### Stroke vs Time

<table>
<thead>
<tr>
<th>1st cycle</th>
<th>L 100 mm</th>
<th>25°C</th>
<th>160 mA</th>
<th>170 MPa</th>
</tr>
</thead>
</table>

- **Stroke (%):**
  - 0.2
  - 0.3
  - 0.4
  - 0.5
  - 0.6
  - 0.7
  - 0.8
  - 0.9
  - 1

- **Time (s):**
  - 0
  - 20
  - 60
  - 140

- **Current (mA):**
  - 180

### Cycle time vs Stress

<table>
<thead>
<tr>
<th>25°C</th>
<th>130 mA</th>
<th>3,5%</th>
</tr>
</thead>
</table>

- **Stress (MPa):**
  - 150
  - 200
  - 250
  - 300
  - 350
  - 400

- **Time (ms):**
  - 0
  - 200
  - 400
  - 600
  - 800

### Cycle time vs Current

<table>
<thead>
<tr>
<th>25°C</th>
<th>170 MPa</th>
<th>3,5%</th>
</tr>
</thead>
</table>

- **Time (s):**
  - 0
  - 0.4
  - 0.8
  - 1.2
  - 1.6

- **Current (mA):**
  - 80
  - 100
  - 120
  - 140
  - 160

- **Time (ms):**
  - actuation
  - heating
  - cooling

### Cycle time vs Temperature

<table>
<thead>
<tr>
<th>160 mA</th>
<th>200 MPa</th>
<th>3,5%</th>
</tr>
</thead>
</table>

- **Temperature (°C):**
  - -10
  - -20
  - -30
  - 0
  - 10
  - 20
  - 30
  - 40
  - 50
  - 60

- **Time (ms):**
  - actuation
  - heating
  - cooling

---

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**SmartFlex®**
76 μm

**Stroke vs Time**
- 1st cycle
- L 100 mm
- 25°C
- 240 mA
- 170 MPa

**Cycle time vs Stress**
- 25°C
- 200 mA
- 3,5%

**Cycle time vs Current**
- 25°C
- 170 MPa
- 3,5%

**Cycle time vs Temperature**
- 240 mA
- 240 MPa
- 3,5%

---

**SAES Group**
www.saesgroup.com
sma@saes-group.com
SmartFlex®
100 μm

1. Stroke vs Time
   - 1st cycle
   - L 100 mm
   - 25°C
   - 380 mA
   - 170 MPa

2. Cycle time vs Stress
   - 25°C
   - 300 mA
   - 3.5%

3. Cycle time vs Current
   - 25°C
   - 170 MPa
   - 3.5%

4. Cycle time vs Temperature
   - 380 mA
   - 200 MPa
   - 3.5%

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SmartFlex®
150 μm

Stroke vs Time
- 1st cycle
- L 100 mm
- 25°C
- 750 mA
- 170 MPa

Cycle time vs Stress
- 25°C
- 600 mA
- 3,5%

Cycle time vs Current
- 25°C
- 170 MPa
- 3,5%

Cycle time vs Temperature
- 750 mA
- 200 MPa
- 3,5%
Stroke vs Time
1° cycle | L 100 mm | 25°C | 2.1 A | 170 MPa

Cycle time vs Stress
25°C | 1.8 A | 3.5%

Cycle time vs Current
25°C | 170 MPa | 3.5%

Cycle time vs Temperature
2.1 A | 200 MPa | 3.5%
Stroke vs Time
- 1st cycle
- L 100 mm
- 25°C
- 3.8 A
- 170 MPa

Cycle time vs Stress
- 25°C
- 3 A
- 3.5%

Cycle time vs Current
- 25°C
- 170 MPa
- 3.5%

Cycle time vs Temperature
- 3.8 A
- 200 MPa
- 3.5%

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SmartFlex®
500 μm

Stroke vs Time
1st cycle | L 100 mm | 25°C | 5.7 A | 170 MPa

Cycle time vs Stress
25°C | 4 A | 3.5%

Cycle time vs Current
25°C | 170 MPa | 3.5%

Cycle time vs Temperature
5.7 A | 200 MPa | 3.5%

SAES Group
www.saesgroup.com
sma@saes-group.com

making innovation happen, together
Different cooling methods improving response time after actuation.

<table>
<thead>
<tr>
<th>Method</th>
<th>Speed performance's increasing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard air convection</td>
<td>1:1</td>
</tr>
<tr>
<td>Solid Heat Sink Materials</td>
<td>2:1</td>
</tr>
<tr>
<td>Forced Air</td>
<td>4:1</td>
</tr>
<tr>
<td>Heat Conductive Grease</td>
<td>8:1</td>
</tr>
<tr>
<td>Silicon</td>
<td>10:1</td>
</tr>
<tr>
<td>Oil Immersion</td>
<td>25:1</td>
</tr>
<tr>
<td>Water with Glycol</td>
<td>25:1</td>
</tr>
</tbody>
</table>

* Getting quicker time response requires more current to heat the wire.
**SmartFlex® 300 μm with silicon sleeve**

