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# Triaxial Force Sensors

## for compression, tensile and shear forces of ±3kN ... ±150kN

**Type 9017C, 9027C, 9047C, 9067C, 9077D (incl. 90x8 and 90x6 sets)**

High-precision triaxial force ring transducers for measurements along any direction of the 3 spatial axes. The 3 axis sensor series enables a simple and precise measurement of the three perpendicular components (x/y/z) of any arbitrarily directed, dynamic or quasi-static force.

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


### Description

The output of the piezoelectric triaxial force sensors is an extremely linear electrical charge over their entire measuring range. This load is directly proportional to the applied force. The sensor housing contains one quartz ring per force component and can be precisely aligned & mounted due to its flattened sides.

The simple and vibration-resistant design of the sensor is extremely stiff and, with its uniquely high natural frequency, enables the measurement of highly dynamic force processes.

With two ceramic discs on the contact surfaces, a high coefficient of friction is guaranteed on the one hand and mass-insulated installation in the machine structure is possible on the other. The magnitude of the measuring range of the shear forces in the x- and y-directions depends directly on the preload in the z direction and the resulting axial static friction.

The signals are picked up via the design-protected, 3-pole connector plug V3 neg., which uses a positioning aid to ensure the exact assignment of the connector pins and protects against twisting.

### Application

Triaxial force sensors 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

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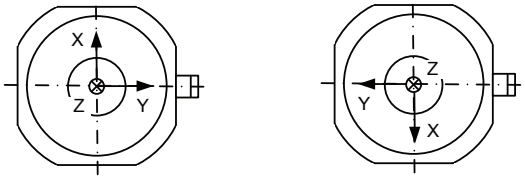
## Sensor Versions

### Types 90x7C/D and 90x8C/D

The sensor Types 90x7C/D and 90x8C/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 90x7C/D Type 90x8C/D

Fig. 1: Triaxial force sensor Type 90x7C/D and 90x8C/D

### Technical data (metric)

| Types | | | 9017C 9018C | 9027C 9028C | 9047C 9048C | 9067C 9068C | 9077D 9078D |
|---|---|---|---|---|---|---|---|
| Range | $F_x$, $F_y$ [1] | kN | –1.5 … 1.5 | –4 … 4 | –15 … 15 | –30 … 30 | –75 … 75 |
| | $F_z$ [1] | kN | –3 … 3 | –8 … 8 | –30 … 30 | –60 … 60 | –150 … 150 |
| | $F_z$ | kN | 0 … 12.5 | 0 … 28 | 0 … 100 | 0 … 200 | 0 … 500 |
| Standard preload | $F_v$ | kN | 9.5 | 20 | 70 | 140 | 350 |
| Overload | $F_x$, $F_y$ [1] | kN | –1.8/1.8 | –5/5 | –18/18 | –35/35 | –90/90 |
| | $F_z$ [1] | kN | –3.6/3.6 | –10/10 | –35/35 | –70/70 | –180/180 |
| Calibrated range | $F_x$ [1] | kN | 0 … 1.5 | 0 … 4 | 0 … 15 | 0 … 30 | 0 … 75 |
| | $F_y$ [1] | kN | 0 … 1.5 | 0 … 4 | 0 … 15 | 0 … 30 | 0 … 75 |
| | $F_z$ [1] | kN | 0 … 3 | 0 … 8 | 0 … 30 | 0 … 60 | 0 … 150 |
| | $F_z$ | kN | 0 … 12.5 | 0 … 28 | 0 … 100 | 0 … 200 | 0 … 500 |
| Permissible moment loading | $M_x$, $M_y$ [1] | N·m | –6.6/6.6 | –22/22 | –150/150 | –500/500 | –2 040/2 040 |
| | $M_z$ [1] | N·m | –6.6/6.6 | –23/23 | –150/150 | –500/500 | –2 040/2 040 |
| Threshold | | N | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Sensitivity | $F_x$, $F_y$ [1] | pC/N | ≈ –25 | ≈ –7.8 | ≈ –8.1 | ≈ –8.1 | ≈ –4.2 |
| | $F_z$ [1] | pC/N | ≈ –11 | ≈ –3.8 | ≈ –3.7 | ≈ –3.9 | ≈ –2 |
| Linearity incl. hysteresis, typically [3] | $F_x$, $F_y$, $F_z$ [1] | %FSO | ±0.2 | ±0.1 | ±0.1 | ±0.1 | ±0.1 |
| Crosstalk | $F_z$ --> $F_x$, $F_y$ [1] | % | ±1 | ±0.5 | ±0.5 | ±0.5 | ±0.5 |
| | $F_x$ <-> $F_y$ [1] | % | ±2.5 | ±2 | ±2 | ±2 | ±1.5 |
| | $F_x$, $F_y$ --> $F_z$ [1] | % | ±2.5 | ±3 | ±3 | ±3 | ±1.5 |
| Capacitance, each channel | | pF | 35 | 30 | 70 | 100 | 1 000 |
| Stiffness | Axial | N/µm | 1 471 | 2 220 | 6 207 | 8 308 | 27 099 |
| | Transverse [2] | N/µm | 219 | 414 | 1 489 | 1 933 | 6 792 |
| | Shear | N/µm | 308 | 606 | 1 938 | 2 446 | 8 449 |
| | Torsion | kN·m/° | 0.317 | 0.907 | 8.35 | 26.86 | 250.00 |
| | Bending | kN·m/° | 0.352 | 0.933 | 7.74 | 29.19 | 300.85 |
| Operating temperature range | | °C | –40 … 120 | | | | –20 ... 80 |
| Insulation resistance at 20°C | | Ω | $>10^{13}$ | | | | |
| Ground insulated | | Ω | $>10^{8}$ | | | | |
| Connecting plug | | | V3 neg. | | | | |
| max. degree of protection to IEC/EN 6052 (depending on cable) | | | IP68 | | | | |
| Weight | | g | 14 | 30 | 91 | 285 | 1 040 |
| **Suitable preload kit** | | | **9460** | **9461** | **9465** | **9451A** | **9455/9455S** |

