KISTLER
measure. analyze. innovate.

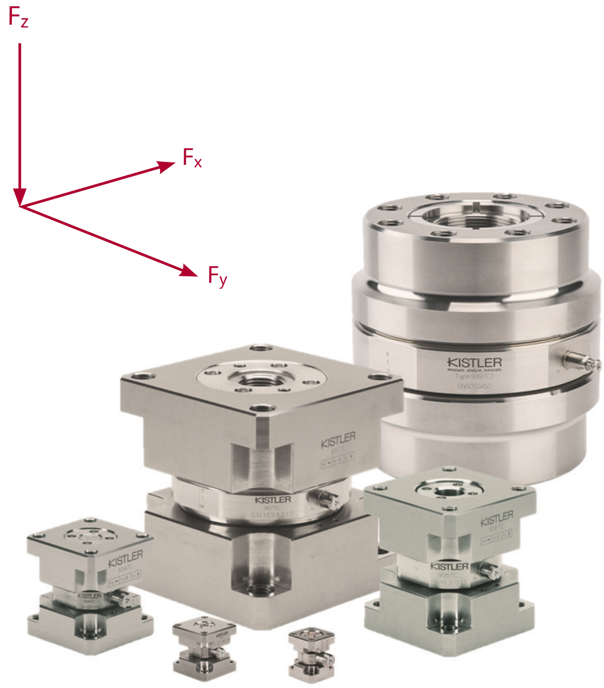
Triaxial load cell

Measuring range in F_z ±3 kN up to -200 ... 450 kN

Types 9317C, 9327C, 9347C, 9367C, 9377D, 9397D, (incl. 93x8C/D)

These triaxial piezoelectric force transducer are piezoelectric load cells for the exact measurement of all forces on the three orthogonal components acting in an arbitrary direction. Independent of the point of force application, the piezo force transducers with the installed triaxial force sensors of the 90x7 family measure all 3 components of the applied force in highest resolution.
The 3 axis load cell out of the 93x7 product family is optimally preloaded, calibrated and immediately ready to measure.

- Accurate measurement independent of the force application point
- Wide frequency range
- Easy installation
- Stainless, sealed sensor case
- Rugged multipole plug connection

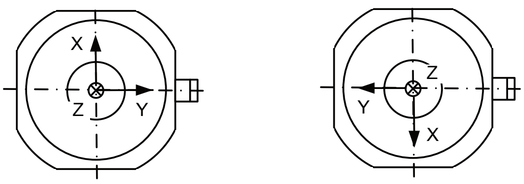


Description
The 3 axis load cell is mounted under preload between two plates and measures both tensile and compression forces in all directions.
Based on the piezoelectric principle, a force produces a proportional electric charge. This is conducted via an electrode to the appropriate connector.
The simple and vibration-resistant design of the force link is very rigid resulting in a high natural frequency, which is a requirement for highly dynamic force measurements.
The 3-pole connector V3 neg. (design protected) is provided with a positioning aid. This guarantees accurate assignment and centering of the connector pins and sockets before connection. The plug connection is protected against rotation. After correct installation, the sensor is ready for use without recalibration.
Quartz triaxial force transducer allow simple, direct and very precise measurements.

Application
3 axis load cells measure:
- Cutting forces during machining
- Impact forces in crash tests
- Recoil forces of rocket engines
- Vibration forces of components for space travel
- Friction forces
- Forces in product testing
- Ground reaction forces in biomechanics
- Vehicle forces on a road and a test stand
- Forces on a wind tunnel balance

Sensor Versions

Types 93x7C/D and 93x8C/D
The sensor Types 93x7C/D and 93x8C/D differ only in the position of the connector in relation to the coordinate system (see Fig. 1). The technical data of both types are identical.



Type 93x7C/D Type 93x8C/D

Fig. 1: Triaxial force sensor Type 93x7C/D and 93x8C/D

93x7C_003-531e-11.24

KISTLER
measure. analyze. innovate.

