)**	**9130B (000-110)**

Accessories					
Preloading disk Dimensions		**Type** G L (mm) D (mm) H (mm)	**9410A0** M2 8 8 3,5		**9410A2** M2,5 8 12 3,5

[1] without preloading

1-Component force sensor assembly kits comprising 2, 3 or 4 sensors

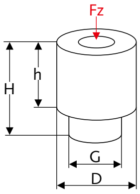
Technical data	Type	9130BA...		9132BA...
				
Assembly kit comprises	Type	9130B		9132B
Connector (sensors are connected undetachably to the flange bushing)		Fischer flange 7-pole, neg.		Fischer flange 7-pole, neg.
Deg. of protection to IEC/EN 60529 with connected cable (e.g. 1971A...)	IP65	•		•
Datasheet: see www.kistler.com		**9130BA (000-694)**		**9130BA (000-694)**

9133B...	**9134B...**	**9135B...**	**9136B...**	**9137B...**
				
0 ... 14	0 ... 26	0 ... 36	0 ... 62	0 ... 80
≈–3,8	≈–3,8	≈–3,8	≈–3,8	≈–3,8
16 6,1 3,5	20 8,1 3,5	24 10,1 3,5	30 12,1 4	36 14,1 5
≈3	≈6,3	≈7,8	≈12,8	≈18,8
3	5	7	14	27
–20 ... 120	–20 ... 120	–20 ... 120	–20 ... 120	–20 ... 120
optional: KIAG 10–32 pos. int. or Mini-Coax neg.	optional: KIAG 10–32 pos. int. or Mini-Coax neg.	optional: KIAG 10–32 pos. int. or Mini-Coax neg.	optional: KIAG 10–32 pos. int. or Mini-Coax neg.	optional: KIAG 10–32 pos. int. or Mini-Coax neg.
•	•	•	•	•
9130B (000-110)	**9130B (000-110)**	**9130B (000-110)**	**9130B (000-110)**	**9130B (000-110)**

9410A3 M3 10 16 4,25	**9410A4** M4 10 20 4,25	**9410A5** M5 10 24 4,25	**9410A6** M6 14 30 5,5	**9410A7** M8 16 36 7

9133BA...	**9134BA...**	**9135BA...**	**9136BA...**	**9137BA...**
9133B	9134B	9135B	9136B	9137B
Fischer flange 7-pole, neg.	Fischer flange 7-pole, neg.	Fischer flange 7-pole, neg.	Fischer flange 7-pole, neg.	Fischer flange 7-pole, neg.
•	•	•	•	•
9130BA (000-694)	**9130BA (000-694)**	**9130BA (000-694)**	**9130BA (000-694)**	**9130BA (000-694)**

1-Component quartz force links, slimline force link

Technical data		Type	9173B	9174B
				
Measuring range	Fz	kN	–3 ... 12	–5 ... 20
Calibrated meas. range	Fz	kN	0 ... 12	0 ... 20
Sensitivity	Fz	pC/N	≈–3,5	≈–3,5
Dimensions	D H h G	mm mm mm	18 22 14 M12×1,25	22 24 16 M16×1,5
Rigidity	$c_{A,z}$	kN/μm	≈0,7	≈1,2
Natural frequency	$f_n(z)$	kHz	≈74	≈66
Weight (without cable)		g	28	40
Operating temperature range		°C	–20 ... 80	–20 ... 80
Connector [1] (with integrated cable)			KIAG 10–32 neg.	KIAG 10–32 neg.
Deg. of protection to IEC/EN 60529		IP65	•	•
With basic insulation			•	•
Preloaded			•	•
Ready for measurement			•	•
Datasheet: see www.kistler.com			**9173B (000-112)**	**9173B (000-112)**

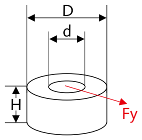
Accessories				
Force distributing cap Dimensions		**Type** D (mm) H (mm)	**9416A3** 14 6	**9416A4** 18 8

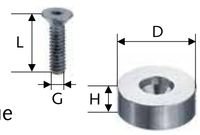
[1] plug coupling Type 1729A2 (included in delivery scope) fitted

9175B	9176B	9177B
		
–8 ... 30	–16 ... 60	–20 ... 75
0 ... 30	0 ... 60	0 ... 75
≈–3,5	≈–3,5	≈–3,5
26 28 19 M20×1,5	32 34 23 M24×2	38 38 28 M30×2
≈1,6	≈2,4	≈3,4
≈57	≈47	≈40
81	147	227
–20 ... 80	–20 ... 80	–20 ... 80
KIAG 10–32 neg.	KIAG 10–32 neg.	KIAG 10–32 neg.
•	•	•
•	•	•
•	•	•
•	•	•
9173B (000-112)	**9173B (000-112)**	**9173B (000-112)**

9416A5 22 9	**9416A6** 28 9	**9416A7** 34 9,8

1-Component force sensors, slimline for shear force

Technical data		Type	9143B...	9144B...
				
Measuring range	Fy	kN	–0,9 ... 0,9	–1,7 ... 1,7
Calibrated meas. ranges	not calibrated			
Sensitivity	Fy	pC/N	≈–6,5	≈–7,5
Dimensions	D d H	mm mm mm	16 6,1 3,5	20 8,1 3,5
Rigidity (Z-axis)	$c_{A,z}$	kN/µm	≈3	≈6,3
Rigidity (Y-axis)	$c_{S,y}$	kN/µm	≈1,2	≈2,4
Weight (without cable)		g	3	5
Operating temperature range		°C	–20 ... 120	–20 ... 120
Connector (with integrated cable)			optional: KIAG 10–32 pos. int. or Mini-Coax neg.	optional: KIAG 10–32 pos. int. or Mini-Coax neg.
Deg. of protection to IEC/EN 60529		IP65	•	•
Datasheet: see www.kistler.com			**9143B (000-113)**	**9143B (000-113)**

Accessories			
Preloading disk Dimensions Tightening torque		**Type** G L (mm) D (mm) H (mm) M (N·m)	**9410A3** M3 10 16 4,25 10

Accessories	**9410A4**
G	M4
L (mm)	10
D (mm)	20
H (mm)	4,25
M (N·m)	23

1-Component force sensor assembly kits for shear force comprising 2, 3 or 4 sensors

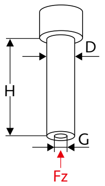
Technical data	Type	9143BA...	9144BA...
			
Assembly kit comprises	Type	9143B	9144B
Connector (nondetachable sensors are connected to the flange bushing)		Fischer flange 7-pole, neg.	Fischer flange 7-pole, neg.
Deg. of protection to IEC/EN 60529 with connected cable (e.g. 1971A...)	IP65	•	•
Datasheet: see www.kistler.com		**9143BA (000-766)**	**9143BA (000-766)**

9145B...	9146B...	9147B...
		
–2,7 ... 2,7	–4 ... 4	–8 ... 8
≈–7,5	≈–7,5	≈–8,1
24 10,1 3,5	30 12,1 4	36 14,1 5
≈7,8	≈12,8	≈18,8
≈3,1	≈5,1	≈7,1
7	14	27
–20 ... 120	–20 ... 120	–20 ... 120
optional: KIAG 10–32 pos. int. or Mini-Coax neg.	optional: KIAG 10–32 pos. int. or Mini-Coax neg.	optional: KIAG 10–32 pos. int. or Mini-Coax neg.
•	•	•
9143B (000-113)	**9143B (000-113)**	**9143B (000-113)**

9410A5 M5 10 24 4,25 46	**9410A6** M6 14 30 5,5 79	**9410A7** M8 16 36 7 135

9145BA...	9146BA...	9147BA...
9145B	9146B	9147B
Fischer flange 7-pole, neg.	Fischer flange 7-pole, neg.	Fischer flange 7-pole, neg.
•	•	•
9143BA (000-766)	**9143BA (000-766)**	**9143BA (000-766)**

1-Component quartz force link, low force

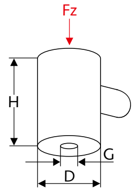
Technical data		Type	9203	9205
				
Measuring range	Fz	N	–500 ... 500	–50 ... 50
Calibrated meas. ranges	Fz Fz Fz	N N N	0 ... 5 0 ... –50 / 0 ... 50 0 ... –500 / 0 ... 500	0 ... –0,5 / 0 ... 0,5 0 ... –5 / 0 ... 5 0 ... –50 / 0 ... 50
Sensitivity	Fz	pC/N	≈–45	≈–115
Dimensions	D H G	mm	M10×1 28,5 M3 (female thread)	M10×1 28,5 M3 (female thread)
Rigidity	$c_{A,z}$	N/µm	≈40	≈4
Natural frequency	$f_n(z)$	kHz	>27	>10
Weight		g	13	19
Operating temp. range [1]		°C	–150 ... 240	–50 ... 150
Connector			KIAG 10–32 neg.	KIAG 10–32 neg., radial
Deg. of protection to IEC/EN 60529 screwed with cable (e.g. 1631C...) welded with cable (e.g. 1983AD...)		 IP65 IP67	 • •	 • •
Preloaded			•	•
Ready for measurement			•	•
Datasheet: see www.kistler.com			**9203 (000-127)**	**9205 (000-129)**

Accessories				
Coupling element Dimensions		**Type** D (mm) H (mm)	**9405** 6,3 18	**9405** 6,3 18
Force introducing cap Dimensions		**Type** D (mm) H (mm)	**3.220.139** 6,3 7	**3.220.139** [2] 6,3 7

[1] operating temperature range depends on the cable used
[2] included in delivery

9207	9215A	9217A
		
–50 ... 50	–20 ... 200	–500 ... 500
0 ... –0,5 / 0 ... 0,5 0 ... –5 / 0 ... 5 0 ... –50 / 0 ... 50	0 ... 2 0 ... 20 0 ... 200	0 ... 5 0 ... –50 / 0 ... 50 0 ... –500 / 0 ... 500
≈–115	≈–95	≈–105
M10×1 28,5 M3 (female thread)	M5×0,5 12,5 M2 (female thread)	M10×1 28,5 M3 (female thread)
≈4	≈100	≈15
>10	>50	>20
19	2,5	16
–50 ... 150	–50 ... 180	–80 ... 205
KIAG 10–32 neg., axial	M4×0,35 neg.	KIAG 10–32 neg.
• •	• •	• •
•	•	•
•	•	•
9207 (000-130)	**9215 (000-487)**	**9217A (000-546)**
9405 6,3 18		**9405** 6,3 18
3.220.139 [2)] 6,3 7	**3.220.217** [2)] 4 3,8	**3.220.139** 6,3 7

