Triaxial load cell

Measuring range in $F_z \pm 3 \, \text{kN}$ up to -200 ... 450 kN

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
### Technical data (metric)

<table>
<thead>
<tr>
<th>Type</th>
<th>9317C</th>
<th>9318C</th>
<th>9327C</th>
<th>9328C</th>
<th>9347C</th>
<th>9348C</th>
<th>9367C</th>
<th>9368C</th>
<th>9377D</th>
<th>9378D</th>
<th>9397D</th>
<th>9398D</th>
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<tbody>
<tr>
<td><strong>Range</strong></td>
<td></td>
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</tr>
<tr>
<td>(Without moment loading, e.g. when four force links are mounted in a force plate)</td>
<td>$F_x, F_y$</td>
<td>kN</td>
<td>-1.5 ... 1.5</td>
<td>-4 ... 4</td>
<td>-15 ... 15</td>
<td>-30 ... 30</td>
<td>-75 ... 75</td>
<td>-100 ... 100</td>
<td></td>
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<tr>
<td>(Example with force application point on the surface of the cover plate)</td>
<td>$F_x, F_y$</td>
<td>kN</td>
<td>-0.2 ... 0.2</td>
<td>-1 ... 1</td>
<td>-5 ... 5</td>
<td>-10 ... 10</td>
<td>-30 ... 30</td>
<td>-60 ... 60</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>(Force application point centric)</td>
<td>$F_z$</td>
<td>kN</td>
<td>-3 ... 3</td>
<td>-8 ... 8</td>
<td>-30 ... 30</td>
<td>-60 ... 60</td>
<td>-150 ... 150</td>
<td>-200 ... 450</td>
<td></td>
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</tr>
<tr>
<td><strong>Overload</strong></td>
<td>$F_x, F_y, F_z$</td>
<td>%</td>
<td>≤10</td>
<td>≤20</td>
<td>≤10</td>
<td>≤10</td>
<td>≤10</td>
<td>≤10</td>
<td>≤10</td>
<td>≤10</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Calibrated range</strong></td>
<td>$F_x, F_y$</td>
<td>kN</td>
<td>0 ... 0.5</td>
<td>0 ... 0.1</td>
<td>0 ... 0.5</td>
<td>0 ... 0.1</td>
<td>0 ... 0.5</td>
<td>0 ... 0.1</td>
<td>0 ... 0.5</td>
<td>0 ... 0.1</td>
<td>0 ... 0.5</td>
<td>0 ... 0.1</td>
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<tr>
<td>(Force application point 10 mm below the surface of the cover plate)</td>
<td>$F_z$</td>
<td>kN</td>
<td>0 ... 0.3</td>
<td>0 ... 0.8</td>
<td>0 ... 3</td>
<td>0 ... 3</td>
<td>0 ... 3</td>
<td>0 ... 3</td>
<td>0 ... 3</td>
<td>0 ... 3</td>
<td>0 ... 3</td>
<td>0 ... 3</td>
</tr>
<tr>
<td><strong>Permissible moment load</strong></td>
<td>$M_x, M_y$</td>
<td>N·m</td>
<td>-8/8</td>
<td>-22/22</td>
<td>-150/150</td>
<td>-500/500</td>
<td>-2 040/2 040</td>
<td>-4 500/4 500</td>
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<td></td>
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<tr>
<td>(with $M_z = 0$; $F_z = 0$)</td>
<td>$M_z$</td>
<td>N·m</td>
<td>-6/6</td>
<td>-23/23</td>
<td>-150/150</td>
<td>-500/500</td>
<td>-2 040/2 040</td>
<td>-11 000/11 000</td>
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</tr>
<tr>
<td><strong>Threshold</strong></td>
<td>$F_x, F_y$</td>
<td>pC/N</td>
<td>≤-26</td>
<td>≤-7.8</td>
<td>≤-8</td>
<td>≤-7.6</td>
<td>≤-3.9</td>
<td>≤-3.7</td>
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<tr>
<td>$F_z$</td>
<td>pC/N</td>
<td>≤-11</td>
<td>≤-3.8</td>
<td>≤-3.7</td>
<td>≤-3.9</td>
<td>≤-1.95</td>
<td>≤-1.95</td>
<td></td>
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<tr>
<td><strong>Sensitivity</strong></td>
<td>$F_x, F_y$</td>
<td>%</td>
<td>≤0.2</td>