[1] With standard pre-load $F_v$ applied.
[2] 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.
[3] For effective values, please refer to the calibration certificate.





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## Technical data (imperial)

| Types | | | 9017C<br>9018C | 9027C<br>9028C | 9047C<br>9048C | 9067C<br>9068C | 9077D<br>9078D |
|---|---|---|---|---|---|---|---|
| Range | $F_x$, $F_y$ [1] | lbf | ±337 | ±899 | ±3 372 | ±6 744 | ±16 860 |
| | $F_z$ [1] | lbf | ±674 | ±1 798 | ±6 744 | ±13 488 | ±33 720 |
| | $F_z$ | lbf | 0 … 2 810 | 0 … 6 294 | 0 … 22 480 | 0 … 44 960 | 0 … 112 400 |
| Standard preload | $F_v$ | lbf | 2 136 | 4 496 | 15 736 | 31 472 | 78 680 |
| Overload | $F_x$, $F_y$ [1] | lbf | ±405 | ±1 124 | ±4 046 | ±7 868 | ±20 232 |
| | $F_z$ [1] | lbf | ±809 | ±2 248 | ±7 868 | ±15 736 | ±40 464 |
| Calibrated range | $F_x$ [1] | lbf | 0 … 337 | 0 … 899 | 0 … 3 372 | 0 … 6 744 | 0 … 16 860 |
| | $F_y$ [1] | lbf | 0 … 337 | 0 … 899 | 0 … 3 372 | 0 … 6 744 | 0 … 16 860 |
| | $F_z$ [1] | lbf | 0 … 674 | 0 … 1 798 | 0 … 6 744 | 0 … 13 488 | 0 … 33 720 |
| | $F_z$ | lbf | 0 … 2 810 | 0 … 6 294 | 0 … 22 480 | 0 … 44 960 | 0 … 112 400 |
| Permissible moment loading | $M_x$, My [1] | in·lbf | ±58.40 | ±194.70 | ±1 327 | ±4 424 | ±18 053 |
| | $M_z$ [1] | in·lbf | ±58.40 | ±203.50 | ±1 327 | ±4 424 | ±18 053 |
| Threshold | | lbf | <0.00225 | <0.00225 | <0.00225 | <0.00225 | <0.00225 |
| Sensitivity | $F_x$, $F_y$ [1] | pC/lbf | ≈ –111 | ≈ –35 | ≈ –36 | ≈ –36 | ≈ –18.7 |
| | $F_z$ [1] | pC/lbf | ≈ –48.9 | ≈ –16.9 | ≈ –16.5 | ≈ –17.3 | ≈ –8.9 |
| *Linearity incl. hysteresis, typically* [3] | $F_x$, $F_y$, $F_z$ [1] | %FSO | ±0.2 | ±0.1 | ±0.1 | ±0.1 | ±0.1 |
| Crosstalk | $F_z$ --> $F_x$, $F_y$ [1] | % | ±1 | ±0.5 | ±0.5 | ±0.5 | ±0.5 |
| | $F_x$ <-> $F_y$ [1] | % | ±2.5 | ±2 | ±2 | ±2 | ±1.5 |
| | $F_x$, $F_y$ --> $F_z$ [1] | % | ±2.5 | ±3 | ±3 | ±3 | ±1.5 |
| Capacitance, each channel | | pF | 35 | 30 | 70 | 100 | 1 000 |
| Stiffness | Axial | lbf/µin | 8.37 | 12.63 | 35.32 | 47.27 | 154.18 |
| | Transverse [2] | lbf/µin | 1.25 | 2.36 | 8.47 | 11.00 | 38.64 |
| | Shear | lbf/µin | 1.75 | 3.45 | 11.03 | 13.92 | 48.07 |
| | Torsion | in·klbf/° | 2.80 | 8.02 | 73.87 | 237.70 | 2 212 |
| | Bending | in·klbf/° | 3.11 | 8.25 | 68.48 | 258.31 | 2 662 |
| Operating temperature range | | °F | –40 … 248 | | | | –4 ... 176 |
| Insulation resistance at 68°F | | Ω | $>10^{13}$ | | | | |
| Ground insulated | | Ω | $>10^{8}$ | | | | |
| Connecting plug | | | V3 neg. | | | | |
| max. degree of protection to IEC/EN 6052 (depending on cable) | | | IP68 | | | | |
| Weight | | oz | 0.49 | 1.06 | 3.21 | 10.05 | 36.68 |
| | | | | | | | |
| **Suitable preload kit** | | | **9460** | **9461** | **9465** | **9451A** | **9455/9455S** |