Technical data (metric)

Type			9317C 9318C	9327C 9328C	9347C 9348C	9367C 9368C	9377D 9378D	9397D 9398D
Range (Without moment loading, e.g. when four force links are mounted in a force plate)	F_x, F_y	kN	–1.5 ... 1.5	–4 ... 4	–15 ... 15	–30 … 30	–75 … 75	–100 ... 100
Range (Example with force application point on the surface of the cover plate)	F_x, F_y	kN	–0.2 … 0.2	–1 … 1	–5 … 5	–10 … 10	–30 … 30	–60 ... 60
Range (Force application point centric)	F_z	kN	–3 … 3	–8 … 8	–30 … 30	–60 … 60	–150 … 150	–200 ... 450
Overload	F_x, F_y, F_z	%	≤10	≤20	≤10	≤10	≤10	≤10
Calibrated range (Force application point 10 mm below the surface of the cover plate)	F_x, F_y	kN	0 … 0.5 0 … 0.05	0 … 1 0 … 0.1	0 … 5 0 … 0.5	0 … 10 0 … 1	0 … 30 0 … 3	0 ... 45 0 ... 4.5
Calibrated range (Force application point centric)	F_z	kN	0 … 3 0 … 0.3	0 … 8 0 … 0.8	0 … 30 0 … 3	0 … 60 0 … 6	0 … 150 0 … 15	0 …300 0 … 30
Permissible moment load ($M_z = 0$; $F_z = 0$)	M_x, M_y	N·m	–8/8	–22/22	–150/150	–500/500	–2 040/ 2 040	–4 500/4 500
Permissible moment load ($M_{x,y} = 0$; $F_z = 0$)	M_z	N·m	–6/6	–23/23	–150/150	–500/500	–2 040/ 2 040	–11 000/ 11 000
Threshold		N	≤0.01					
Sensitivity	F_x, F_y	pC/N	≈–26	≈–7.8	≈–8	≈–7.6	≈–3.9	≈–3.7
	F_z	pC/N	≈–11	≈–3.8	≈–3.7	≈–3.9	≈–1.95	≈-1.95
Linearity incl. hyst., each axis 2)	typical	%FSO	≤±0.2					
Crosstalk (Crosstalk F_x, $F_y \rightarrow F_z$ is ≤±2% when, for example, four force links are mounted in a dynamometer)	$F_z \rightarrow F_x$, F_y	%	≤±1	≤±1	≤±1	≤±1	≤±1	≤±1
	$F_x \leftrightarrow F_y$	%	≤±3	≤±3	≤±2	≤±2	≤±2	≤±2
	F_x, $F_y \rightarrow F_z$	%	≤±4	≤±3	≤±3	≤±3	≤±3	≤±4
Stiffness	Axial	N/µm	877	1 379	2 749	3 880	8465	13 362
	Lateral 1)	N/µm	45	73	205	312	1 011	1 531
	Shear	N/µm	194	391	890	1 167	2 795	2 806
	Torsional	Nm/°	227	682	4 834	16 093	110 630	277 750
	Bending	Nm/°	222	625	4 572	14 778	106 540	332 180
Natural frequency (fixed-free)	f_n (x), f_n (y)	kHz	≈5	≈3.2	≈3.6	≈2.4	≈2.0	≈1.8
	f_n (z)	kHz	≈20	≈12	≈10	≈6	≈6.0	≈3.7
Operating temperature range		°C	-40 … 120					-40 … 80
Insulation resistance at 20 °C		Ω	$>10^{13}$					$>10^{12}$
Ground isolated		Ω	$>10^{8}$					
Capacitance, each channel		pF	35	30	70	100	1 000	1 000
Connecting plug			V3 neg.					
Weight		kg	0.085	0.380	1.0	3.0	10.5	13.84
Degree of protection (Depending on the type of used cable, Type 1698A ...)			IP65 - IP68					

1) Resistance of the sensor to shear and bending deformation. (Theoretical) assumption: The sensor is fixed at the bottom, the shear force acts at the top, so that the lever length is equal to the total sensor height.
2) guaranteed < 0.5%FSO

93x7C_003-531e-11.24

KISTLER
measure. analyze. innovate.

