Expansion Joints Guide

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Elastomer Formed Bellows (EFB):
- several to multi-ply (2 to 16 layers)
- high flexibility
- short construction length
- low displacement forces
- big movement capacity
- small corrugation height
- vibration absorbing
1 Vibration Absorbers General

Spectrum of mechanical oscillation

In the context of sound insulation and vibration absorbers we operate in the field of mechanical vibrations in the frequency range up to the limit of audibility.

Mechanical vibrations are generated in generators and transferred over the medium, but principally through the pipeline into the entire pipe system. The vibrations are perceived both as annoying noise from the environment; on the other hand they strain to a large extent the materials subjected to vibrations.

For pipelines installed without vibration absorbers, this can therefore quickly lead to fractures and failures endangering the operational safety and efficiency of the plant.

BOA vibration absorbers are used in all applications where piping and equipment must be protected from vibration /oscillation and stresses. The use of BOA vibration absorbers increases operating safety, durability and comfort of the facilities.

Vibration absorbers are very flexible pipe elements. Due to theirs design they are capable to reduce part of the energy of an oscillating system. The figure shows the oscillogram of such a reduced vibration.

BOA vibration absorbers are particularly successful in the following areas:
- connection of piping to rotating or oscillating machinery
- pumps, compressors, engines, burners, etc.
- domestic installations, industrial plants
- heaters, climat control systems, fans, heat recovery systems
- gas, water and wastewater systems

2 Standard Program BOA Vibration Absorbers (EFB)

2.1 Vibration absorber Alpha-C (unrestrained) and Epsilon-C (restrained)

BOA proposes two different types: Alpha-C unrestrained and Epsilon-C restrained

- Design of the basic element according to our long proved BOA practice as multi-layered bellows made of high-grade chrome-nickel steel (up to PN 16:all layers in 1.4571; PN 25: inner and outer layer in 1.4571, intermediate layers in 1.4541).
- The multi-ply design guarantees a smooth bellows of high flexibility (low spring rate) with optimal absorbing capacity – at least equal in effectiveness compared with rubber expansion joints, but with significantly longer service life.
- Thanks to the high-grade quality of the bellows material, BOA vibration absorbers are suitable for high media or ambient temperature from -180°C up to +550°C (for temperatures over 120°C ask for metal cushions for the limit bars instead of rubber).
- Almost all types (except for Epsilon-C PN25) are provided with collared movable flanges ensuring easy installation and no contact of the medium with the carbon steel flanges, but only with the stainless/austenitic steel bellows material.
- Flanges (and tie-bars of the type Epsilon-C) are made of carbon steel and are galvanized and passivated (except for Epsilon PN 25).
- In studying the tables of expansion joints with flanges, it has to be considered that the flanges comprise partly threaded holes for the screw part, and partly through holes. This is because the bellows outer diameter and the hole diameter are too close, so that there is no space for the screw head. Other versions on request.
2.2 Reduction

2.2.1 Expansion capacity

NOTE (Hereinafter the term load cycle is used for full load change cycle.)
The maximum permissible expansion capacity is indicated on the expansion joint. It refers to 1000 load cycles (for expansion joints conforming to EC standards: 500 load cycles with safety factor 2). At higher load cycles, the expansion capacity must be reduced by the load cycle factor $K_L$ according to table 1. For the accurate determination of the load factor $K_L$, the following formula can be applied:

$$K_L = (1000 / N_{adm})^{0.29}$$

<table>
<thead>
<tr>
<th>Load cycles</th>
<th>Load cycle factor $K_L$</th>
</tr>
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<tbody>
<tr>
<td>1'000</td>
<td>1.00</td>
</tr>
<tr>
<td>2'000</td>
<td>0.82</td>
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<td>3'000</td>
<td>0.73</td>
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<td>5'000</td>
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<td>0.51</td>
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<td>30'000</td>
<td>0.37</td>
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<td>50'000</td>
<td>0.32</td>
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<tr>
<td>100'000</td>
<td>0.26</td>
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<tr>
<td>200'000</td>
<td>0.22</td>
</tr>
<tr>
<td>1'000'000</td>
<td>0.14</td>
</tr>
<tr>
<td>25'000'000</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Table 1

2.2.2 Temperature related movement and pressure reduction

NOTE
The admissible operating pressure is determined by the nominal pressure considering the reduction factor $K_P$ according to tab. 2. At higher temperatures, the expansion capacity $K_\Delta$ has to be reduced according to the reduction factors.