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<tr>
<td><strong>Linearity incl. hyst., each axis</strong></td>
<td>$F_x \rightarrow F_x, F_y$</td>
<td>%</td>
<td>≤1</td>
<td>≤1</td>
<td>≤1</td>
<td>≤1</td>
<td>≤1</td>
<td>≤1</td>
<td>≤1</td>
<td>≤1</td>
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<tr>
<td>$F_y \rightarrow F_x, F_y$</td>
<td>%</td>
<td>≤3</td>
<td>≤3</td>
<td>≤3</td>
<td>≤3</td>
<td>≤3</td>
<td>≤3</td>
<td>≤3</td>
<td>≤3</td>
<td>≤3</td>
<td>≤3</td>
<td>≤3</td>
</tr>
<tr>
<td>$F_x, F_y \rightarrow F_z$</td>
<td>%</td>
<td>≤4</td>
<td>≤3</td>
<td>≤3</td>
<td>≤3</td>
<td>≤3</td>
<td>≤3</td>
<td>≤3</td>
<td>≤3</td>
<td>≤3</td>
<td>≤3</td>
<td>≤3</td>
</tr>
<tr>
<td><strong>Stiffness</strong></td>
<td>Axial N/μm</td>
<td>877</td>
<td>1 379</td>
<td>2 749</td>
<td>3 880</td>
<td>8 465</td>
<td>13 362</td>
<td></td>
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<tr>
<td>Lateral 1) N/μm</td>
<td>45</td>
<td>73</td>
<td>205</td>
<td>312</td>
<td>1 011</td>
<td>1 531</td>
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<tr>
<td>Shear N/μm</td>
<td>194</td>
<td>391</td>
<td>890</td>
<td>1 167</td>
<td>2 795</td>
<td>2 806</td>
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<tr>
<td>Torsional Nm/°</td>
<td>227</td>
<td>682</td>
<td>4 834</td>
<td>16 093</td>
<td>110 630</td>
<td>277 750</td>
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<tr>
<td>Bending Nm/°</td>
<td>222</td>
<td>625</td>
<td>4 572</td>
<td>14 778</td>
<td>106 540</td>
<td>332 180</td>
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<tr>
<td><strong>Natural frequency</strong></td>
<td>$f_n (x)$ kHz</td>
<td>≤5</td>
<td>≤3.2</td>
<td>≤3.6</td>
<td>≤2.4</td>
<td>≤2</td>
<td>≤10</td>
<td>≤10</td>
<td>≤10</td>
<td>≤10</td>
<td>≤10</td>
<td>≤10</td>
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<tr>
<td>$f_n (y)$ kHz</td>
<td>≤5</td>
<td>≤3.2</td>
<td>≤3.6</td>
<td>≤2.4</td>
<td>≤2</td>
<td>≤10</td>
<td>≤10</td>
<td>≤10</td>
<td>≤10</td>
<td>≤10</td>
<td>≤10</td>
<td>≤10</td>
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<tr>
<td>$f_n (z)$ kHz</td>
<td>≤20</td>
<td>≤12</td>
<td>≤10</td>
<td>≤6</td>
<td>≤6</td>
<td>≤12</td>
<td></td>
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<tr>
<td><strong>Operating temperature range</strong></td>
<td>°C</td>
<td>-40 ... 120</td>
<td>-40 ... 80</td>
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<tr>
<td><strong>Insulation resistance at 20 °C</strong></td>
<td>Ω</td>
<td>&gt;10 13</td>
<td>&gt;10 12</td>
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<tr>
<td><strong>Ground isolated</strong></td>
<td>Ω</td>
<td>&gt;10 8</td>
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</tr>
<tr>
<td><strong>Capacitance, each channel</strong></td>
<td>pF</td>
<td>35</td>
<td>30</td>
<td>70</td>
<td>100</td>
<td>1 000</td>
<td>1 000</td>
<td></td>
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<tr>
<td><strong>Weight</strong></td>
<td>kg</td>
<td>0.085</td>
<td>0.380</td>
<td>3.0</td>
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<td>13.84</td>
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<tr>
<td><strong>Degree of protection</strong></td>
<td></td>
<td>IP65 - IP68</td>
<td></td>
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</tr>
</tbody>
</table>