Technical data (imperial)

Type			9317C 9318C	9327C 9328C	9347C 9348C	9367C 9368C	9377D 9378D	9397D 9398D
Range (Without moment loading, e.g. when four force links are mounted in a force plate)	F_x, F_y	lbf	–337 … 337	–899 … 899	–3 372 … 3 372	-6 744 … 6 744	–16 860 … 16 860	–22 480 … 22 480
Range (Example with force application point on the surface of the cover plate)	F_x, F_y	lbf	–44 … 44	–224 … 224	–1 124 … 1 124	–2 248 … 2 248	–6 744 … 6 744	–13 488 … 13 488
Range (Force application point centric)	F_z	lbf	–674 ... 674	–1 798 … 1 798	-6 744 … 6 744	–13 488 … 13 488	–33 721 … 33 721	–44 961 … 101 164
Overload	F_x, F_y, F_z	%	≤10	≤20	≤10	≤10	≤10	≤10
Calibrated range (Force application point 10 mm below the surface of the cover plate)	F_x, F_y	lbf	0 … 112 0 … 11	0 … 224 0 … 22	0 … 1 124 0 … 112	0 … 2 248 0 … 224	0 ... 6 744 0 ... 674	0 … 10 116 0 … 1 011
Calibrated range (Force application point centric)	F_z	lbf	0 … 674 0 … 67	0 … 1 798 0 … 179	0 … 6 744 0 … 674	0 … 13 488 0 ... 1 348	0 … 33 721 0 … 3 372	0 … 67 442 0 … 6 744
Permissible moment load (M_z = 0; F_z = 0)	M_x, M_y	in·lbf	–70/70	–194/194	–1 327/ 1 327	–4 425/ 4 425	–18 055/ 18 055	–39 828/ 39 828
Permissible moment load ($M_{x,y}$ = 0; F_z = 0)	M_z	in·lbf	–53/53	–203/203	–1 327/ 1 327	–4 425/ 4 425	–18 055/ 18 055	–97 358/ 97 358
Threshold		lbf	≤0.00225					
Sensitivity	F_x, F_y	pC/lbf	≈–115	≈–34	≈–35	≈–33	≈–17	≈–16
	F_z	pC/lbf	≈–48	≈–16	≈–16	≈–17	≈–8	≈–8
Linearity incl. hyst., each axis 2)	typical	%FSO	≤±0.2					
Crosstalk (Crosstalk F_x, F_y → F_z is ≤±2% when, for example, four force links are mounted in a dynamometer)	F_z → F_x, F_y	%	≤±1	≤±1	≤±1	≤±1	≤±1	≤±1
	F_x ↔ F_y	%	≤±3	≤±3	≤±2	≤±2	≤±2	≤±2
	F_x, F_y → F_z	%	≤±4	≤±3	≤±3	≤±3	≤±3	≤±4
Stiffness	Axial	lbf/µin	5.01	7.87	15.74	22.54	48.12	76.12
	Lateral 1)	lbf/µin	0.25	0.41	1.16	1.76	5.72	8.68
	Shear	lbf/µin	1.10	2.21	5.04	6.61	15.80	15.87
	Torsional	in·klbf/°	0.16	0.50	3.56	11.87	81.57	204.74
	Bending	in·klbf/°	0.16	0.46	3.37	10.88	78.62	244.86
Natural frequency (fixed-free)	f_n (x), f_n (y)	kHz	≈5	≈3.2	≈3.6	≈2.4	≈2.0	≈1.8
	f_n (z)	kHz	≈20	≈12	≈10	≈6	≈6.0	≈3.7
Operating temperature range		°C	-40 … 248					-40 … 176
Insulation resistance at 20 °C		Ω	$>10^{13}$					$>10^{12}$
Ground isolated		Ω	$>10^{8}$					
Capacitance, each channel		pF	35	30	70	100	1 000	1 000
Connecting plug			V3 neg.					
Weight		lbs	0.187	0.837	2.204	6.613	23.148	30.534
Degree of protection Depending on the type of used cable, Type 1698A ...			IP65 - IP68					