1-Component quartz force link, miniature

Technical data		Type	9210	9211B
				
Measuring range	Fz	kN	0 ... 0,25	0 ... 2,5
Calibrated meas. ranges	Fz Fz	kN kN	 0 ... 0,25	0 ... 0,25 0 ... 2,5
Rigidity	$c_{A,z}$	kN/µm	0,4	0,4
Natural frequency	$f_n(z)$	kHz	>200	≈200
Sensitivity	Fz	pC/N	≈–10	≈–4,4
Dimensions	D H G	mm mm	3,5 4,7	6 6
Weight		g	1	1,5
Operating temp. range [1]		°C	–40 ... 200	–40 ... 200
Connector			Fischer 102 Triax	Fischer 102 Triax
Cable technology Single wire with/without plug Coaxial Replaceable cable			 •	 • • •
Deg. of protection to IEC/EN 60529		IP65	•	•
Preloaded				
Ready for measurement			•	•
Datasheet: see www.kistler.com			**9210 (000-601)**	**9211 (000-555)**

Accessories			
Thrust washer [2] Dimensions	**Type** D (mm) H (mm)	**9406** 3,4 2	**9411** 5,5 2

[1] operating temperature range depends on the cable used
[2] included in delivery

9213B	**9204**	**9212**
		
0 ... 2,5	0 ... 10	–2,2 ... 22,2
0 ... 0,25 0 ... 2,5	0 ... 1,0 0 ... 10	0 ... 2,2 0 ... 22,2
0,26	0,16	0,87
≈200	≈80	≈70
≈–4,4	≈–1,6	≈–11
6 8,5 M2,5 (female thread)	12,6 9,5 M2,5 (female thread)	17,8 12,7 10-32 UNF
2	8	19
–40 ... 200	–40 ... 200	–196 ... 150
Fischer 102 Triax	Fischer 102 Triax	10–32 UNF
• • •	• • •	 • •
•	•	•
		•
•	•	•
9213 (000-132)	**9204 (000-128)**	**9212 (000-418)**
9413 5,5/2,8 2		

Multi-component force sensors

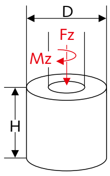
Kistler's piezoelectric sensors with multiple measuring directions are the elite class of piezoelectric force measuring instruments. These highly sensitive measuring elements are compactly embedded in the case, which is made of selected high-grade steel.

Multi-component load washers are the basic elements of the measurement technology. The sensor elements themselves are only slightly preloaded; they are integrated into the customer's structure and installed with the required preload. This preload corresponds to a load offset. Our Force Links can be used directly by customers for immediate measurements. These preloaded quartz Force Links are calibrated in the factory. They can be used in both directions along all measuring axes.

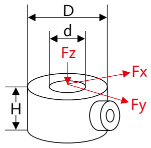
Multi-component force sensors are generally installed in groups of four, in what are known as dynamometers or measurement platforms. Single signals from the piezoelectric sensors can be summed by grouping the individual connectors together. This makes it possible to set up dynamometers that cover the range from 3-component force measurements to 6-component force/moment measurements. For this purpose, Kistler offers prepared sensor kits, as well as ready-to-use dynamometers.

Benefits
- Multi-component measurement
- Extremely rigid, so high natural frequencies can be attained
- Durable
- High loading capacity
- Compact design

2-Component sensors, miniature

Technical data		Type	9345B	9365B
				
Measuring range	Fz Mz	kN N·m	–10 ... 10 –25 ... 25	–20 ... 20 –200 ... 200
Calibrated meas. ranges	Fz Mz	kN N·m	0 ... 1 0 ... 10 0 ... –2,5 / 0 ... 2,5 0 ... –25 / 0 ... 25	0 ... 2 0 ... 20 0 ... –20 / 0 ... 20 0 ... –200 / 0 ... 200
Rigidity (calculated)	$c_{A,z}$ $c_{T,z}$	kN/µm N·m/µm	≈1,7 ≈0,19	≈2,8 ≈0,92
Natural frequency	f_n(z) f_n(Mz)	kHz kHz	>41 >32	>33 >25
Sensitivity	Fz Mz	pC/N pC/N·m	≈–3,7 ≈–190	≈–3,6 ≈–140
Dimensions	D H	mm mm	39 42	56.5 60
Weight		g	267	834
Operating temperature range		°C	–40 ... 120	–40 ... 120
Connector			V3 neg.	V3 neg.
Deg. of protection to IEC/EN 60529 screwed with cable (e.g. 1698AD...)		IP65	•	•
Preloaded			•	•
Ready for measurement			•	•
Datasheet: see www.kistler.com			**9345B (000-630)**	**9345B (000-630)**

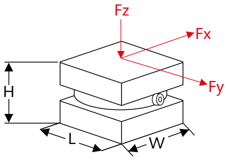
3-Component force sensors

Technical data		Type	9017C/9018C	9027C/9028C
				
Measuring ranges	Fx, Fy Fz	kN kN	–1,5 ... 1,5 –3 ... 3 Standard installation with 9,5 kN preloading	–4 ... 4 –8 ... 8 Standard installation with 20 kN preloading
Calibrated meas. ranges	Fx, Fy Fz Fz (without preloading)	kN kN kN	0 ... 1,5 0 ... 3 0 ... 12,5	0 ... 4 0 ... 8 0 ... 28
Sensitivity	Fx, Fy Fz	pC/N pC/N	≈–25 ≈–11	≈–7,8 ≈–3,8
Dimensions	D d H	mm mm mm	19 6,5 10	28 8,1 12
Rigidity	$c_{S,xy}$ $c_{A,z}$	kN/µm kN/µm	0,3 1,4	0,6 2,2
Weight		g	14	30
Operating temperature range		°C	–40 ... 120	–40 ... 120
Connector			V3 neg.	V3 neg.
Deg. of protection to IEC/EN 60529 screwed with cable (e.g. 1698AA/AB) welded with cable (e.g. 1698ACsp)		 IP65 IP67	 • •	 • •
Datasheet: see www.kistler.com			**9017C (000-960)**	**9027C (000-726)**

Accessories				
Preloading element Thread × pitch/length Preloading force		Type Fv (kN)	**9460** M6 × 0,75 / 29 9,5	**9461** M8 × 1 / 40 20
Wrench adapter		Type	**9479**	**9475**
Preloading element Thread × pitch/length Preloading force		Type Fv (kN)		
Wrench adapter		Type		
Preloading element Thread × pitch/length Preloading force		Type Fv (kN)		
Wrench adapter		Type		

9047C/9048C	9067C/9068C	9077C/9078C
		
–15 ... 15 –30 ... 30 Standard installation with 70 kN preloading	–30 ... 30 –60 ... 60 Standard installation with 140 kN preloading	–75 ... 75 –150 ... 150 Standard installation with 350 kN preloading
0 ... 15 0 ... 30 0 ... 100	0 ... 30 0 ... 60 0 ... 200	0 ... 75 0 ... 150 0 ... 500
≈–8,1 ≈–3,7	≈–8,1 ≈–3,9	≈–4,2 ≈–2
45 14,1 14	65 26,5 21	105 40,5 26
1,9 6,1	2,4 8	8,4 26
91	285	1040
–40 ... 120	–40 ... 120	–40 ... 120
V3 neg.	V3 neg.	V3 neg.
• •	• •	• •
9047C (000-592)	**9067C (000-609)**	**9077C (000-610)**
9465 M14 × 1,5 / 57 70	**9451A** M20 × 1,5 / 78 140	
9472	**9471**	
		9455 M40 × 2 / 105 350
		9473
	9459 M26 × 0,75 / 76 140	
	9477	

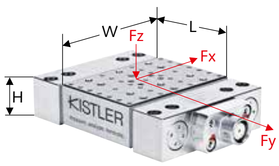
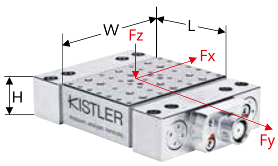
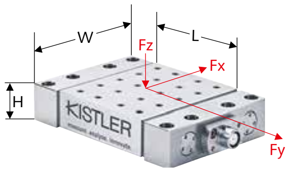
3-Component quartz force links

Technical data		Type	9317C	9327C
				
Measuring ranges	Fx, Fy Fz	kN kN	–0,5 … 0,5 –3 … 3	–1 … 1 –8 … 8
Calibrated meas. ranges	Fx, Fy Fz	kN kN	0 … 0,05 / 0 … 0,5 0 … 0,3 / 0 … 3	0 … 0,1 / 0 … 1 0 … 0,8 / 0 … 8
Sensitivity	Fx, Fy Fz	pC/N pC/N	≈–25 ≈–11	≈–7,8 ≈–3,8
Dimensions	L×W×H	mm	25×25×30	42×42×42
Rigidity	$c_{S,xy}$ [1] $c_{A,z}$	kN/µm kN/µm	0,19 0,9	0,39 1,4
Natural frequency	$f_n(x)$, $f_n(y)$ $f_n(z)$	kHz kHz	≈5,6 ≈20	≈3,2 ≈12
Weight		g	85	380
Operating temperature range		°C	–40 … 120	–40 … 120
Connector			V3 neg.	V3 neg.
Deg. of protection to IEC/EN 60529 screwed with cable (e.g. 1698AA/AB) welded with cable (e.g. 1698ACsp)		 IP65 IP67	 • •	 • •
With basic insulation			•	•
Preloaded			•	•
Ready for measurement			•	•
Datasheet: see www.kistler.com			**9317C (003-124)**	**9327C (000-725)**

[1] disregarding bending

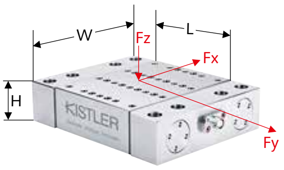
9347C	9367C	9377C
		
–5 ... 5 –30 ... 30	–10 ... 10 –60 ... 60	–30 ... 30 –150 ... 150
0 ... 0,5 / 0 ... 5 0 ... 3 / 0 ... 30	0 ... 1 / 0 ... 10 0 ... 6 / 0 ... 60	0 ... 3 / 0 ... 30 0 ... 15 / 0 ... 150
≈–7,8 ≈–3,7	≈–7,6 ≈–3,9	≈–3,9 ≈–1,95
55×55×60	80×80×90	120×120×125
0,89 2,7	1,2 3,8	3,2 8,2
≈3,6 ≈10	≈2,4 ≈6	≈2 ≈6
1000	3000	10500
–40 ... 120	–40 ... 120	–40 ... 120
V3 neg.	V3 neg.	V3 neg.
 • •	 • •	 • •
•	•	•
•	•	•
•	•	•
9347C (000-604)	**9367C (000-613)**	**9377C (000-612)**

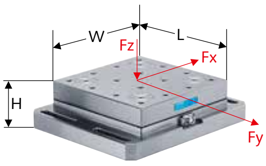
Multi-component dynamometers / force measurement platforms

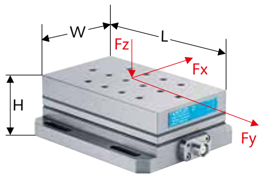
Technical data		Type	9119AA1	9119AA2	9129AA
					