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>$K_P$</th>
<th>$K_\Delta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>-10 to 20</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>50</td>
<td>0.92</td>
<td>0.97</td>
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<tr>
<td>100</td>
<td>0.87</td>
<td>0.94</td>
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<tr>
<td>150</td>
<td>0.83</td>
<td>0.92</td>
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<tr>
<td>200</td>
<td>0.79</td>
<td>0.90</td>
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<tr>
<td>250</td>
<td>0.74</td>
<td>0.88</td>
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<td>300</td>
<td>0.67</td>
<td>0.86</td>
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<tr>
<td>350</td>
<td>0.60</td>
<td>0.85</td>
</tr>
<tr>
<td>400</td>
<td>0.53</td>
<td>0.84</td>
</tr>
</tbody>
</table>

Table 2

1) linear interpolation for intermediate values
3 Installation Instructions Vibration Absorbers

3.1 General safety recommendations

Prior to installation and start-up, installation and start-up instructions must be read and observed. Installation, start-up and maintenance work shall only be performed by qualified and authorized staff.

Maintenance
Vibration absorbers are maintenance free.

CAUTION
Prior to disassembly and maintenance, the system must be
- depressurized,
- cooled down,
- emptied.

Otherwise there is a risk of accident!

Transport, packaging and storage
- The consignment must be checked for completeness upon receipt.
- Any transport damage must be reported to the carrier and the manufacturer.
- At an intermediate storage we recommend to use the original packaging.

Admissible ambient conditions for storage and transport:
- ambient temperature - 4°C to +70 °C
- relative humidity up to 95%.

Vibration absorbers must be protected against wetness, humidity, dirt, shocks and damage.

Warranty
A warranty claim requires professional installation and start-up in accordance with installation and start-up instructions. The necessary installation, start-up and maintenance work must be performed by qualified and authorized staff.

Operating pressure
NOTE
- The permissible operating pressure results in the nominal pressure considering the reduction factors given in section 2.2 "Reduction".
- At higher temperatures, the expansion capacity has to be reduced according to the reduction factors (see section 2.2).

Start-up and check
Before starting-up check if
- the pipeline is installed with sufficient inclination to avoid water pockets
- there is sufficient drainage
- pipe anchors and pipe supports/ guides are firmly installed prior to filling and pressure testing the system
- the expansion joint is not stressed by torsion, especially not expansion joints with socket attachment
- the flow direction has been observed for expansion joints with inner sleeves
- the steel bellows is free of dirt, welding, plaster or mortar splatters or any other soiling; clean if necessary
- all screwed connections are tightened properly
- the general due diligence requirements to avoid corrosion damage are observed, such as water treatment, or prevention of galvanic corrosion in copper and galvanized pipes.

Insulation
Expansion joints may be insulated exactly as the pipeline.
- If no coating is provided, protect the bellows by means of a slidable metal sleeve to avoid insulation material dropping into the convolutions.
- If the expansion joint is to be placed under plaster, a protective cover is essential. This ensures the bellows’ function, protects against soiling and avoids contact with structure materials.

Improper operation
- The limits given in the technical data of the standard range must not be exceeded.
- Swinging suspensions adjacent to expansion joints are not permitted.
- Do not clean the newly installed pipeline by blowing it with steam to avoid water hammers and unacceptable vibration stimulating of the bellows.

System start-up
CAUTION
- During pressure testing and operation, the allowable test pressure or operating pressure defined for the expansion joint must not be exceeded.
- Excessive pressure peaks as a consequence of valves closing too abruptly, water hammers etc. are not permitted.
- Avoid contact with aggressive media.
- The start-up of steam lines must be performed such that the condensate has time to drain off.
3.2 Installation advice

Assembly
- Anchor points and pipe guides must be firmly installed before filling and pressure testing the system.
- Expansion joints must be installed without being subject to torsion. This applies particularly to expansion joints with socket connection.
- The steel bellows must be protected against damage and dirt (e.g. welding, plaster or mortar splatter).
- Steam pipelines should be installed in such a way that water hammers are avoided. This can be achieved by adequate drainage, insulation, by preventing water pockets and by sufficient inclination of the line.
- Observe the flow direction while installing expansion joints with inner sleeves.
- Avoid the installation of expansion joints in the immediate vicinity of pressure reducers, hot steam coolers and shut-down valves, if high-frequency oscillations are expected due to turbulence. Otherwise special measures must be installed (e.g. thick-walled sleeves, perforated disks, calming sections etc.).
- If high frequency vibrations or turbulence or high flow speed are expected, we recommend the installation of expansion joints with inner sleeve.
- Inner sleeves are also recommended for expansion joints with DN ≥ 150, if the flow speed of air, gas or steam media exceeds 8 m/s, or 3 m/s in case of liquid media.