1) Resistance of the sensor to shear and bending deformation. (Theoretical) assumption: The sensor is fixed at the bottom, the shear force acts at the top, so that the lever length is equal to the total sensor height.
2) guaranteed < 0.5%FSO

Mounting

The two contact surfaces of the component which transfer the forces onto the force link must be flat, rigid and clean. When four force links are used to construct a dynamometer, they must be machined to the same level. The base and cover plates of the dynamometer must be selected for sufficient rigidity.
All mounting holes of the 3-component load cells have an internal thread, which allows mounting with four dedicated screws. In addition, a central screw connection is possible, if necessary. The load cells of Type 9317C, 9327C, 9347C as well as 9367C can alternatively be fastened from the inside with four smaller screws. For information on the exact dimensioning or tightening torques, please consult the operating instructions at www.kistler.com/force.

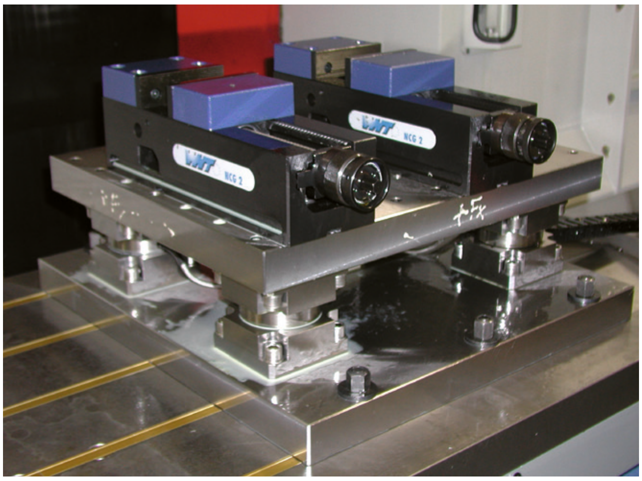


Fig. 1: Exemplary application of a 3-component force transducer, here using the Types 9347C/9348C as an example