Measuring range	Fx, Fy	kN	–4 … 4	–4 … 4	–10 … 10
	Fz	kN	–4 … 4	–4 … 4	–10 … 10
	Mz	Nom			
Calibrated meas. ranges	Fx, Fy	kN	0 … 0,04	0 … 0,04	0 … 0,1
			0 … 0,4	0 … 0,4	0 … 1
			0 … 4	0 … 4	0 … 10
	Fz	kN	0 … 0,04	0 … 0,04	0 … 0,1
			0 … 0,4	0 … 0,4	0 … 1
			0 … 4	0 … 4	0 … 10
	Mz	N·m			
Natural frequency	$f_n(x)$	kHz	≈6,0	≈4,3	≈3,5
	$f_n(y)$	kHz	≈6,4	≈4,6	≈4,5
	$f_n(z)$	kHz	≈6,3	≈4,4	≈3,5
	$f_n(Mz)$	kHz			
Sensitivity	Fx	pC/N	≈–26	≈–26	≈–8
	Fy	pC/N	≈–13	≈–13	≈–4,1
	Fz	pC/N	≈–26	≈–26	≈–8
	Mz	pC/Nm			
Dimensions	L	mm	39	55	90
	W	mm	80	80	105
	H	mm	26	26	32
	D	mm			
Weight		kg	0,93	1,35	3,2
Operating temperature range		°C	–20 … 70	–20 … 70	–20 … 70
Connector			Fischer flange, 9-pole, neg.	Fischer flange, 9-pole, neg.	Fischer flange, 9-pole, neg.
Deg. of protection to IEC/EN 60529 with cable connected		IP67	•	•	•
Ready for measurement			•	•	•
Datasheet: see www.kistler.com			**9119AA1 (003-060)**	**9119AA2 (003-055)**	**9129AA (000-709)**

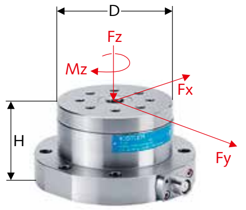
Accessories				
Connecting cable 	**Type**	**1687B5 (3-component), 1677A5 (6-component)**	**1687B5 (3-component), 1677A5 (6-component)**	**1687B5 (3-component), 1677A5 (6-component)**
		**1689B5 (3-component), 1679A5 (6-component)**	**1689B5 (3-component), 1679A5 (6-component)**	**1689B5 (3-component), 1679A5 (6-component)**

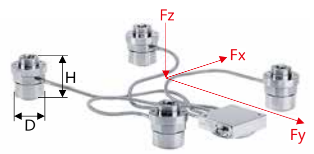
[1] depending on cover plate size and material
[2] mounted on steel cover plate, 300 × 300 × 35 mm











9139AA	9255C	9257B	9272	9366CC...
–30 … 30 –30 … 30	–30 … 30 –10 … 60	–5 … 5 –5 … 10	–5 … 5 –5 … 20 –200 … 200	–25 … 25 [1] –25 … 60 [1]
0 … 0,3 0 … 3 0 … 30 0 … 0,3 0 … 3 0 … 30	0 … 3 0 … 30 0 … 6 0 … 60	0 … 0,5 0 … 5 0 … 1 0 … 10	0 … 0,5 0 … 5 0 … 2 0 … 20 0 … ±20 0 … ±200	0 … 2,5 [1] 0 … 25 [1] 0 … 6 [1] 0 … 60 [1]
≈2,9 ≈2,9 ≈3,0	≈2,2 ≈2,2 ≈3,3	≈2,3 ≈2,3 ≈3,5	≈3,1 ≈3,1 ≈6,3 ≈4,2	≈0,2 … ≈1,6 [2] ≈0,2 … ≈1,6 [2] ≈0,2 … ≈1,6 [2]
≈–8,2 ≈–4,2 ≈–8,2	≈–7,9 ≈–7,9 ≈–3,9	≈–7,5 ≈–7,5 ≈–3,7	≈–7,8 ≈–7,8 ≈–3,5 ≈–160	≈–7,8 ≈–7,8 ≈–308
140 190 58	260 260 95	170 100 60	 70 100	 90 72
12,9	52	7,3	4,2	7
–20 … 70	–20 … 70	0 … 70	0 … 70	–20 … 70
Fischer flange, 9-pole, neg.	Fischer flange, 9-pole, neg.	Fischer flange, 9-pole, neg.	Fischer flange, 9-pole, neg.	Fischer flange, 9-pole, neg.
•	•	•	•	•
•	•	•	•	
9139AA (003-198)	**9255C (003-051)**	**9257B (000-151)**	**9272 (000-153)**	**9366C (000-681)**

1687B5 (3-component), 1677A5 (6-component)	**1687B5 (3-component), 1677A5 (6-component)**	**1687B5 (3-component), 1677A5 (6-component)**	**1677A5 (6-component)**	**1687B5 (3-component), 1677A5 (6-component)**
1689B5 (3-component), 1679A5 (6-component)	**1689B5 (3-component), 1679A5 (6-component)**	**1689B5 (3-component), 1679A5 (6-component)**	**1679A5 (6-component)**	**1689B5 (3-component), 1679A5 (6-component)**

Strain sensors

Piezoelelectric sensors from Kistler can be used for high-resolution measurements of the strains occurring on a structure.

To achieve this, the sensor is mounted in a suitable position. If an indirect force measurement is required, the sensor is calibrated. The relevant factors here are the geometry of the structure, the material's modulus of elasticity and the mechanical stress.

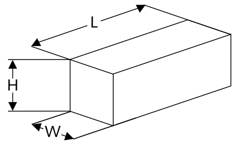
$\sigma = \frac{F}{A}$ and strain $\varepsilon = \frac{\Delta l}{l_0}$

Surface strain sensors are attached to the structure with the mounting screw. The structure's strain is transmitted to the measuring element through static friction.

Strain measuring pins need a cylindrical mounting bore in which the sensor is then inserted and preloaded. Kistler offers strain measurement sensors with axial and radial alignment to the axis of the bore hole.

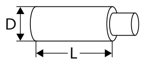
Benefits
- Durable, no creep
- Protected against overload
- Cost-to-benefit ratio
- High loading capacity
- Simple to install
- Fault-resistant
- Straightforward retrofitting

Surface strain sensor

Technical data		Type	9232A...	9237B...	9238B...
					
Measuring range		με	–600 ... 600	–800 ... 800	–20 ... 20 to –800 ... 800
Calibrated meas. ranges*		με	0 ... –300 0 ... 300	0 ... 500	0 ... 50 0 ... 500
Sensitivity*		pC/με	≈–80	≈–34	
Output signal		V			±10 (programmable ±1 ... 10)
Dimensions	L W H	mm mm mm	40 17 15	51,5 25,4 26,7	68,1 26,9 27,5
Natural frequency	f_n	kHz	≥12	≥6	
Weight		g	50	165/190	190
Operating temperature range		°C	0 ... 70	–30 ... 120	–10 ... 70
Connector			KIAG 10–32 neg.	KIAG 10–32 neg.	M12×1 8-pole, shielded
Serial interface					RS-232C
Deg. of protection to IEC/EN 60529					
screwed with cable (e.g. 1631C...)		IP65	•	•	
welded with cable (e.g. 1983C...)		IP67	•		
screwed with cable (e.g. 1787A...)		IP67			•
Ready for measurement			•	•	•
Datasheet: see www.kistler.com			**9232A (000-137)**	**9237B (000-823)**	**9238B (000-822)**

* Data valid only for the test setup used at Kistler.
For precise force measurements, the sensor must be recalibrated after it is mounted.

Strain measuring pin

Technical data		Type	9240A...	9241C...
				
Measuring range		με	0 ... 500	0 ... 500
Calibrated meas. ranges*		με	0 ... 200	0 ... 200
Sensitivity*		pC/με	≈–9,5	≈–15
Dimensions	D L	mm mm	8 14,5	10 18
Hollow preloading bolt				
Natural frequency	f_n	kHz		
Weight		g	34	38
Operating temperature range		°C	–40 ... 200	–40 ... 200
Connector			acc. to choice: KIAG 10–32 pos. M3 pos.	acc. to choice: KIAG 10–32 pos. Mini-Coax neg.
Deg. of protection to IEC/EN 60529 with connected cable with cable Type 1983AB... and welded-on plug		IP64 IP67	•	•
Datasheet: see www.kistler.com			**9240A (003-229)**	**9241C (000-140)**

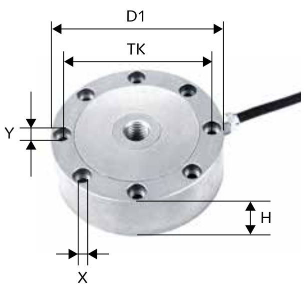
Accessories			
Mounting tool	**Type**	**1300A161A100**	**1393B**
	Type	**1300A163A300**	**1393Bsp100-300**
Force distributing cap	**Type**		
Ground isolation set	**Type**		
Reamer	**Type**		
Screw tap	**Type**		

* Data valid only for the test setup used at Kistler.
For precise force measurements, the sensor must be recalibrated after it is mounted.

9243B...	9245B..., 9245B3	9247A...
		
–1500 ... 1500 (with nominal preload)	–1500 ... 1500 (with nominal preload)	–1400 ... 1400 (with nominal preload)
0 ... 350	0 ... 350	not calibrated
≈–15	≈15	≈8,6
8 13	M10×1 29	M5×0,5 23,7
M10×1		
>110	>50	
4,8 (without cable and preloading screw)	36	2,5
–40 ... 200	–40 ... 350	–40 ... 200
M4×0,35 neg.	Fischer KE 102 neg.	M4×0,35 neg.
• •	 • 	• •
9243B (000-538)	**9245B (000-142)**	**9247A (000-143)**

1385A200		**1300A9**
1385sp100-800 / 1387sp100-800		
9841		
9487A		
1300A21	**1300A21**	**1300A79 / 1300A79Q01**
		1357A

1-Component strain gage force sensors



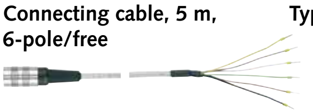
Type 4576A...

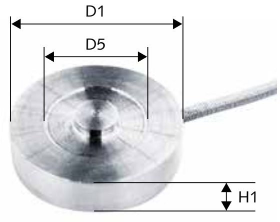
Technical data		Type	4576A0,5...	4576A1...	4576A2...
Measuring range	Fz	kN	–0,5 ... 0,5	–1 ... 1	–2 ... 2
Dimensions	H	mm	16	16	16
	D1	mm	54,5	54,5	54,5
	TK	mm	45	45	45
	X	mm	4,5	4,5	4,5
	Y	mm	8	8	8

Technical data		Type	4576A5...	4576A10...	4576A20...
Measuring range	Fz	kN	–5 ... 5	–10 ... 10	–20 ... 20
Dimensions	H	mm	16	16	25
	D1	mm	54,5	54,5	79
	TK	mm	45	45	68
	X	mm	4,5	4,5	4,5
	Y	mm	8	8	8

Technical data		Type	4576A50...	4576A100...	4576A200...
Measuring range	Fz	kN	–50 ... 50	–100 ... 100	–200 ... 200
Dimensions	H	mm	35	50	50
	D1	mm	119	155	155
	TK	mm	105	129	129
	X	mm	6,6	13,5	13,5
	Y	mm	11	20	20

General technical data		
Nominal sensitivity	mV/V	1,5 (optional: 1,0)
Weight	Kg	0,25 ... 5,0
Operating temperature range	°C	15 ... 70
Service temperature range	°C	–30 ... 80
Bridge resistance	Ω	350
Connector for maXYmos family		D-Sub 9-pole plug
Deg. of protection to IEC/EN 60529		IP52 (0 ... 10 kN) IP67 (20 ... 200 kN)
Datasheet: see www.kistler.com		**4576A (000-675)**

Accessories		
Connecting cable, 5 m, 6-pole/6-pole 	**Type**	**KSM071860-5**
Connecting cable, 5 m, 6-pole/free 	**Type**	**KSM103820-5**



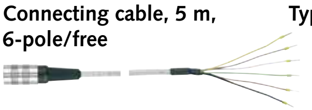
Type 4577A...