3.2.1 Unrestrained vibration absorbers, e.g. Alpha-C

Pipe guides, pipe supports
- Provide inclination for drainage
- Align the pipeline, distance between pipe guides according to fig. 1, table 3 and diagram 2

NOTE
Sliding or roller supports are the safest measures to avoid buckling and lifting of the pipeline.

CAUTION
Swing suspensions are not permitted adjacent to expansion joints!

Diagram 1

![Diagram 1](image)

\[ \Delta = \text{expansion capacity of the expansion joint [mm]} \]
\[ L_1 = \text{max. } 2 \times \text{DN} + \frac{\Delta}{2} \text{ [mm]} \]
\[ L_2 = 0.7 \times L_1 \text{ [mm]} \]
\[ L_3 = 400 \times \sqrt{\text{DN}} \text{ [mm]} \text{ valid only for steel pipelines} \]
\[ L_3 \text{ is the distance between the pipe supports according to the formula above. If buckling must be expected, } L_3 \text{ must be reduced according to diagram 2.} \]
Anchor points

- Install main anchors at locations where the pipeline changes direction.
- Limit by anchors each pipe section to be compensated for.
  - Only one vibration absorber is allowed between two anchors.
  - Main anchors must be installed at locations where the pipeline changes direction. They must take up the pressure thrusts of the expansion joints as well as the frictional forces of the pipe supports/guides.
  - Intermediate anchors must be installed if the movement capacity of one axial expansion joint is not sufficient to compensate for the entire expansion of a long pipeline. In that case, several axial expansion joints are required.
  - In vacuum mode, the anchor points must be capable to take up tensile and pressure forces.

---

Table 3 (only valid for steel pipelines)

<table>
<thead>
<tr>
<th>DN</th>
<th>L₁ [mm]</th>
<th>L₂ [mm]</th>
<th>L₃ [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>30 +Δ</td>
<td>1050</td>
<td>1550</td>
</tr>
<tr>
<td>20</td>
<td>40 +Δ</td>
<td>1200</td>
<td>1750</td>
</tr>
<tr>
<td>25</td>
<td>50 +Δ</td>
<td>1400</td>
<td>2000</td>
</tr>
<tr>
<td>32</td>
<td>64 +Δ</td>
<td>1550</td>
<td>2250</td>
</tr>
<tr>
<td>40</td>
<td>80 +Δ</td>
<td>1750</td>
<td>2500</td>
</tr>
<tr>
<td>50</td>
<td>100 +Δ</td>
<td>1950</td>
<td>2800</td>
</tr>
<tr>
<td>65</td>
<td>130 +Δ</td>
<td>2250</td>
<td>3200</td>
</tr>
<tr>
<td>80</td>
<td>160 +Δ</td>
<td>2500</td>
<td>3550</td>
</tr>
<tr>
<td>100</td>
<td>200 +Δ</td>
<td>2800</td>
<td>4000</td>
</tr>
<tr>
<td>125</td>
<td>250 +Δ</td>
<td>3100</td>
<td>4450</td>
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<tr>
<td>150</td>
<td>300 +Δ</td>
<td>3450</td>
<td>4900</td>
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<tr>
<td>200</td>
<td>400 +Δ</td>
<td>3950</td>
<td>5650</td>
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<td>250</td>
<td>500 +Δ</td>
<td>4400</td>
<td>6300</td>
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<td>600 +Δ</td>
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<td>7450</td>
</tr>
<tr>
<td>400</td>
<td>800 +Δ</td>
<td>5600</td>
<td>8000</td>
</tr>
<tr>
<td>450</td>
<td>900 +Δ</td>
<td>5900</td>
<td>8450</td>
</tr>
<tr>
<td>500</td>
<td>1000 +Δ</td>
<td>6250</td>
<td>8900</td>
</tr>
<tr>
<td>600</td>
<td>1200 +Δ</td>
<td>6850</td>
<td>9800</td>
</tr>
<tr>
<td>700</td>
<td>1400 +Δ</td>
<td>7450</td>
<td>10600</td>
</tr>
<tr>
<td>800</td>
<td>1600 +Δ</td>
<td>7900</td>
<td>11300</td>
</tr>
</tbody>
</table>