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
## Technical data (imperial)

<table>
<thead>
<tr>
<th>Type</th>
<th>9317C</th>
<th>9327C</th>
<th>9347C</th>
<th>9367C</th>
<th>9377D</th>
<th>9397D</th>
</tr>
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<tbody>
<tr>
<td><strong>Range</strong></td>
<td></td>
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</tr>
<tr>
<td>(Without moment loading, e.g. when four force links are mounted in a force plate)</td>
<td>F&lt;sub&gt;x&lt;/sub&gt;, F&lt;sub&gt;y&lt;/sub&gt;</td>
<td>F&lt;sub&gt;x&lt;/sub&gt;, F&lt;sub&gt;y&lt;/sub&gt;</td>
<td>F&lt;sub&gt;x&lt;/sub&gt;, F&lt;sub&gt;y&lt;/sub&gt;</td>
<td>F&lt;sub&gt;x&lt;/sub&gt;, F&lt;sub&gt;y&lt;/sub&gt;</td>
<td>F&lt;sub&gt;x&lt;/sub&gt;, F&lt;sub&gt;y&lt;/sub&gt;</td>
<td>F&lt;sub&gt;x&lt;/sub&gt;, F&lt;sub&gt;y&lt;/sub&gt;</td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td>lbf</td>
<td>lbf</td>
<td>lbf</td>
<td>lbf</td>
<td>lbf</td>
<td>lbf</td>
</tr>
<tr>
<td><strong>Calibrated range</strong></td>
<td>-337 ... 337</td>
<td>-372 ... 372</td>
<td>-744 ... 744</td>
<td>-2248 ... 2248</td>
<td>-3372 ... 3372</td>
<td>-16860 ... 16860</td>
</tr>
<tr>
<td><strong>Overload</strong></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td><strong>Calibrated range</strong></td>
<td>0 ... 112</td>
<td>0 ... 112</td>
<td>0 ... 224</td>
<td>0 ... 224</td>
<td>0 ... 224</td>
<td>0 ... 3372</td>
</tr>
<tr>
<td><strong>Permissible moment load</strong></td>
<td>M&lt;sub&gt;x&lt;/sub&gt;, M&lt;sub&gt;y&lt;/sub&gt;</td>
<td>M&lt;sub&gt;x&lt;/sub&gt;, M&lt;sub&gt;y&lt;/sub&gt;</td>
<td>M&lt;sub&gt;x&lt;/sub&gt;, M&lt;sub&gt;y&lt;/sub&gt;</td>
<td>M&lt;sub&gt;x&lt;/sub&gt;, M&lt;sub&gt;y&lt;/sub&gt;</td>
<td>M&lt;sub&gt;x&lt;/sub&gt;, M&lt;sub&gt;y&lt;/sub&gt;</td>
<td>M&lt;sub&gt;x&lt;/sub&gt;, M&lt;sub&gt;y&lt;/sub&gt;</td>
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<td><strong>Threshold</strong></td>
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<td>lbf</td>
<td>lbf</td>
<td>lbf</td>
<td>lbf</td>
</tr>
<tr>
<td><strong>Sensitivity</strong></td>
<td>F&lt;sub&gt;x&lt;/sub&gt;, F&lt;sub&gt;y&lt;/sub&gt;</td>
<td>F&lt;sub&gt;x&lt;/sub&gt;, F&lt;sub&gt;y&lt;/sub&gt;</td>
<td>F&lt;sub&gt;x&lt;/sub&gt;, F&lt;sub&gt;y&lt;/sub&gt;</td>
<td>F&lt;sub&gt;x&lt;/sub&gt;, F&lt;sub&gt;y&lt;/sub&gt;</td>
<td>F&lt;sub&gt;x&lt;/sub&gt;, F&lt;sub&gt;y&lt;/sub&gt;</td>
<td>F&lt;sub&gt;x&lt;/sub&gt;, F&lt;sub&gt;y&lt;/sub&gt;</td>
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<tr>
<td><strong>Stiffness</strong></td>
<td>Axial</td>
<td>Lateral</td>
<td>Shear</td>
<td>Torsional</td>
<td>Bending</td>
<td>Natural frequency</td>
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<tr>
<td></td>
<td>lbf/µin</td>
<td>lbf/µin</td>
<td>lbf/µin</td>
<td>in-lbf/°</td>
<td>in-lbf/°</td>
<td>kHz</td>
</tr>
<tr>
<td><strong>Operating temperature range</strong></td>
<td>°C</td>
<td>°C</td>
<td>°C</td>
<td>°C</td>
<td>°C</td>
<td>°C</td>
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<tr>
<td><strong>Insulation resistance at 20 °C</strong></td>
<td>Ω</td>
<td>Ω</td>
<td>Ω</td>
<td>Ω</td>
<td>Ω</td>
<td>Ω</td>
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<tr>
<td><strong>Ground isolated</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Capacitance, each channel</strong></td>
<td>pF</td>
<td>pF</td>
<td>pF</td>
<td>pF</td>
<td>pF</td>
<td>pF</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>lbs</td>
<td>lbs</td>
<td>lbs</td>
<td>lbs</td>
<td>lbs</td>
<td>lbs</td>
</tr>
</tbody>
</table>
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
Triaxial load cell – Measuring range in \( F_z \) ±3 kN up to -200 ... 450 kN
Types 9317C, 9327C, 9347C, 9367C, 9377D, 9397D