Technical data		Type	4577A0,1	4577A0,2	4577A0,5	4577A1
Measuring range	Fz	kN	0,1	0,2	0,5	1
Bridge resistance		Ω	350	350	350	350
Dimensions	H1	mm	9,9	9,9	9,9	9,9
	D1	mm	31,8	31,8	31,8	31,8
	D5	mm	19	19	19	19

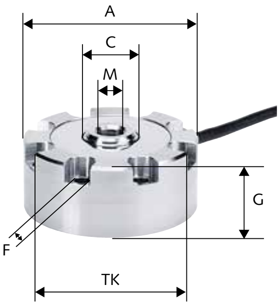
Technical data		Type	4577A2	4577A5	4577A10	4577A20
Measuring range	Fz	kN	2	5	10	20
Bridge resistance		Ω	350	700	700	700
Dimensions	H1	mm	9,9	9,9	9,9	16
	D1	mm	31,8	31,2	31,2	37,6
	D5	mm	19	19,5	19,5	25,7

Technical data		Type	4577A50	4577A100	4577A200
Measuring range	Fz	kN	50	100	200
Bridge resistance		Ω	700	700	350
Dimensions	H1	mm	16	25,4	38,1
	D1	mm	37,6	50,3	76,2
	D5	mm	25,7	34,7	45

General technical data		
Nominal sensitivity	mV/V	1
Weight	Kg	0,04 ... 1,2
Operating temperature range	°C	15 ... 70
Service temperature range	°C	–20 ... 100
Connector for maXYmos family		D-Sub 9-pole plug
Deg. of protection to IEC/EN 60529		IP64
Datasheet: see www.kistler.com		**4577A (000-674)**

Accessories		
Connecting cable, 5 m, 6-pole/6-pole 	**Type**	**KSM071860-5**
Connecting cable, 5 m, 6-pole/free 	**Type**	**KSM103820-5**

1-Component strain gage force sensors



Type 4579A...

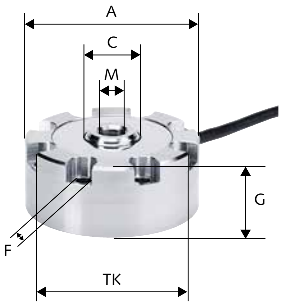
Technical data		Type	4578A0,1	4578A0,2	4578A0,5
Measuring range	Fz	kN	–0,1 ... 0,1	–0,2 ... 0,2	–0,5 ... 0,5
Dimensions	A	mm	70	70	70
	C	mm	20	20	20
	F	mm	6,4	6,4	6,4
	M	mm	M12	M12	M12
	G	mm	28	28	28
	TK	mm	60	60	60

Technical data		Type	4578A1	4578A2	4578A5
Measuring range	Fz	kN	–1 ... 1	–2 ... 2	–5 ... 5
Dimensions	A	mm	70	70	70
	C	mm	20	20	20
	F	mm	6,4	6,4	6,4
	M	mm	M12	M12	M12
	G	mm	28	28	28
	TK	mm	60	60	60

Technical data		Type	4578A10
Measuring range	Fz	kN	–10 ... 10
Dimensions	A	mm	70
	C	mm	20
	F	mm	6,4
	M	mm	M12
	G	mm	28
	TK	mm	60

General technical data		
Nominal sensitivity	mV/V	2,0±0,005
Weight (without cable)	Kg	≤0,5
Operating temperature range	°C	15 ... 50
Service temperature range	°C	–20 ... 50
Bridge resistance	Ω	350
Connector for maXYmos family		D-Sub 9-pole plug
Deg. of protection to IEC/EN 60529		IP42
Datasheet: see www.kistler.com		**4578A (000-866)**

Accessories		
Force distributing cap	**Type**	**4578AZ01**



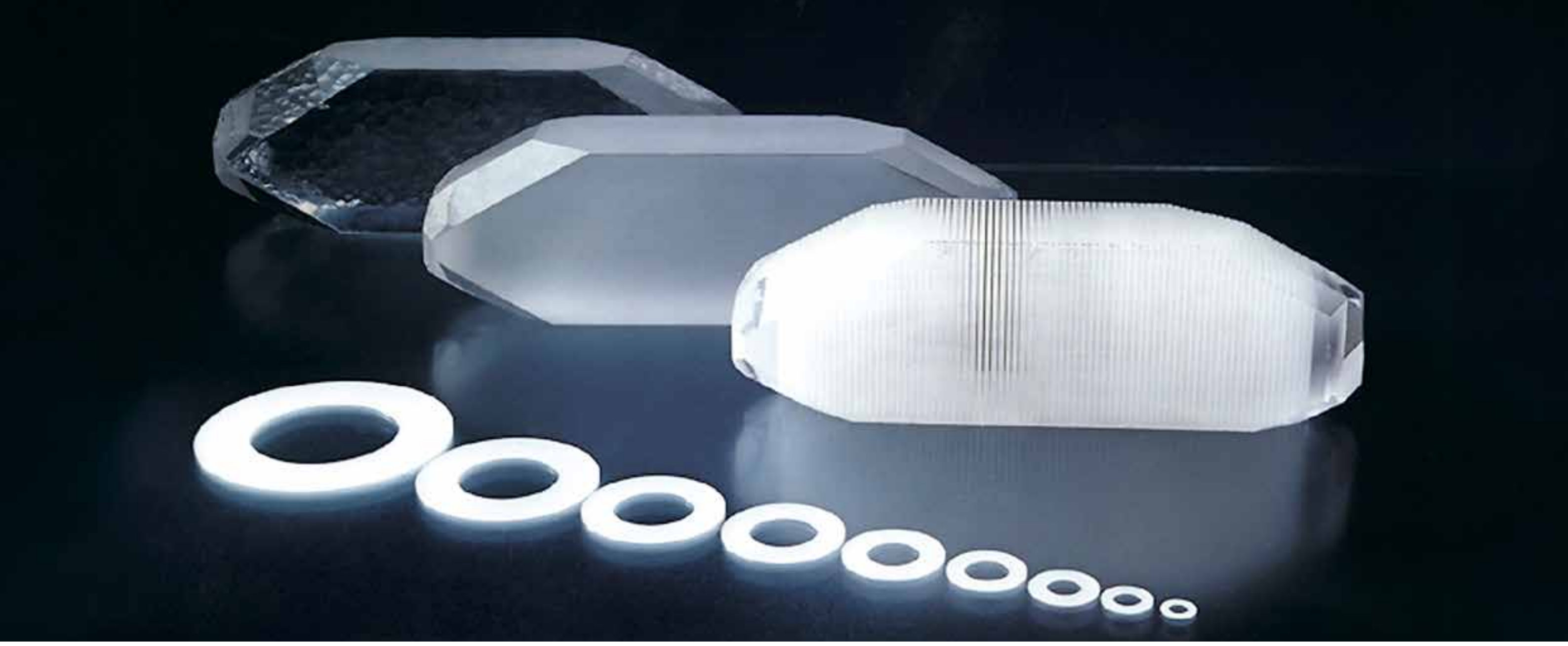
Type 4579A...

Technical data		Type	4579A20	4579A50	4579A100
Measuring range	Fz	kN	–20 ... 20	–50 ... 50	–100 ... 100
Dimensions	A	mm	150	150	165
	C	mm	40	40	50
	F	mm	11	11	13
	M	mm	M24×2	M24×2	M36×3
	G	mm	40	40	42
	TK	mm	130	130	145

Technical data		Type	4579A200	4579A300	4579A500
Measuring range	Fz	kN	–200 ... 200	–300 ... 300	–500 ... 500
Dimensions	A	mm	165	203	203
	C	mm	50	94	94
	F	mm	13	13	13
	M	mm	M36×3	M45×3	M45×3
	G	mm	42	64	64
	TK	mm	145	165	165

General technical data		
Nominal sensitivity	mV/V	2,0±0,005
Weight (without cable)	Kg	3,7 ... 14,4
Operating temperature range	°C	15 ... 50
Service temperature range	°C	–20 ... 50
Bridge resistance	Ω	350
Connector for maXYmos family		D-Sub 9-pole plug
Deg. of protection to IEC/EN 60529		IP67
Datasheet: see www.kistler.com		**4579A (000-867)**

Accessories		
Force distributing cap, measuring range 20/50 kN	**Type**	**4579AZ20/50**
Force distributing cap, measuring range 100/200 kN	**Type**	**4579AZ100/200**
Force distributing cap, measuring range 300/500 kN	**Type**	**4579AZ300/500**



Most Kistler sensors operate with a measuring element that essentially consists of thin quartz plates, disks or rods

Basics of measurement technology

Piezoelectric measurement technology

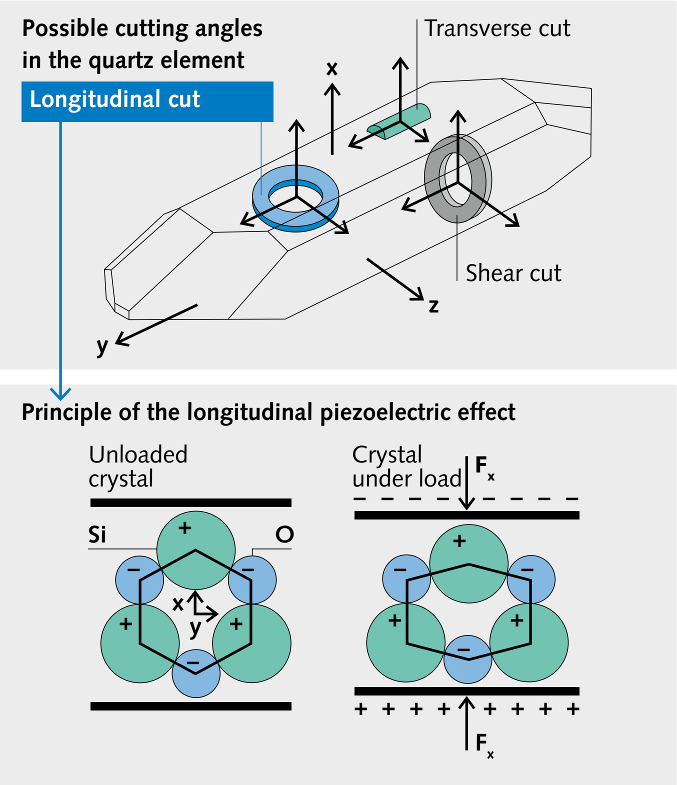
Kistler offers piezoelectric and strain gage sensors. The piezoelectric sensors are ideal for measuring tasks with exceptionally extreme requirements with regard to geometry, temperature range and dynamics. Kistler therefore relies mainly on the piezoelectric principle for measuring dynamic forces in assembly and testing.