Diagram 2

Anchor point
Guide support
Expansion joint

Fig. 2

Anchor point
Guide support

Intermediate anchor between expansion joints

Fig. 3
Vibration compensation

- The expansion joint should be installed as close as possible to the vibrating unit to make use of its entire absorption capacity.
- The vibration absorber must be installed as close as possible to the vibration source so as to avoid resonance of the other parts.
- Primarily it must be ensured that the vibration amplitude acts laterally, i.e. perpendicular to the vibration absorber axis.
- Install an anchor directly behind the expansion joint. Installation is made without prerestraint.

CAUTION
If unrestrained vibration absorbers are installed, the reaction force must be taken into account.

3.2.2 Restrained vibration absorbers, e.g. Epsilon-C

Pipe guides, pipe supports

- When installing restrained vibration absorbers (fig. 5), which can take up lateral expansion only in one plane, pay attention to consistency between the direction of the pipe expansion and the movement capability of the expansion joints (perpendicular to the bolt axis). The nominal lateral expansion capacity can be taken from the technical data tables in section 4. Restrained vibration absorbers have no special demands on guide supports. For short-leg boiler and turbine room pipelines guide bearing is not necessary.
- The weight of the pipeline (including medium and insulation) and all wind and additional loads must be absorbed by suitable pipe hangers or supports. Movements of the expansion joint must not be hindered!
- Long pipe sections before and after the restrained vibration absorber need a guide support.

Anchor points

- Only one vibration absorber is allowed between two anchor points. The anchor points must absorb the inherent resistance of the expansion joint, resulting from the bending resistance of the bellows and the pin friction of the hinge supports as well as the frictional forces of the guides/supports.

NOTE
Pipe guides with excessive frictional resistance resulting from a too high surface pressure, dirt or corrosion deposits may block and cause considerable pressure peaks in the pipeline, its anchors and connections.

Special characteristics:

- very low anchor loads as the tie bars restrain the pressure thrust resulting from internal pressure
- less demanding regarding pipe supports/ guides

Vibration compensation

Restrained vibration absorbers are suitable for compensating mechanical oscillations in pressure lines laterally in circular plane, such as for pumps, compressors and other power machinery (fig. 6). If the machine is securely mounted on a concrete base, in most cases the installation of a lateral expansion joint is sufficient. However, if the machine is mounted on a flexible foundation, two lateral expansion joints making a 90° L-arc system are to be provided (fig. 7) in order to compensate for the all-around vibrations. Immediately behind the expansion joint, an anchor point independent from the flexible foundation is required!

Install the expansion joint as close as possible to the vibrating unit.
Installation without prerestraint!

CAUTION
In general, vibrations of very high frequency due to strong turbulent flows, such as those occurring after safety, reducing and shut-down valves, as well as vibrations caused by vibrating gas or liquid columns can not be compensated.
4 Technical Data BOA Standard Vibration Absorbers (EFB)

4.1 Vibration absorbers Type Alpha-C (unrestrained)

Type Alpha-C (unrestrained)

Consider the reaction force of the expansion joint: 10x cross section area = reaction force in [N/bar]

Type designation: L = with inner sleeve; B = without inner sleeve; * = optionally with/without inner sleeve

If an inner guide sleeve is required by the customer, the construction length can be different from the data table below.

<table>
<thead>
<tr>
<th>DN</th>
<th>PN</th>
<th>Type</th>
<th>Nominal expansion capacity[1]</th>
<th>Outside Ø</th>
<th>Thickness</th>
<th>Hole circle Ø</th>
<th>Number of holes</th>
<th>Outside Ø</th>
<th>Male face Ø</th>
<th>Effective area of bellows</th>
<th>Spring rate ± 30%</th>
<th>Spring rate ± 30%</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>6</td>
<td>Alpha-C</td>
<td>23 ± 15</td>
<td>160 ± 17</td>
<td>185 ± 16</td>
<td>220 ± 18</td>
<td>130 ± 16</td>
<td>140 ± 16</td>
<td>70 ± 15</td>
<td>130 ± 16</td>
<td>104 ± 16</td>
<td>104 ± 16</td>
</tr>
<tr>
<td>50</td>
<td>6</td>
<td>Alpha-C</td>
<td>25 ± 17</td>
<td>140 ± 17</td>
<td>162 ± 16</td>
<td>180 ± 18</td>
<td>130 ± 16</td>
<td>140 ± 16</td>
<td>70 ± 15</td>
<td>130 ± 16</td>
<td>104 ± 16</td>
<td>104 ± 16</td>
</tr>
<tr>
<td>65</td>
<td>6</td>
<td>Alpha-C</td>
<td>25 ± 18</td>
<td>140 ± 17</td>
<td>162 ± 16</td>
<td>180 ± 18</td>
<td>130 ± 16</td>
<td>140 ± 16</td>
<td>70 ± 15</td>
<td>130 ± 16</td>
<td>104 ± 16</td>
<td>104 ± 16</td>
</tr>
</tbody>
</table>