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

### Dimensions (metric)

<table>
<thead>
<tr>
<th>Type</th>
<th>( H )</th>
<th>( h_1 )</th>
<th>( h_2 )</th>
<th>( h_3 )</th>
<th>( h_4 )</th>
<th>( h_5 )</th>
<th>( d_1 )</th>
<th>( d_2 )</th>
<th>( d_3 )</th>
<th>( a )</th>
<th>( b )</th>
</tr>
</thead>
<tbody>
<tr>
<td>9327C, 9328C</td>
<td>42 ±0.3</td>
<td>15</td>
<td>12</td>
<td>21</td>
<td>7.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>32</td>
<td>42</td>
</tr>
<tr>
<td>9347C, 9348C</td>
<td>60 ±0.3</td>
<td>25</td>
<td>14</td>
<td>32</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>42</td>
<td>55</td>
</tr>
<tr>
<td>9367C, 9368C</td>
<td>90 ±0.3</td>
<td>34.5</td>
<td>21</td>
<td>45</td>
<td>15</td>
<td>10</td>
<td>18.6</td>
<td>13</td>
<td>M10</td>
<td>60</td>
<td>80</td>
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<tr>
<td>9377D, 9378D</td>
<td>125 ±0.02</td>
<td>49.5</td>
<td>26</td>
<td>62.5</td>
<td>20</td>
<td>16</td>
<td>25</td>
<td>17</td>
<td>M16</td>
<td>96</td>
<td>120</td>
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</table>

### Dimensions (imperial)

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<thead>
<tr>
<th>Type</th>
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<th>( h_1 )</th>
<th>( h_2 )</th>
<th>( h_3 )</th>
<th>( h_4 )</th>
<th>( h_5 )</th>
<th>( d_1 )</th>
<th>( d_2 )</th>
<th>( d_3 )</th>
<th>( a )</th>
<th>( b )</th>
</tr>
</thead>
<tbody>
<tr>
<td>9327C, 9328C</td>
<td>1.653 ±0.012</td>
<td>0.590</td>
<td>0.472</td>
<td>0.826</td>
<td>0.295</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>1.259</td>
<td>1.653</td>
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<tr>
<td>9347C, 9348C</td>
<td>2.362 ±0.012</td>
<td>0.984</td>
<td>0.551</td>
<td>1.259</td>
<td>0.393</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>1.653</td>
<td>2.165</td>
</tr>
<tr>
<td>9367C, 9368C</td>
<td>3.543 ±0.012</td>
<td>1.358</td>
<td>0.826</td>
<td>1.771</td>
<td>0.590</td>
<td>0.393</td>
<td>0.732</td>
<td>0.511</td>
<td>M10</td>
<td>2.362</td>
<td>3.149</td>
</tr>
<tr>
<td>9377D, 9378D</td>
<td>4.921 ±0.001</td>
<td>1.948</td>
<td>1.023</td>
<td>2.460</td>
<td>0.787</td>
<td>0.629</td>
<td>0.984</td>
<td>0.669</td>
<td>M16</td>
<td>3.779</td>
<td>4.724</td>
</tr>
</tbody>
</table>

This information corresponds to the current state of knowledge. Kistler reserves the right to make technical changes. Liability for consequential damage resulting from the use of Kistler products is excluded.

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Triaxial load cell – Measuring range in $F_z$ ±3 kN up to -200 ... 450 kN
Types 9317C, 9327C, 9347C, 9367C, 9377D, 9397D

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°)
Triaxial load cell – Measuring range in \( F_z \) ±3 kN up to -200 ... 450 kN
Types 9317C, 9327C, 9347C, 9367C, 9377D, 9397D

**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).

**Included accessories**

- none

**Optional accessories**

- Connecting cable, 3 wire 1698A...
- Summing box 5417
- Summing box 5447Asp
- Summing cable 1684A

**Ordering key**

- Triaxial force transducer Type 9317C
  25x25x30 mm, -3 … 3 kN
- Triaxial force transducer Type 9327C
  42x42x42 mm, -8 … 8 kN
- Triaxial force transducer Type 9347C
  55x55x60 mm, -30 … 30 kN
- Triaxial force transducer Type 9367C
  80x80x90 mm, -60 … 60 kN
- Triaxial force transducer Type 9377D
  120x120x125 mm, -150 … 150 kN
- Triaxial force transducer Type 9397D
  D 150/135x150 mm, -200 ... 450 kN
- Triaxial force transducer Type 9397D2
  D 150/135x150 mm, -200 ... 450 kN 22.5° rotated

**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 multi-axis force measurement systems.

**Fig. 7: Summing box Type 5417**

**Fig. 8: Multi-Channel charge amplifier Type 5167A...**
Measuring system with triaxial load cells

Triaxial load cell

Connecting cable

Charge amplifier

Triaxial load cell – Measuring range in Fz ±3 kN up to -200 ... 450 kN
Types 9317C, 9327C, 9347C, 9367C, 9377D, 9397D

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

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

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