[1] With standard pre-load Fv applied.
[2] 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.
[3] For effective values, please refer to the calibration certificate.

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## Dimensions Triaxial Force Sensor Type 90x7C/D and 90x8C/D

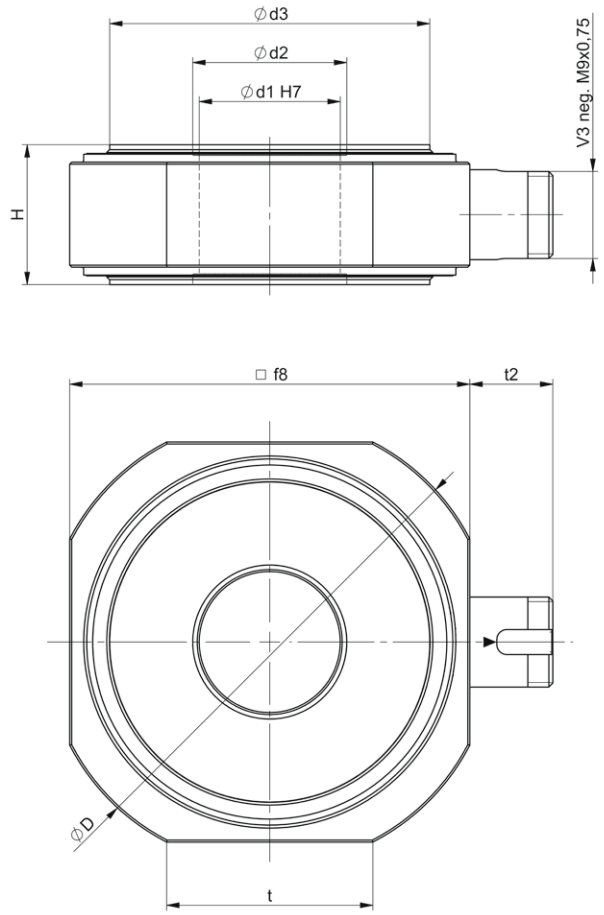


Fig. 2: Triaxial ring force transducer

### Dimension metric [mm]

| Type | D | d1 | d2 | d3 | H | □ | t | t2 |
|---|---|---|---|---|---|---|---|---|
| **9017C, 9018C** | $19^{\ 0}_{-0.2}$ | 6.5 | 8.2 | 12.3 | $10^{\ 0}_{-0.02}$ | 16.5 | 9.4 | 8.3 |
| **9027C, 9028C** | $28^{\ 0}_{-0.2}$ | 8.1 | 9.6 | 18 | $12^{\ 0}_{-0.02}$ | 24 | 14.4 | 10 |
| **9047C, 9048C** | $45^{\ 0}_{-0.2}$ | 14.1 | 15.4 | 32 | $14^{\ 0}_{-0.02}$ | 40 | 20.6 | 8.3 |
| **9067C, 9068C** | $65^{\ 0}_{-0.2}$ | 26.5 | 30 | 47.4 | $21^{\ 0}_{-0.02}$ | 60 | 25 | 10 |
| **9077D, 9078D** | $105^{\ 0}_{-0.2}$ | 40.5 | 51 | 86.2 | $26^{\ 0}_{-0.05}$ | 100 | 32 | 10 |

### Dimension imperial [in]

| Type | D | d1 | d2 | d3 | H | □ | t | t2 |
|---|---|---|---|---|---|---|---|---|
| **9017C, 9018C** | $0.748^{\ 0}_{-0.008}$ | 0.256 | 0.323 | 0.484 | $0.394^{\ 0}_{-0.001}$ | 0.650 | 0.370 | 0.327 |
| **9027C, 9028C** | $1.102^{\ 0}_{-0.008}$ | 0.319 | 0.378 | 0.709 | $0.472^{\ 0}_{-0.001}$ | 0.945 | 0.567 | 0.394 |
| **9047C, 9048C** | $1.772^{\ 0}_{-0.008}$ | 0.555 | 0.606 | 1.260 | $0.551^{\ 0}_{-0.001}$ | 1.575 | 0.811 | 0.327 |