Pierre and Jacques Curie discovered the piezoelectric effect in 1880. When placed under a mechanical load (Greek "piezein": to press or squeeze), piezoelectric materials generate electrical charges. The finite insulation resistance means that purely static measurements are impossible with piezoelectric sensors. Together with signal conditioning devices from Kistler, however, these sensors have excellent quasistatic and dynamic measurement properties.

In 1950, Walter P. Kistler patented the charge amplifier for piezoelectric signals, paving the way for the exploitation of an effect that had been known for decades.

Particularly good use can be made of the piezoelectric effect with a quartz crystal: when subject to a mechanical load, it generates a charge signal that is directly proportional to the acting force. The benefit: due to the high rigidity of the crystal, the measuring deflection is low. Quartz can be used to cut both pressure-sensitive and shear-sensitive elements. Various piezo-effects are differentiated according to the position of the polar crystal axes in relation to the acting force:

- Longitudinal effect
- Shear effect
- Transverse effect



Benefits

- Compact size
- Extensive force measuring range
- Excellent overload protection
- No wear
- High rigidity and natural frequency
- Measurements without almost any deflection are possible

Longitudinal effect

A charge is developed on the surfaces to which the force is applied, where it can be measured via electrodes. In the case of the longitudinal piezoelectric effect, the magnitude of the electric charge Q depends on the piezoelectric coefficient and the applied force F_x and not on the dimensions of the crystal disks. The only way to increase this charge yield is to connect several disks mechanically in series and electrically in parallel (factor n). The magnitude of the output charge then becomes:

$$Q_x = d_{11} \cdot F_x \cdot n$$

The piezoelectric coefficient d_{11} is dependent on direction, and it indicates the crystal's degree of force sensitivity in the direction of the corresponding crystallographic axis. The position of the crystal cut therefore determines the properties and purpose of use the quartz force link. Piezoelectric elements cut to produce the longitudinal effect are sensitive to compression forces and therefore mainly suitable for simple and sturdy sensors to measure forces.

Shear effect

Similarly to the longitudinal effect, the piezoelectric sensitivity involved in the shear effect is independent of the size and shape of the piezoelectric element. In this case too, the charge is developed on the piezo element's loaded surfaces. For a load in the x-direction applied to n elements connected mechanically in series and electrically in parallel, the charge is:

$$Q_x = 2 \cdot d_{11} \cdot F_x \cdot n$$

Shear-sensitive piezo elements are used for sensors measuring shear forces, torque and strain, and also for acceleration sensors. They are suitable for manufacturing sensors whose excellent performance is unaffected by temperature fluctuations, as the changes in the stresses (preloading) in the sensor structure – caused by temperature fluctuations – act in a direction perpendicular to the sensitive shear axis.

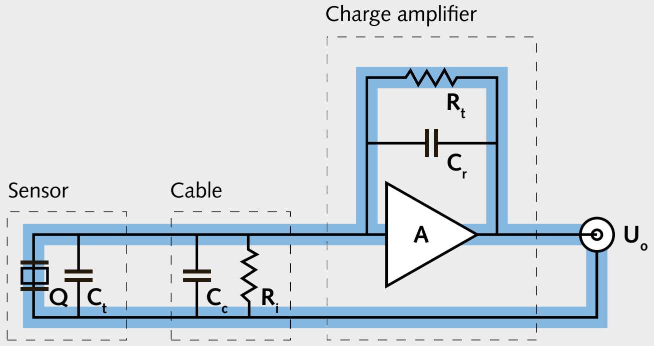
Transverse effect

In the transverse effect, a force F_y acting in the direction of one of the electrical crystal axes y produces a charge on the surfaces of the corresponding electrical axis x. In contrast to the longitudinal piezoelectric effect, the magnitude of this charge (which occurs on the unloaded surfaces) is dependent on the geometric dimensions of the piezoelectric element. Assuming a solid rectangular element with dimensions a (thickness) and b (height/length), the charge is:

$$Q_y = -d_{11} \cdot F_y \cdot b/a$$

The transverse effect therefore makes it possible to obtain a greater charge yield through suitable shaping and alignment of the piezoelectric elements. Elements exhibiting this effect can be used for high-sensitivity pressure, strain and force sensors.

Block diagram of a measuring chain



U_o = Output voltage
A = Amplification factor
C_t = Sensor capacitance
C_c = Cable capacitance
C_r = Range or negative feedback capacitor
R_t = Time constant resistance (or insulation resistance of range capacitor)
R_i = Input insulation resistance (cable and sensor)
Q = Electric charge yielded by the piezoelectric element

Charge amplifiers

Charge amplifiers convert the charge produced by a piezoelectric sensor into a proportional voltage:

$$U_o = \frac{-Q}{C_r} \cdot \frac{1}{1+\frac{1}{AC_r}(C_t+C_r+C_c)}$$

the amplifier acts as an integrator, constantly compensating the electrical charge produced by the sensor on the range capacitor, in proportion to the acting measurand. Most Kistler charge amplifiers allow adjustment of sensor sensitivity and measuring range.

Time constant and drift

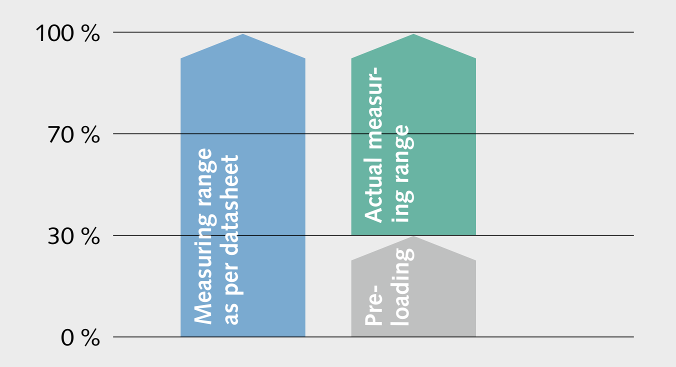
Two of the more important considerations in the practical use of charge amplifiers are the time constant and the drift. The time constant τ is defined as the discharge time of a capacitor by which 1/e (37 %) of the initial value has been reached:

$$\tau = R_t \cdot C_t$$

Drift is defined as an undesirable change in the output signal over a long period of time. This drift determines the potential duration of quasistatic measurements.

Measuring methods

Kistler's sensors allow both direct and indirect force measurements. This permits flexible positioning of the sensors, so solutions are available for every conceivable measuring task.

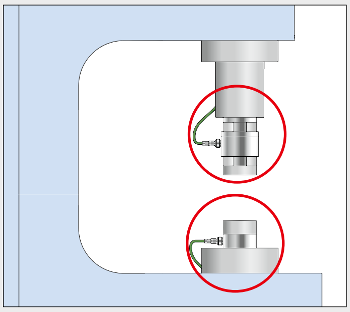


Preloading

To achieve measurements of the desired accuracy, piezoelectric sensors are preloaded by 20 % to 70 % for symmetrical compression and tensile forces, depending on their design and application. Therefore, the resultant measuring range actually corresponds to the total measuring range stated on the datasheet less the preloading value.

Installation variants

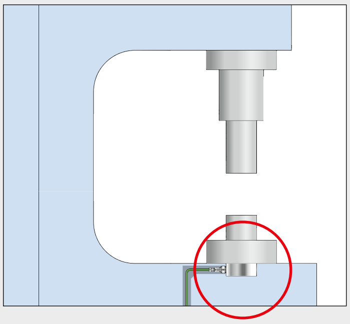
For direct measurements, the sensor is positioned fully in the force flux, and it measures the entire force. This approach yields high measurement accuracy that is virtually independent of the force application point. If the sensor cannot be positioned directly in the force flux, it will only measure part of the force; the remainder passes through the structure in which it is mounted (known as the force shunt). With indirect force measurement, strain sensors are used to measure the process force via the structural strain. The deformation resulting from application of force to a structure can be measured as force-proportional strain. The process force is therefore determined indirectly from the surface or structural strain. Kistler strain sensors internally convert strain into a proportional force, and generate a corresponding charge signal. This is why they are often referred to as force-strain sensors. The sensitivity is determined as electric charge Q (pC) per unit strain με (μm/m).



Direct force measurement in the force flux
In this case, the entire process force passes through the sensor (force shunt quota n <≈10 %).

The sensor is mounted fully in the force flux and it measures the entire process force.

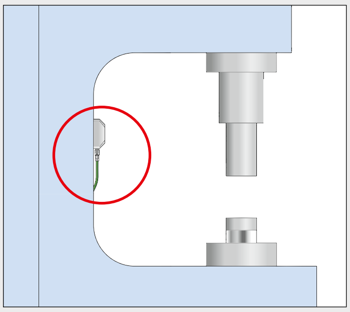
Benefits
- High sensitivity
- High measuring accuracy
- High repeatability
- Good linearity and low hysteresis
- Wide range of preloaded calibrated sensors that are easy to mount



Force shunt measurement
A fraction of the process force passes through the sensor (n ≈10 ... 99 %).

The sensor is installed in the machine's structure. Most of the process force usually passes into the shunt.

Benefits
- Overload protection
- Cost-effective design
- Measurement of process forces up to 100/(100–n) times the sensor’s measuring range
- Good measurement accuracy under constant conditions
- High repeatability



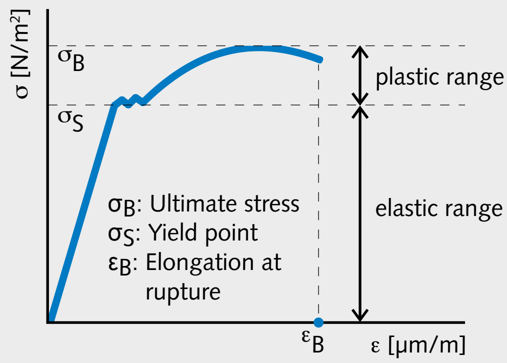
Indirect force measurement
Only a negligible part of the process force passes through the sensor (n >>99 %).

Benefits
- Most convenient mounting method
- Easily retrofitted on existing machines
- Overload protection
- Cost-effective design

Strain gage measurement technology

The principle of operation of the strain gage is based on a physical effect: the electrical resistance of a wire changes in proportion to any change in length caused by stretching or compression. Kistler uses this principle to measure the torque on rotating shafts and in some force sensors.

"Hooke's linear law"



Strain gages measure the deformation of structures in the linearly elastic range.