Dimensions 3 axis load cells

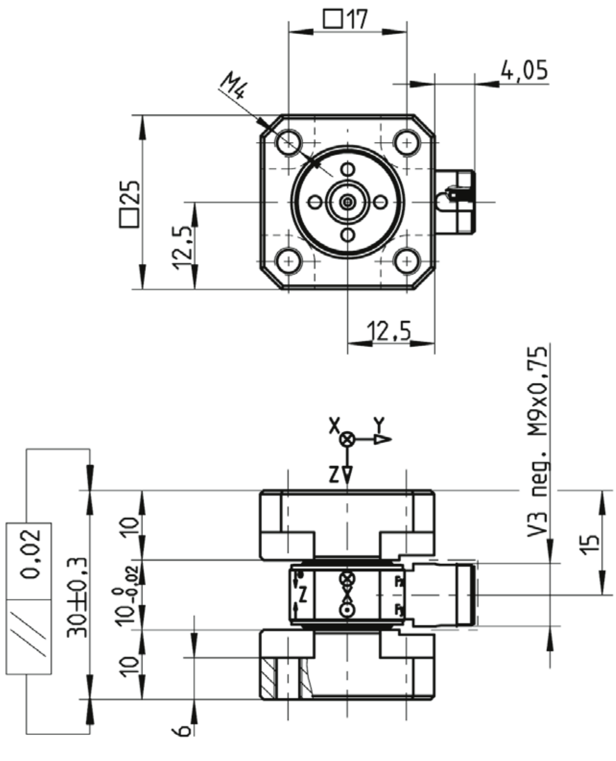


Fig. 2: Dimensions of the triaxial load cell Type 9317C

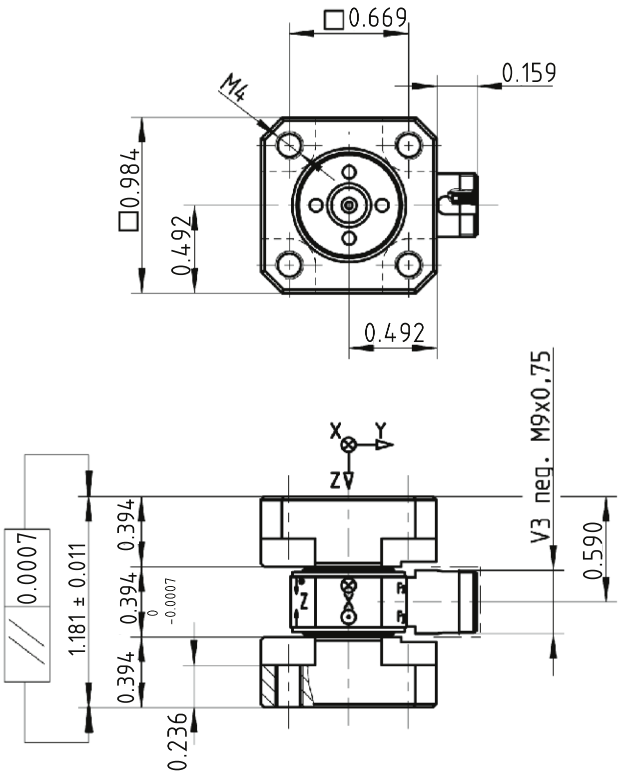


Fig. 3: Imperial dimensions [in] of the triaxial load cell Type 9317C

93x7C_003-531e-11.24

measure. analyze. innovate.

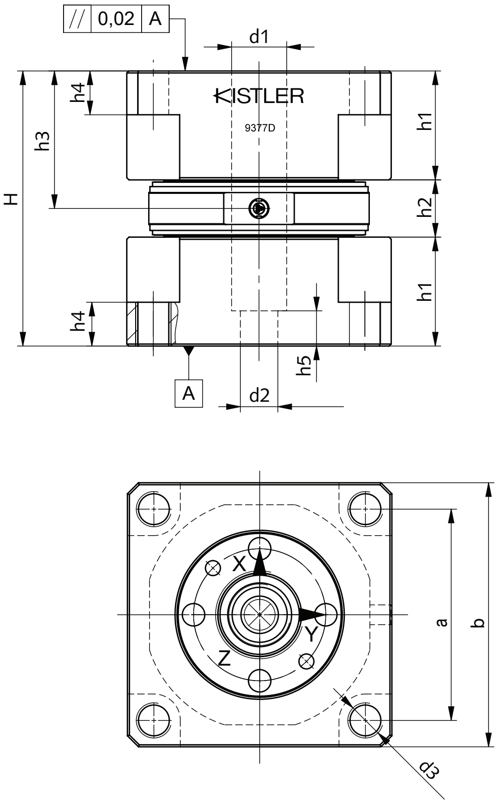


Fig. 4: Dimensions of the triaxial load cell Type 9377D

Dimensions (metric)

Type	H	h1	h2	h3	h4	h5	d1	d2	d3	a	b
9327C, 9328C	42 ±0.3	15	12	21	7.5	-	-	-	M6	32	42
9347C, 9348C	60 ±0.3	25	14	32	10	-	-	-	M8	42	55
9367C, 9368C	90 ±0.3	34.5	21	45	15	10	18.6	13	M10	60	80
9377D, 9378D	$125\ ^{0}_{-0.02}$	49.5	26	62.5	20	16	25	17	M16	96	120