| **9067C, 9068C** | $2.559^{\ 0}_{-0.008}$ | 1.043 | 1.181 | 1.866 | $0.827^{\ 0}_{-0.001}$ | 2.362 | 0.984 | 0.394 |
| **9077D, 9078D** | $4.134^{\ 0}_{-0.008}$ | 1.594 | 2.008 | 3.394 | $1.024^{\ 0}_{-0.002}$ | 3.937 | 1.260 | 0.394 |

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### Type 90x6C4 and 90x6D4
### Set of Four Matched Triaxial Force Sensors

The sets consist of four selected sensors, two of each Type 90x7C/D and 90x8C/D. Jointly ground to the same height, they are used for installation in multi-component dynamometers and multi-component force plates.

The connectors of the four sensors are all directed inwards (see Fig. 3).

The four force sensors are selected so that they demonstrate optimum specifications with regard to constant sensitivity and minimal crosstalk when they are mounted in a dynamometer.

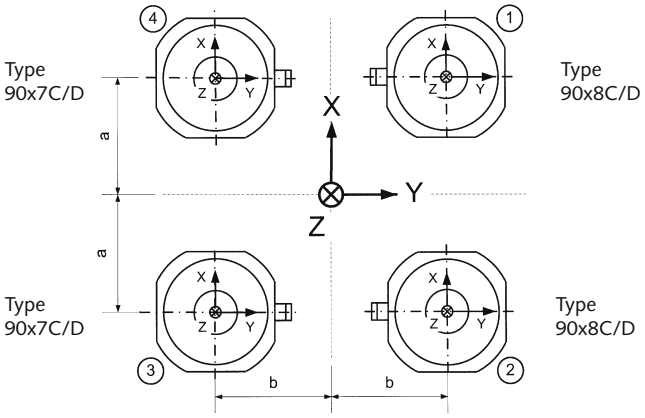


Fig. 3: Set of four matched trixial ring force transducer Type 90x6C4 / 90x6D4

### Preloading Elements

Preloading elements are available for all of our sensors. The suitable types are listed in the technical data, detailed data sheets can be downloaded on our homepage.

Fig. 5: Sets of preloading elements

### Mounting

The force sensor must be mounted under preload. The shear forces $F_x$ and $F_y$ are transferred by friction from the base and cover plates to the surface of the sensor.

The measuring ranges indicated in the technical data are valid for the standard preload.