Principle of operation

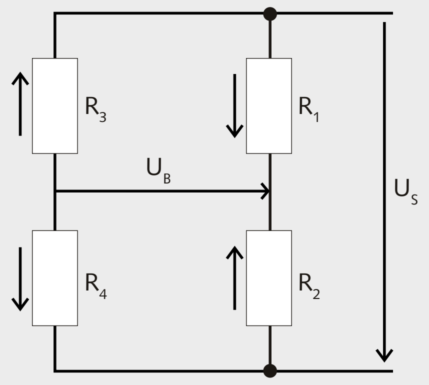
When the measuring wire undergoes a strain ε, its length L, cross-sectional area A and specific resistance ρ will change. The wire is commonly replaced with thin (≈0,005 mm) metallic foil from which a meandrous pattern is etched to form a measuring grid. This produces strain gages with very small dimensions (e.g. 1 × 1 mm measuring grids) capable of measuring at an almost exact point.

Force detectors

For use in strain gage load sensors, the gages are bonded onto a force detector made of a very strong material that exhibits linearly elastic characteristics up to the rated load. This means that the mechanical stress σ produced by the load on the force detector is linearly related to the strain ε according to Hooke's law:

$$\sigma = E \cdot \varepsilon$$

Wheatstone measuring bridge



R1–R4: Resistors or strain gages
U_S: Supply voltage
U_B: Output voltage
E_B: Bridge sensitivity

Wheatstone measuring bridge

This measuring bridge consists of four resistors or strain gages. It is supplied with voltage U_S. The output voltage U_B is taken off the middle of the bridge. The sensitivity of the bridge E_B gives the relationship between output voltage with gage factor (k) and strain ε.

$$E_B = \frac{U_B}{U_S} = k \cdot \varepsilon$$

Full bridges are almost always used for strain gage sensors. The bridge is generally supplemented by other resistors to compensate for various factors.

Measuring chain with strain gages

The voltages produced by the bridge are in the range of a few mV. The leads for the unamplified analog signals are kept as short as possible to minimize the effect of any electromagnetic fields. A differential amplifier generally amplifies and then digitizes the voltage. Such amplifiers have a very high input resistance and high common-mode rejection.

Benefits of strain gage sensors

- Allow tensile and compression measurements without having to preload measuring elements
- Static measurements are possible over long periods of time
- Absolute measurement values

Measuring chains

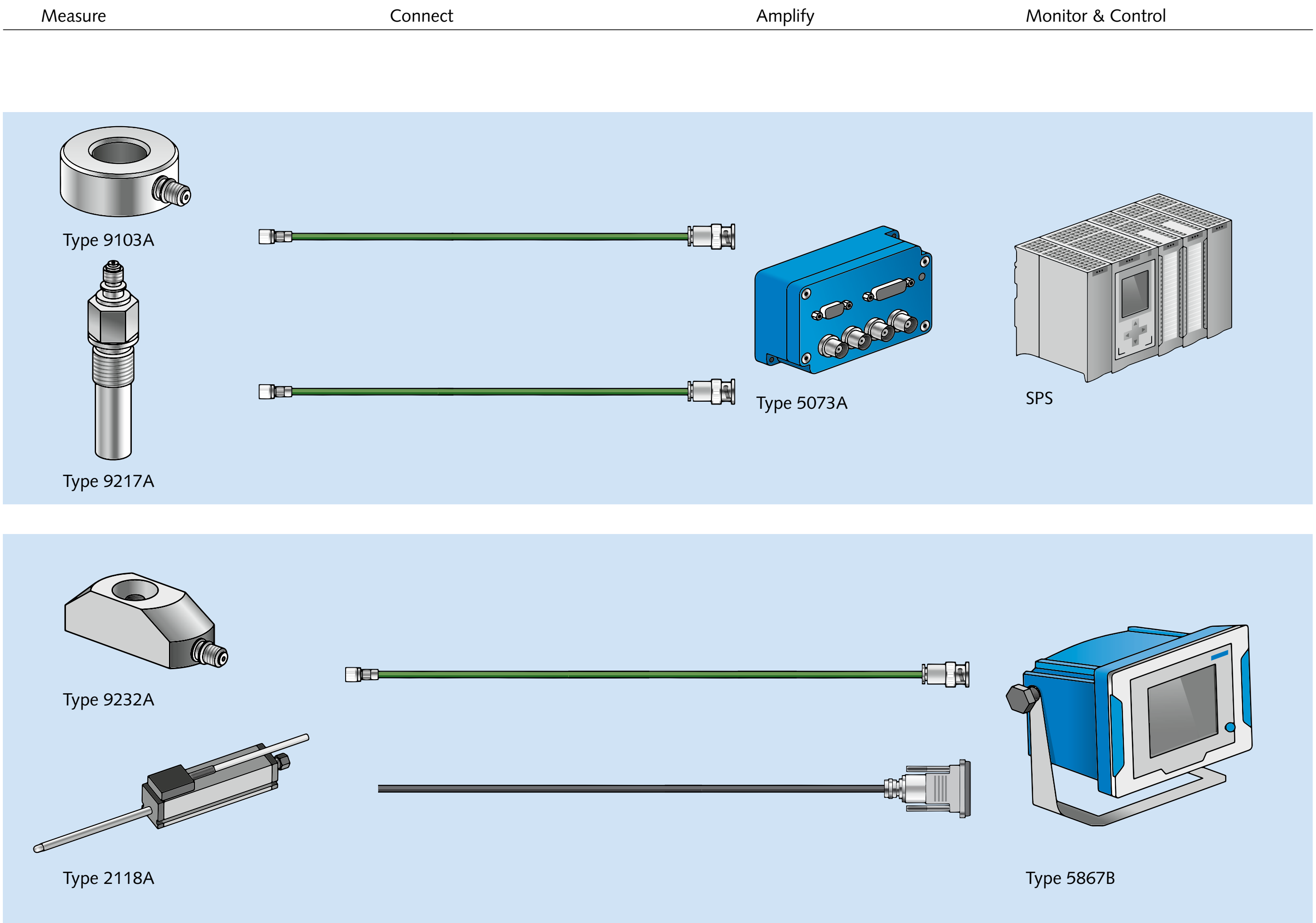
In order to integrate sensor technology into a given application, it is necessary to clarify these points in order to provide the basis for selecting the relevant components to generate the measuring chain:

- Measuring range and mode: direct, indirect, and technology
- Ambient conditions: temperature, gases and liquids, mechanics
- Signal analysis with Kistler instrument or using customer's system

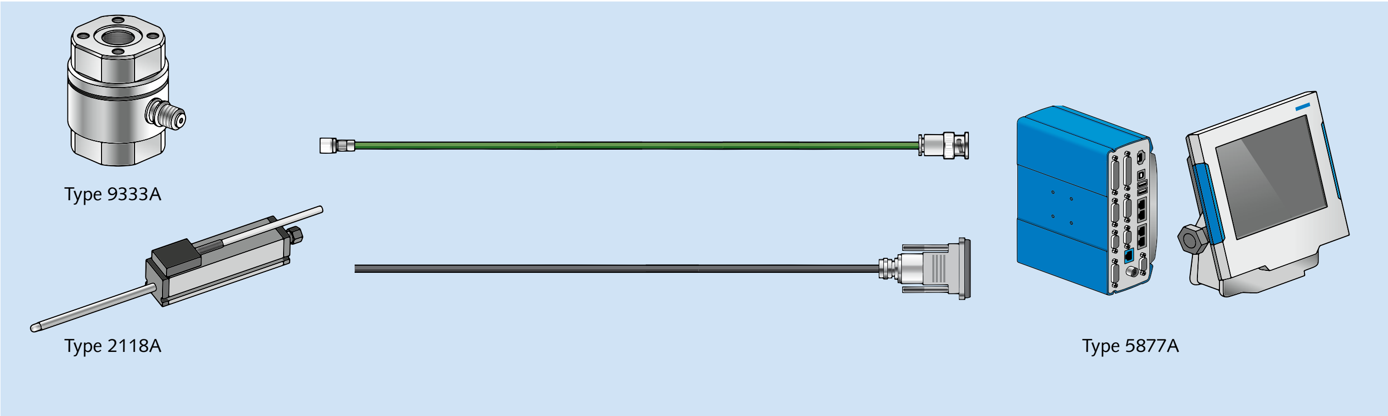
Ideally, the measurand should be captured as close to the process as possible; the easiest way to implement this is with a preloaded and calibrated sensor. Load washers and strain sensors are calibrated in the installed condition.

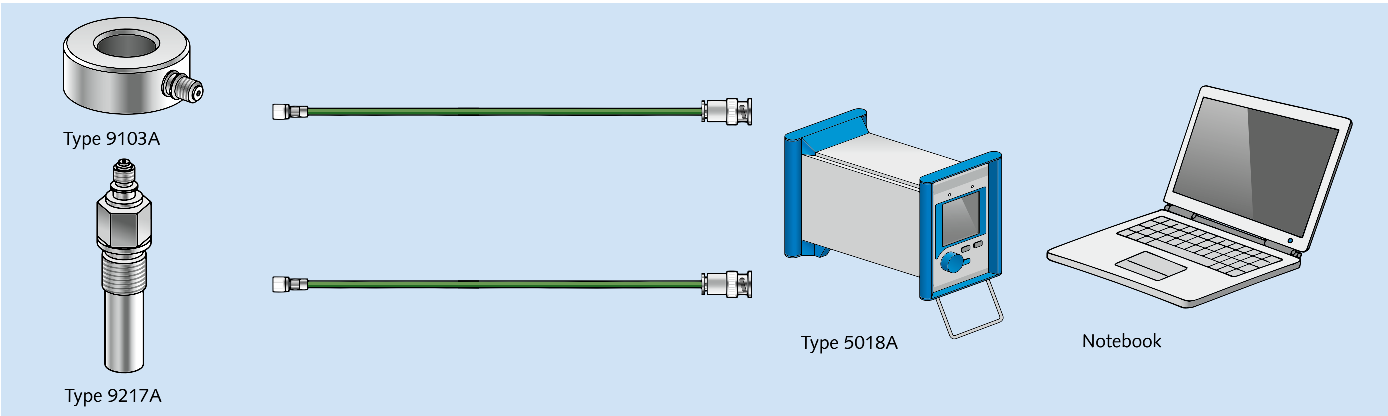
The high-insulation cable, with a typical insulation value >1E13 Ohm, is a particularly important element of piezoelectric measuring technology, and it should be selected according to the ambient conditions.