Dimensions (imperial)

Type	H	h1	h2	h3	h4	h5	d1	d2	d3	a	b
9327C, 9328C	1.653 ±0.012	0.590	0.472	0.826	0.295	-	-	-	M6	1.259	1.653
9347C, 9348C	2.362 ±0.012	0.984	0.551	1.259	0.393	-	-	-	M8	1.653	2.165
9367C, 9368C	3.543 ±0.012	1.358	0.826	1.771	0.590	0.393	0.732	0.511	M10	2.362	3.149
9377D, 9378D	$4.921\ ^{0}_{-0.001}$	1.948	1.023	2.460	0.787	0.629	0.984	0.669	M16	3.779	4.724

93x7C_003-531e-11.24

KISTLER
measure. analyze. innovate.

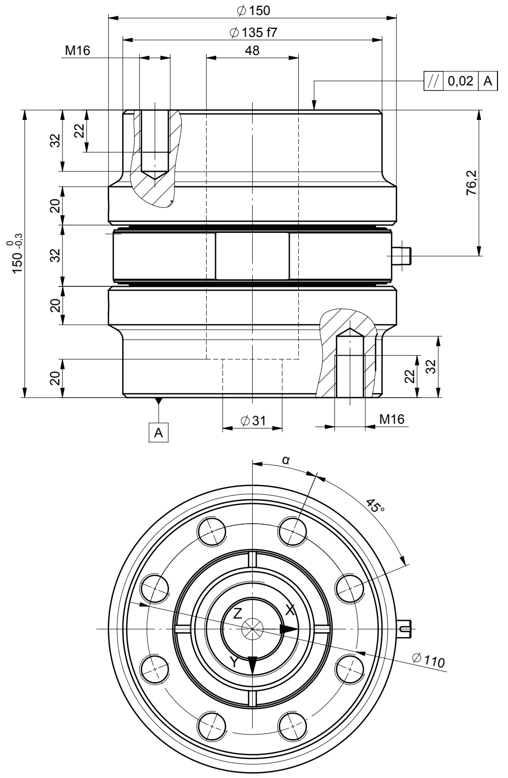


Fig. 5: Metric dimensions of the triaxial load cell Type 9397D1
(For the 9397D3, the hole pattern is rotated by 22.5°)

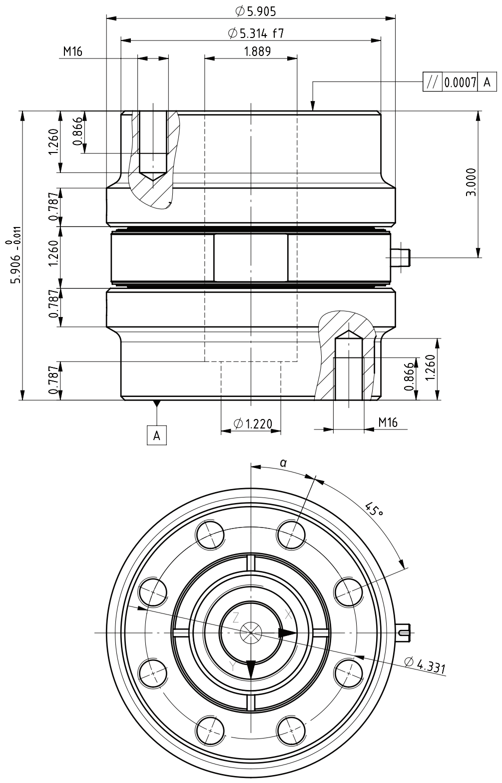


Fig. 6: Imperial dimensions [in] of the triaxial load cell Type 9397D1
(For the 9397D3, the hole pattern is rotated by 22.5°)

Introduction of force
When only one force link is used, then if at all possible the resulting force vector should run through the center of the sensor. An eccentric introduction of force produces a moment load on the sensor. This is allowed only up to the specified values. The maximum force ranges must be reduced accordingly.
A sufficiently rigid constructed dynamometer with four force links largely prevents moment loads on the sensor element.