[1] Nominal expansion capacity: these indications are meant for 1000 full load cycles SL=1 at 20°C either axial or lateral.
### Consider the reaction force of the expansion joint

10x cross section area = reaction force in [N/bar]

If an inner guide sleeve is required by the customer, the construction length can be different from the data table.

Subject to changes; latest specifications on www.boagroup.com

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**Type designation:** L = with inner sleeve; B = without inner sleeve; * = optionally with/without inner sleeve

---

**Type Alpha-C (unrestrained)**

---

1 Nominal expansion capacity: these indications are meant for 1000 full load cycles SL=1 at 20°C either axial or lateral

Consider the reaction force of the expansion joint: 10x cross section area = reaction force in [N/bar]

Type designation: L = with inner sleeve; B = without inner sleeve; * = optionally with/without inner sleeve

If an inner guide sleeve is required by the customer, the construction length can be different from the data table.

---

**Bellows**

- **Effective area of bellows**
- **Spring rate ± 30%**
- **Spring rate ± 30%**

---

**Flange**

- **Outside Ø**
- **Thickness**
- **Hole circle Ø**
- **Number of holes**
- **Male face Ø**

---

**Nominal expansion capacity**

- **Axial**
- **Lateral (without inner sleeve)**
- **Universal**

---

**Weight**

- **(without inner sleeve)**
- **± 30%**

---

**Subject to changes; latest specifications on www.boagroup.com**
4.2 Vibration absorbers Type Epsilon-C (restrained)

Type Epsilon-C (restrained)

1) Nominal expansion capacity; these indications are meant for 1000 full load cycles as permanent oscillations
If an inner guide sleeve is required by the customer, the construction length can be different from the data table below.

<table>
<thead>
<tr>
<th>DN</th>
<th>PN</th>
<th>Type</th>
<th>Overall length</th>
<th>Flange</th>
<th>Tie rod</th>
<th>Bellows</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>(without inner sleeve)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>± Δl</td>
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<td></td>
<td></td>
<td></td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
</tr>
<tr>
<td>40</td>
<td>6</td>
<td>Epsilon-C</td>
<td>0.8</td>
<td>130</td>
<td>3.5</td>
<td>211</td>
</tr>
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<td>40</td>
<td>10</td>
<td>Epsilon-C</td>
<td>0.6</td>
<td>130</td>
<td>7.3</td>
<td>246</td>
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<td>16</td>
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<td>130</td>
<td>7.3</td>
<td>246</td>
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<td>Epsilon-C</td>
<td>0.2</td>
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<td>6</td>
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<td>281</td>
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<tr>
<td>50</td>
<td>16</td>
<td>Epsilon-C</td>
<td>0.3</td>
<td>130</td>
<td>10.1</td>
<td>281</td>
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<tr>
<td>50</td>
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<td>266</td>
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<td>80</td>
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<td>0.4</td>
<td>130</td>
<td>6.5</td>
<td>271</td>
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<td>10</td>
<td>Epsilon-C</td>
<td>0.4</td>
<td>130</td>
<td>10.1</td>
<td>281</td>
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<td>80</td>
<td>16</td>
<td>Epsilon-C</td>
<td>0.4</td>
<td>130</td>
<td>10.1</td>
<td>281</td>
</tr>
<tr>
<td>80</td>
<td>25*</td>
<td>Epsilon-C</td>
<td>0.3</td>
<td>160</td>
<td>12.5</td>
<td>285</td>
</tr>
<tr>
<td>100</td>
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<td>Overall length</td>
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</table>

**Type Epsilon-C (restrained)**

If an inner guide sleeve is required by the customer, the construction length can be different from the data table.

Subject to changes; latest specifications on www.boagroup.com