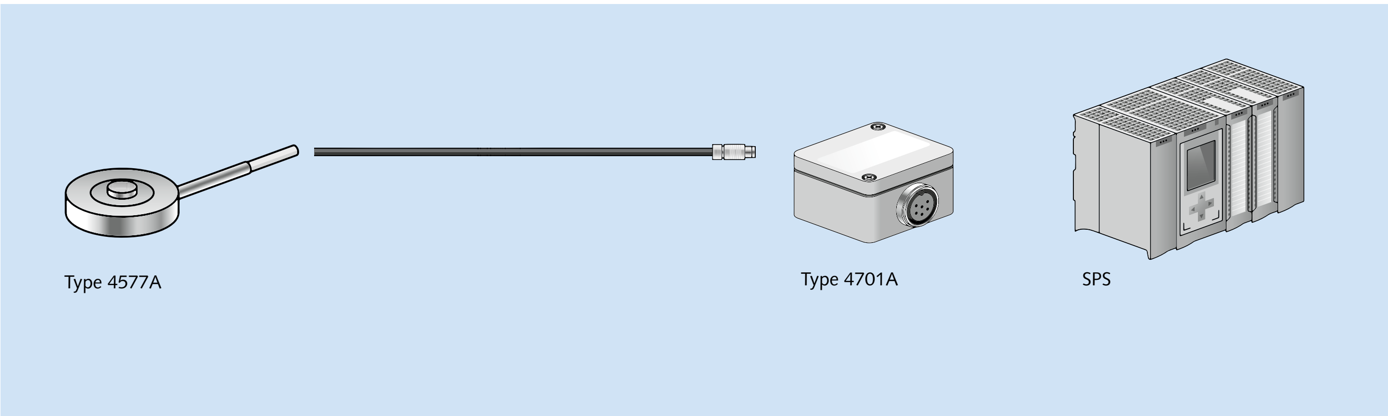
After conversion of the sensor signals, they can be evaluated by an amplifier in the customer's system. For the analysis of dedicated XY processes (such as force-displacement monitoring), the maXYmos family is highly suitable thanks to its user-friendly operation and wide variety of interfaces (Y-channel: piezo, strain gage, +/– 10V; X-channel: potentiometer, +/– 10V, incremental).

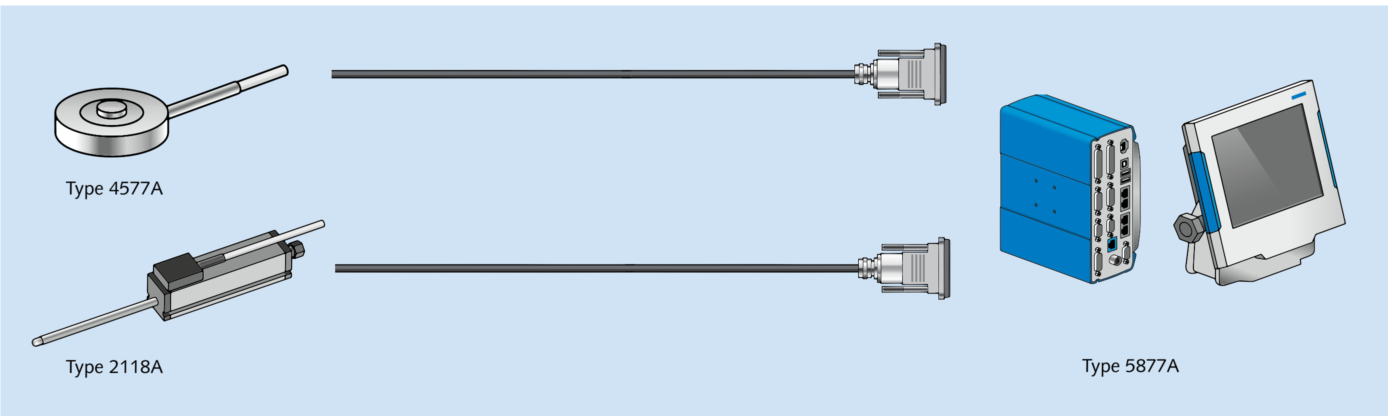


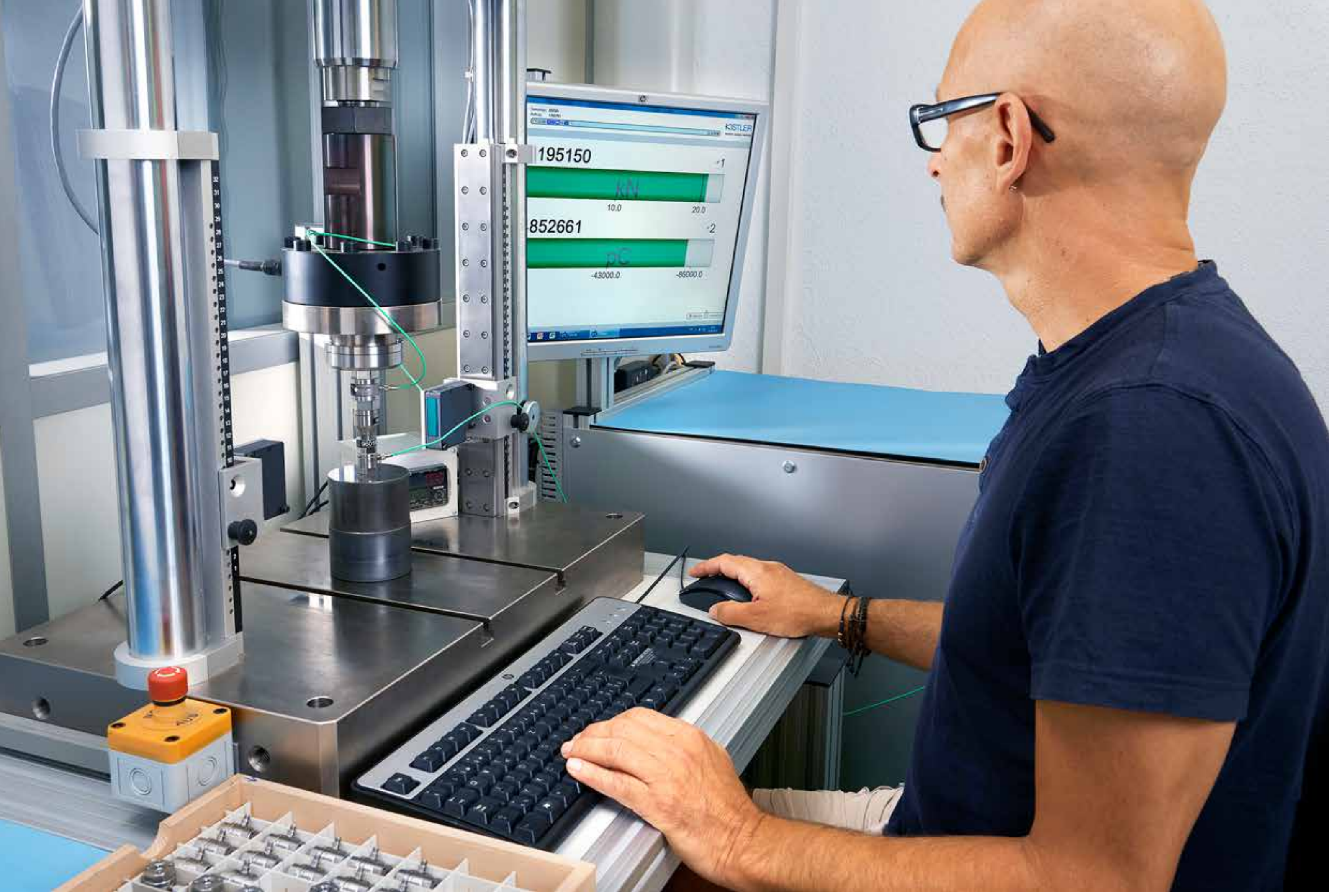
Measure | Connect | Amplify | Monitor & Control











Sensors must be meticulously calibrated in order to guarantee reliable measurement results

Calibration

Sensors and measuring instruments must be calibrated at regular intervals, as their characteristics and hence the measurement uncertainties can change over time as a result of frequent use, aging and environmental factors. Instruments used for calibration are traceable to national standards and subject to a uniform international quality control. Calibration certificates document calibration values and conditions.

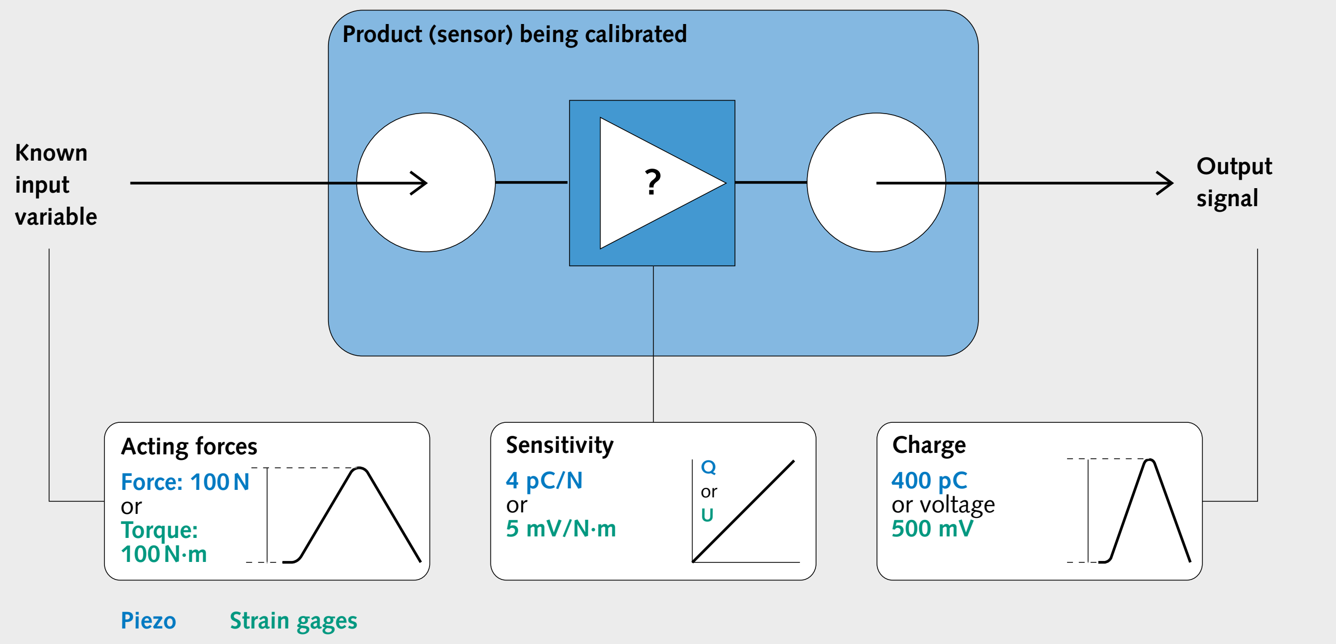
Safe and reliable measurements
Quality assurance systems and product liability laws call for systematic monitoring of all test equipment needed for measuring quality characteristics. This is the only way to ensure that measurement and test results provide a reliable and dependable benchmark for quality control.

All sensors and electronic measuring devices are subject to some degree of measurement uncertainty. As the deviations involved can change over time, the test equipment must be calibrated at regular intervals.

This involves determining the deviation of the measured value from an agreed reference value, which is also referred to as the calibration standard. The result of a calibration can either be used to assign the actual values of the measurand to the readings or to determine correction factors for them. The required information is documented on the calibration certificate.

Definition: Calibration is the use of a defined method under specified conditions to determine the relationship between a known input variable and a measured output variable.