Different cooling methods improving response time after actuation

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</tr>
<tr>
<td>Water with Glycol</td>
<td>100:1</td>
</tr>
</tbody>
</table>

Increased cooling time performances

**Stroke vs Time First cycle**
- L 100 mm
- 25°C
- 3.5 A
- 170 MPa

**Cycle time vs Stress**
- 25°C
- 3.5 A
- 3.5%

**Cycle time vs Current**
- 25°C
- 170 MPa
- 3.5%

**Cycle time vs Temperature**
- 3.5 A
- 170 MPa
- 3.5%

* Getting quicker time response requires more current to heat the wire
Increased cooling time performances

<table>
<thead>
<tr>
<th>Different cooling methods improving response time after actuation</th>
<th>Speed performance’s increasing</th>
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</thead>
<tbody>
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<td>Oil Immersion</td>
<td>25:1</td>
</tr>
<tr>
<td>Water with Glycol</td>
<td>100:1</td>
</tr>
</tbody>
</table>

Stroke vs Time First cycle
| L 100 mm | 25°C | 6,5 A | 170 MPa |

Cycle time vs Stress
| 25°C | 6,0 A | 3,5% |

Cycle time vs Current
| 25°C | 170 MPa | 3,5% |

Cycle time vs Temperature
| 6,0 A | 170 MPa | 3,5% |

* Getting quicker time response requires more current to heat the wire.
If your application requires an electro-mechanical termination we can support you with different crimp solutions according to your requirements. Our standard solutions are specified below. For new design we are available to study and develop customized part for you. Crimped Smartflex wires can be ordered both for prototypes and large volume production.

**Barrel Crimp**

<table>
<thead>
<tr>
<th>Wire Diameter [μm]</th>
<th>50</th>
<th>76</th>
<th>100</th>
<th>150</th>
<th>200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrel 4 mm</td>
<td>1,6</td>
<td>3,6</td>
<td>6,3</td>
<td>14</td>
<td>25</td>
</tr>
<tr>
<td>Barrel 2 mm</td>
<td>1,2</td>
<td>2,7</td>
<td>4,7</td>
<td>10</td>
<td>-</td>
</tr>
</tbody>
</table>

**Typical delivery packaging**

**Design parameters to order crimped Smartflex wire**

La, Lb ratio: 5:1
CRIMPS for SmartFlex® Wires

### Ring Type Crimp

**Typical Pull-Out Max Force [N]**

<table>
<thead>
<tr>
<th>Wire Diameter [μm]</th>
<th>150</th>
<th>200</th>
<th>300</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ring Type</td>
<td>10</td>
<td>19</td>
<td>35</td>
</tr>
</tbody>
</table>

### T Type Crimp

**Typical Pull-Out Max Force [N]**

<table>
<thead>
<tr>
<th>Wire Diameter [μm]</th>
<th>400</th>
<th>500</th>
</tr>
</thead>
<tbody>
<tr>
<td>T type</td>
<td>50</td>
<td>80</td>
</tr>
</tbody>
</table>

### Book Crimp

**Typical Pull-Out Max Force [N]**

<table>
<thead>
<tr>
<th>Wire Diameter [μm]</th>
<th>100</th>
<th>180</th>
</tr>
</thead>
<tbody>
<tr>
<td>T type</td>
<td>4.7</td>
<td>15</td>
</tr>
</tbody>
</table>

**NOTE:** SAES can support you to study and develop different book crimp to weld on PCB

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SMA compression springs can be used as very fast and miniaturized thermal-actuators. When heated above As (austenite start temperature) they expand developing a high force.

**Mechanical and functional characteristics of some exemplifying compression spring**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>130</td>
<td>1,5</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>10</td>
<td>25</td>
<td>1,5</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>16</td>
<td>2,2</td>
<td>50</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>18</td>
<td>1,5</td>
<td>30</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>0,6</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

SMA compression springs can be customized according to your design and application requirements.
SMA tensile springs can be used as very fast and miniaturized thermal-actuators. When heated above As (austenite start temperature) they contract, developing a high force.

**Typical behaviour of a SMA tensile spring**

SMA tensile springs can be customized according to your design and application requirements.

**Mechanical and functional characteristics of some exemplifying tensile spring**

<table>
<thead>
<tr>
<th>D [mm]</th>
<th>L₀ [mm]</th>
<th>d [mm]</th>
<th>F [N]</th>
<th>s [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Diameter</td>
<td>Free Length</td>
<td>Wire Diameter</td>
<td>Typical Force</td>
<td>Typical Stroke</td>
</tr>
<tr>
<td>12</td>
<td>60</td>
<td>1,5</td>
<td>10</td>
<td>160</td>
</tr>
<tr>
<td>8</td>
<td>12</td>
<td>1,5</td>
<td>20</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>30</td>
<td>0,8</td>
<td>3</td>
<td>100</td>
</tr>
</tbody>
</table>

SMA tensile springs can be customized according to your design and application requirements.