The exact sensitivity of the preloaded sensors must be confirmed by an on-site calibration.

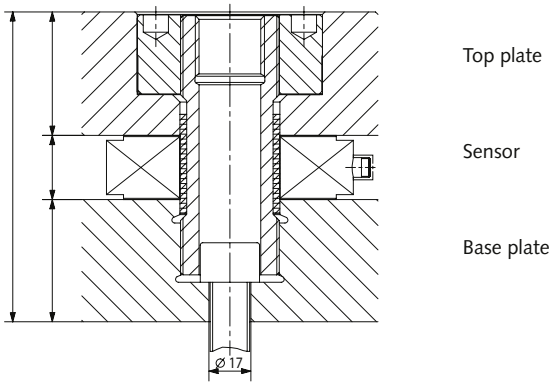


Fig. 4: Generic example of a sensor mounting with preload. Specific values can be found in the manual

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### Triaxial load cells

All triaxial ring force transducers are also available ready mounted as calibrated load cell/force link.

Fig. 6: Force Links Type 93x7/93x8...

### 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 a dynamometer is constructed, the four sensors of Type 90x6... are connected mechanically in parallel. The measuring signals (electric charge) of the four sensors can also be connected in parallel (summed). The summing box Type 5417 allows simple and reliable connection of the measuring signals for the desired type of multi-component force measurement.

The summing box Type 5417 provides a simple and reliable connection of the measuring signals for either a pure force measurement with 3 output channels (Type 5417Q01), or a full dynamometer setting with 8 outputs, that allows the calculation of bending and tortional moments (Type 5417).

Fig. 7: Summing box Type 5417

### Measuring Signal Processing

Charge amplifier channels are additionally required for the complete measuring system. These convert the measuring signal into a voltage. The reading is exactly proportional to the force applied.

The multi-channel charge amplifier Type 5167A... has been designed specifically for multi-component force measuring systems.

Fig. 8: Multichannel charge amplifier Type 5167A...

### Accessories Included

- None

| Optional Accessories | Type |
|---|---|
| • Set of preloading elements | 945x, 946x |
| • Wrench key | 947x |
| • Connection cable | 1698A... |
| • Summing box | 5417/5417Q01 |
| • Summing box | 5447Asp |
| • Summing cable | 1684A |

### Ordering key

**Type 90** ☐ ☐ ☐

| | |
|---|---|
| –3 ... 3 kN | **1_C** |
| –8 ... 8 kN | **2_C** |
| –30 ... 30 kN | **4_C** |
| –60 ... 60 kN | **6_C** |
| -150 ... 150 kN | **7_D** |

| | |
|---|---|
| Standard orientation | **7** |
| Inverted orientation | **8** |
| Set of 4 sensors (2x 90x7C and 2x 90x8C) | **6** |

**Ordering example:**
**Type 9067C**
Triaxial force sensor, Range: –60 ... 60 kN; standard orientation of connector

**Ordering example:**
**Type 9078D**
Triaxial force sensor, Range –150 ... 150 kN, inverted orientation of connector

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## Measuring system with triaxial force sensors

**Triaxial ring force transducer**


**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 | 5039A | 5073A... | 5074A... | 5877B... | Laboratory Amplifier 5015A... | 5018A... | 5080A... | 5165A... | 5167A... | DAQ KiDAQ | SumBox 5417 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | Channels | 1 | 1 | 1-4 | 1-4 | 1 | 1 | 1 | 1-8 | 1,4 | 4,8 | 4, ...52 | 12->8 |
| | | | | | | | | | | | | | IP65 | IP65 | IP60 | IP67 | IP53 | IP20 | IP40 | IP40 | IP20 | IP20 | IP20 | 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 force sensors and summing box Type 5417

**4 pcs. of triaxial ring force transducers**


**Connecting cable**

**Summing box 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 | 5039A | 5073A... | 5074A... | 5877B... | Laboratory Amplifier 5015A... | 5018A... | 5080A... | 5165A... | 5167A... | KiDAQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | Channels | 1 | 1 | 1-4 | 1-4 | 1 | 1 | 1 | 1-8 | 1,4 | 4,8 | 4, ...52 |
| | | | | | | | | | | | | | IP65 | IP65 | IP60 | IP67 | IP53 | IP20 | IP40 | IP40 | IP20 | IP20 | 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





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