Principle of sensor calibration

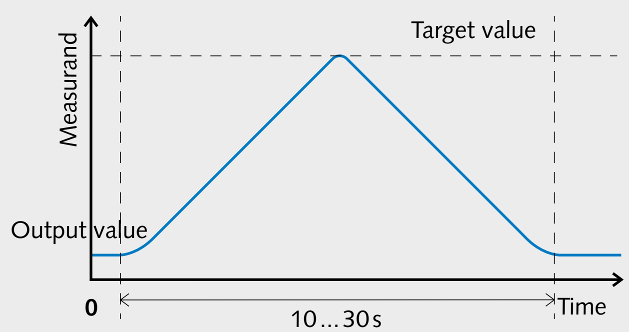


Calibration process

During calibration, sensors are subjected to known quantities of a physical measurand (such as force) and the corresponding values of the output variable are recorded. The magnitude of this load is accurately known, as it is measured with a traceably calibrated "factory standard" at the same time. Depending on the method, sensors are calibrated either across the entire measuring range or in a partial range:

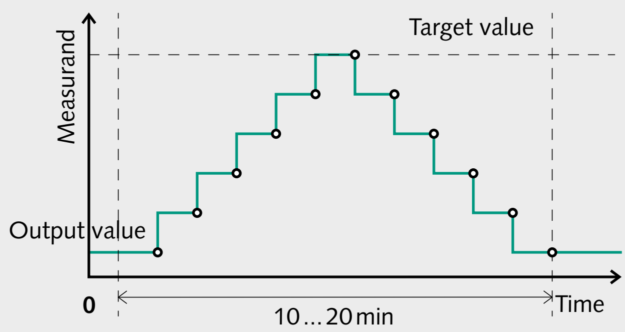
- at a single point,
- continuously, or
- stepwise at several different points.

Piezo calibration



During **continuous calibration**, the load is continuously increased to the required value within a defined time and then reduced to zero within the same time. A "best straight line" passing through the origin is defined for the resultant characteristic, which is never exactly linear. The gradient of this line corresponds to the sensitivity of the sensor within the calibrated measuring range.

Strain gage calibration



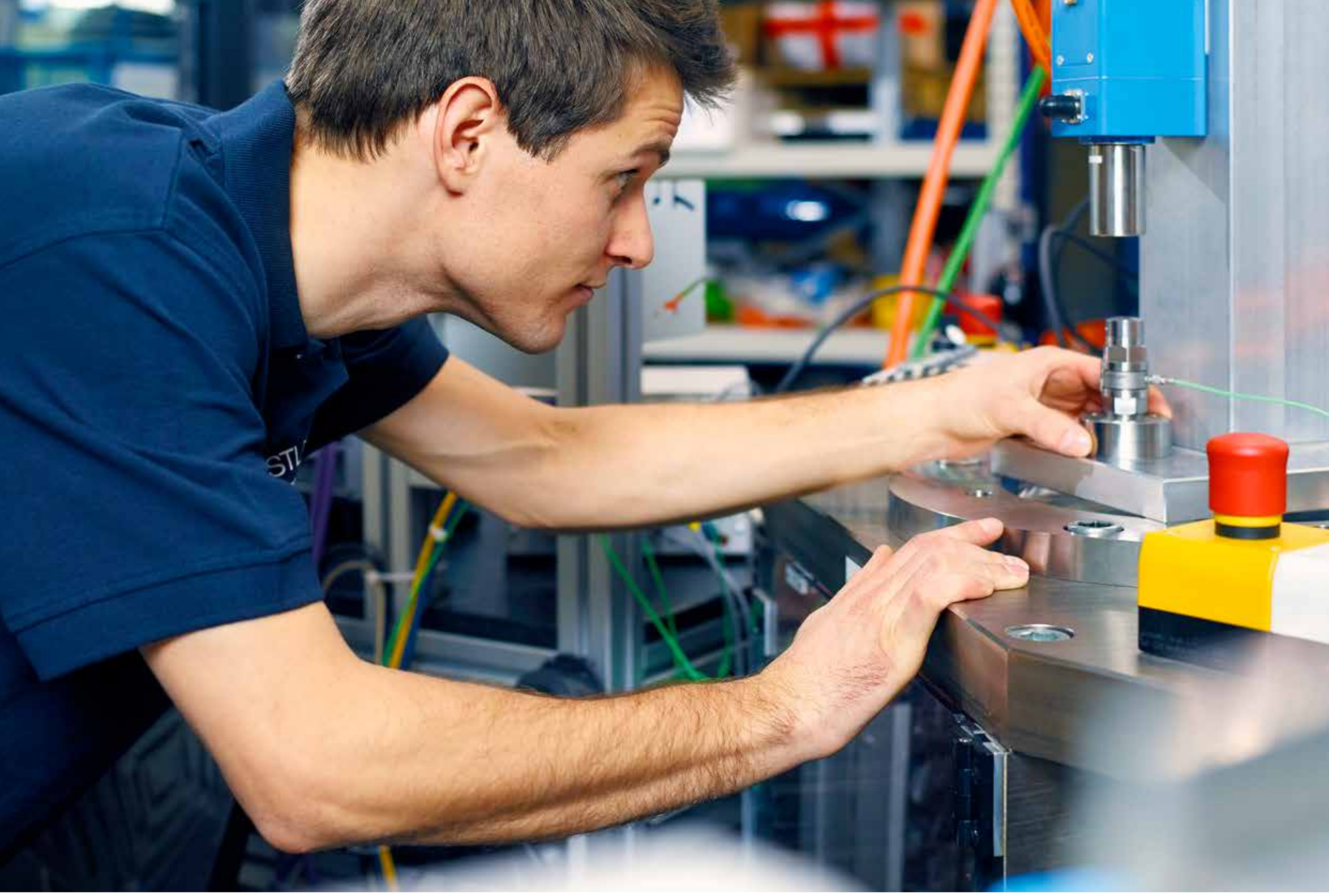
Step-by-step calibration involves the application of a load with or without unloading between successive increases or decreases, depending on the calibration method used. The process is halted after each increment until the measurement stabilizes.

Linearity is determined by the deviation of the characteristic from the best straight line. Hysteresis corresponds to the maximum difference between the rising and falling characteristics. Most Kistler single- or multiaxial force and torque sensors are factory calibrated.

The continuous approach is the most suitable calibration method for piezoelectric sensors. Strain gage sensors are preferably calibrated step-by-step.

Kistler offers diverse calibration options:

- The sensor equipment can be sent to the production plant
- Onsite calibration in the plant
- Calibration equipment for in-house calibration



From professional advice on installation to speedy deliveries of spare parts: Kistler's comprehensive range of services and training is at your disposal across the globe

Service: customized solutions from A to Z

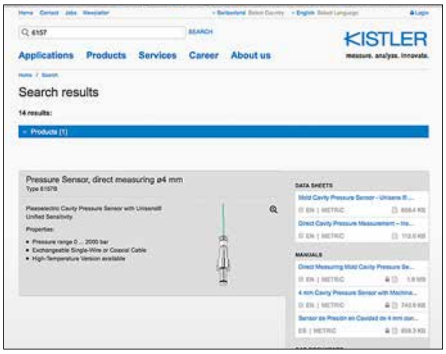
Kistler offers sales and service wherever automated manufacturing processes take place.

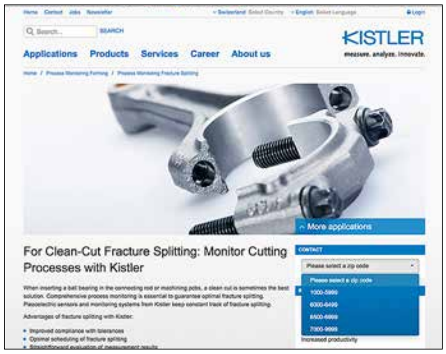
In addition to sensors and systems, Kistler offers a host of services – from professional advice on installation to speedy worldwide deliveries of spare parts. For an overview of the services we offer, visit **www.kistler.com**. For detailed information on our training courses, please contact our local distribution partners (see page 51).

Kistler service at a glance
- Advice
- Support with system commissioning
- Process optimization
- Periodic onsite calibration of sensors
- Education and training events
- Development services

Kistler – at our customers' service across the globe

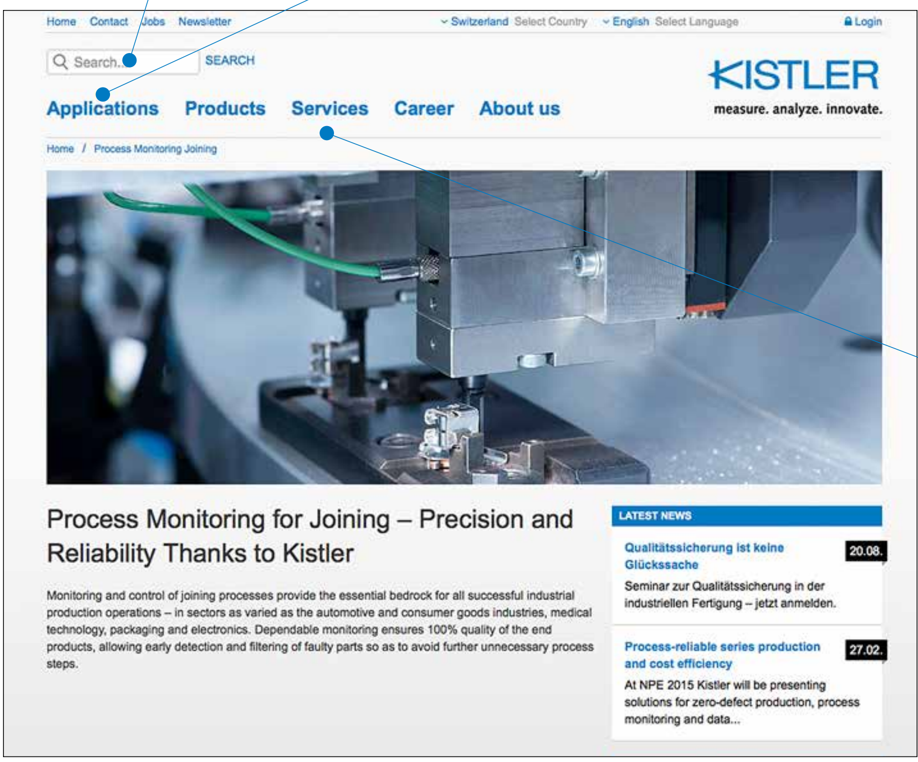
With around 1 500 employees, the Kistler Group leads the global market for dynamic measuring technology. 31 group companies and over 30 distributors ensure close contact with customers, individual application support and short delivery times.

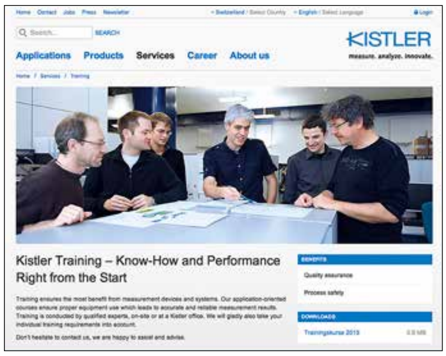




Datasheets and documents
Use our search engine to download datasheets, brochures or CAD data.

Your contacts
No matter whether you come to us for advice or for support with an installation – on our website, you will find the contact details for your personal partner anywhere in the world.





Education and training events
Education and training courses – when our sensors and measuring systems are explained by experienced Kistler experts – are the most efficient way for you to acquire the expertise you need.

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