Parallel connection
When used as a dynamometer, four sensors of Type 90x6C4 are mechanically connected in parallel. The respective measuring signals (electrical charge) of the four sensors can also be connected in parallel (summed). The summing box Type 5417 enables the simple and reliable connection of the measuring signals for the desired Type of multi-component force measurement - either for a pure force measurement with 3 output channels (Type 5417Q01) or a complete dynamometer configuration with 8 outputs, which enables the calculation of bending and torsion moments (Type 5417).

Fig. 7: Summing boxType 5417

Measurement signal processing
Charge amplifier channels are still required for the complete measurement system. These convert the measurement signal into an electrical voltage. The measured value is exactly proportional to the acting force.
The multichannel charge amplifier Type 5167A... was specially built for multiaxis force measurement systems.

Fig. 8: Multi-Channel charge amplifier Type 5167A...

Included accessories
- none

Optional accessories	**Type**
• Connecting cable, 3 wire	1698A...
• Summing box	5417
• Summing box	5447Asp
• Summing cable	1684A

Ordering key	**Type**
• **Triaxial force transducer** 25x25x30 mm, -3 … 3 kN	**9317C**
• **Triaxial force transducer** 42x42x42 mm, -8 … 8 kN	**9327C**
• **Triaxial force transducer** 55x55x60 mm, -30 … 30 kN	**9347C**
• **Triaxial force transducer** 80x80x90 mm, -60 … 60 kN	**9367C**
• **Triaxial force transducer** 120x120x125 mm, -150 … 150 kN	**9377D**
• **Triaxial force transducer** D 150/135x150 mm, -200 ... 450 kN	**9397D1**
• **Triaxial force transducer** D 150/135x150 mm, -200 ... 450 kN 22.5° rotated	**9397D3**

KISTLER
measure. analyze. innovate.

Measuring system with triaxial load cells

Triaxial load cell

Connecting cable

Charge amplifier

Output Signal		Cable	Cable Properties	Length [m] min	Length [m] max	Temp. Range		IEC/EN 60529	Connector Sensor	Connector Amplifier	IEC/EN 60529		Industrial Amplifier 5030A (Channels 1) IP65	5039A (1) IP65	5073A... (1-4) IP60	5074A... (1-4) IP67	5877B... (1) IP53	Laboratory Amplifier 5015A... (1) IP20	5018A... (1) IP40	5080A... (1-8) IP40	5165A... (1,4) IP20	5167A... (4,8) IP20	DAQ KiDAQ (4, ... ,52) IP20	SumBox 5417 (12->8) IP65
separate	3	1698AA...	PFA synthetic braiding	0.2	20	-40...120°C	Plug screwed*	IP65	V3 pos.	3x BNC pos.	IP40	Plug screwed	-	(✓)	✓	-	(✓)	(✓)	(✓)	✓	✓	✓	✓	-
		1698AH...	PFA synthetic braiding	0.5	20					3x SMC neg.			-	-	-	-	-	-	-	-	-	-	-	-
		1698AE...	PFA synthetic braiding	0.2	20					3x KIAG 10-32 pos.	IP65		(✓)	-	-	✓	-	-	-	-	-	-	-	-
		1698AV...	PFA, suitable for vacuum	0.2	20					3x KIAG 10-32 pos.	IP65		(✓)	-	-	✓	-	-	-	-	-	-	-	-
		1698AN...	TPC black Ø3.6mm	0.1	20			IP67	V3 pos. 90°	3x KIAG 10-32 pos.	IP65		(✓)	-	-	✓	-	-	-	-	-	-	-	-
		1698AK...	TPC black Ø3.6mm	0.5	20					Fischer 9-pole pos.			-	-	-	-	-	-	-	✓	-	✓	-	✓
		1698AF...	TPC black Ø3.6mm	0.5	20			IP68	V3 pos.	3x Mini Coax neg.	IP40		-	-	-	-	-	-	-	-	-	-	-	-
		1698AL...	TPC black Ø3.6mm	0.5	20					3x KIAG 10-32 pos.	IP65		(✓)	-	-	✓	-	-	-	-	-	-	-	-
		1698AM...	PFA, steel braiding	0.3	15								(✓)	-	-	✓	-	-	-	-	-	-	-	-
		1698AB...	TPC black Ø3.6mm	0.5	20					Fischer 9-pole pos.			-	-	-	-	-	-	-	✓	-	✓	-	✓
		1698AI...	PFA, steel braiding Ø7.5mm	0.3	15								-	-	-	-	-	-	-	✓	-	✓	-	✓
		1698AG...[1]	PFA, steel braiding Ø7.5mm	0.3	15		welded	IP67	V3 pos.	3x Mini Coax neg.	IP40		-	-	-	-	-	-	-	-	-	-	-	-
		1698AC...[1]	PFA, steel braiding Ø7.5mm	0.3	15					Fischer 9-pole pos.	IP65		-	-	-	-	-	-	-	✓	-	✓	-	✓

1) not suitable with 9306A and preloaded load cells 93x7C (structure is not weldable anymore)

*no welding possible

(✓) more than one Amp needed

Dynamometer: measuring system with four triaxial load cells and summing box Type 5417

4 pcs of triaxial load cells

Connecting cable

Summing box Type 5417

Drop cable

Charge amplifier

Output Signal		Cable	Cable Properties	Length [m] min	Length [m] max	Temp. Range		IEC/EN 60529	Fischer Connector Dynamometer	Connector Amplifier	IEC/EN 60529		Industrial Amplifier 5030A (Channels 1) IP65	5039A (1) IP65	5073A... (1-4) IP60	5074A... (1-4) IP67	5877B... (1) IP53	Laboratory Amplifier 5015A... (1) IP20	5018A... (1) IP40	5080A... (1-8) IP40	5165A... (1,4) IP20	5167A... (4,8) IP20	KiDAQ (4, ... ,52) IP20
separate	8	Z16620sp	PFA	1	20	-5...70°C	plugged	IP40	9-pole pos.	8x BNC pos.	IP40	plugged	-	(✓)	(✓)	-	(✓)	(✓)	(✓)	✓	✓	✓	✓
		1685B...	TPC black Ø5.6mm	1	20			IP65	9-pole pos.	Fischer 9-pole pos.	IP65		-	-	-	-	-	-	-	✓	-	✓	-
		1686A...	TPC black Ø5.6mm	1	20				9-pole pos. 90°				-	-	-	-	-	-	-	✓	-	✓	-
		1681B...	PFA with flexible steel hose	1	20				9-pole pos.				-	-	-	-	-	-	-	✓	-	✓	-
		1677AQ01...	TPC black Ø5.6mm	1	20		boltable	IP65	Flange 9-pole pos.				-	-	-	-	-	-	-	✓	-	✓	-
		1677AQ02...	TPC, steel braiding	1	20			IP67	Flange 9-pole pos.				-	-	-	-	-	-	-	✓	-	✓	-
		1677A...	PFA with flexible steel hose	0.5	20								-	-	-	-	-	-	-	✓	-	✓	-
		1679A...		0.5	20				Flange 9-pole pos. 90°				-	-	-	-	-	-	-	✓	-	✓	-
		1679AQ01...	TPC, steel braiding	2	20								-	-	-	-	-	-	-	✓	-	✓	-

Please check out further triaxial cable solutions on our homepage www.kistler.com/force

93x7C_003-531e-11.24