Solutions in microspace
The history of mps started 70 years ago with the development and manufacturing of miniature, high-precision ball bearings. Thanks to the reliability and quality of mps ball-bearings, the company has taken part in the conquest of space.

Today we are continuing to take on the toughest challenges by developing complex microsystems of increasingly minute dimensions while constantly fulfilling the technical requirements set out. Helping to ensure the achievements and success of our customers is our principal motivation. Pushing back the limits of micro technology by devising and continually improving manufacturing processes is a task that fascinates our multidisciplinary workshop teams. Constantly maintaining and developing our unique know-how in assembling micro technical components, the fruit of pure Swiss watchmaking tradition, is the pride of the specialists who work in our micro-assembly departments. Guaranteeing and certifying a high level of quality by putting in place stringent control procedures illustrates the authority of our quality assurance experts.

The enthusiasm with which each new project is approached reflects our passion for our work. We look forward to sharing it with you.

mps is currently enjoying a high rate of growth thanks to its entrepreneurial and innovative ability, and the support of the FAULHABER Group, which puts its two priorities – technology and its employees' skills – at the service of its customers.

mps focuses its activities on developing microsystems for global customers in specific fields, which include medical devices, automation/industrialization, optical measurement systems and the watch industry.

As a traditional manufacturer of high-precision micro mechanical components, mps successfully produces and develops its well-known and reputed product lines:
- microsphere®: micro-balls and four-point contact watch bearings for medical and semi-conductors
- microlinea®: linear bearings and high-performance ball screws

The quality of mps microsystems is appreciated by leading manufacturers. mps supplies several thousands of such systems each year.

The final precision of the systems relies on:
- a creative design using state-of-the-art materials and techniques,
- a long experience in precision machining and in centerless grinding techniques,
- recognized know-how in high-precision linear and/or rotating motion bearing systems,
- selection of parts to be assembled, sorted and matched to the nearest micron,
- an assembly process within a controlled environment, carried out by highly qualified personnel.

mps supplies the pick-up systems for high-speed pick-and-place machines for handling electronic components 2mm x 1mm in size that have to be positioned with a precision of some microns.
Calculation for the theoretical life expectancy
In Europe we consider a nominal life expectancy of 100,000 meters; this is the reason of the utilization of the factor $10^3$ in the following formula (in Japan: 50,000 meters). The load ratings shown in the leaflet were calculated according to DIN 636.

General formulas
The theoretical life expectancy has no practical value unless the following conditions are scrupulously fulfilled:
- Strength and direction of constant loads carefully determined
- Constant speed
- Constant temperature not exceeding 100°C.
- Strict cleanliness in mounting and during running
- Careful choice and dosage of lubricant

In all cases of complexity or doubt it is advisable to consult our technical staff.

In achieved distance

$L = \left( \frac{C}{P} \right) \cdot 10^3$

$L_h = \left( \frac{C}{P} \right) \cdot \frac{10^3}{f \cdot s \cdot 60}$

$L_s = \frac{L}{f \cdot s \cdot 60}$

Newton / lb conversion
1 Newton = 0.225 lb
1 lb = 4.45 Newton
### Load ratings

<table>
<thead>
<tr>
<th>Reference</th>
<th>d [mm]</th>
<th>D [mm]</th>
<th>B [mm]</th>
<th>r min [mm]</th>
<th>Ø balls [mm]</th>
<th>static Co [N]</th>
<th>dynamic C [N]</th>
</tr>
</thead>
<tbody>
<tr>
<td>L 204X</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>0.02</td>
<td>0.500</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>L 306X</td>
<td>3</td>
<td>6</td>
<td>7</td>
<td>0.13</td>
<td>0.600</td>
<td>31</td>
<td>30</td>
</tr>
<tr>
<td>L 408X</td>
<td>4</td>
<td>8</td>
<td>10</td>
<td>0.24</td>
<td>0.794</td>
<td>66</td>
<td>61</td>
</tr>
<tr>
<td>L 510X</td>
<td>5</td>
<td>10</td>
<td>14</td>
<td>0.24</td>
<td>1.250</td>
<td>131</td>
<td>132</td>
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<tr>
<td>L 612X</td>
<td>6</td>
<td>12</td>
<td>18</td>
<td>0.39</td>
<td>1.588</td>
<td>250</td>
<td>245</td>
</tr>
</tbody>
</table>

### Example of part number definition

- L 204X-L23ar: miniature precision linear bearing
- L 204X-L23ar: dimension: first digit bore = 2 [mm] second 2 digits outer diameter = 4 [mm]
- L 204X-L23ar: stainless steel material
- L 204X-L23ar: lubricant: L = oil; G = grease
- L 204X-L23ar: type of lubricant
- L 204X-L23ar: rust protection, dipped in oil

### Technical Specifications

- **Housing**: stainless steel AISI 440C
- **Cage**: brass
- **Shields**: stainless steel AISI 302 or AISI 303
- **Balls**: stainless steel AISI 440C
- **Lubrication**: Standard: Winsor Lube L245X (other oil on request)

### Bearing tolerances

- Bore diameter 0/+8 [µm]
- Outside diameter 0/-8 [µm]

### Recommended tolerances for shaft: 0/-6 [µm]

Max. interference fit of outer ring -1/-3 [µm]

On request, mps can deliver linear bearings only in stainless steel (with stainless cage)
Effective load capacity $C_{\text{eff}}$

The effective load capacity is determined by the following coefficients:

- $f_1$: coefficient related to the angle of application of the load on the bearing
- $f_2$: coefficient related to the buckling angle of the shaft
- $f_3$: coefficient related to the displacement length
- $f_4$: coefficient related to the hardness of the shaft
- $f_5$: coefficient related to the temperature (for DBL only)
- $F_i$: coefficient related to the number of bearings per unit

On the basis of the above coefficients, the effective load capacity is calculated as follows:

$$C_{\text{eff}} = C \cdot f_1 \cdot f_2 \cdot f_3 \cdot f_4 \cdot f_5 \cdot F_i$$

Coefficient $f_1$

If the load applies directly on 1 row of balls, the coefficient $f_1 = 0.7$.

In the other case, coefficient $f_1 = 1$.

Coefficient $f_2$

As soon as a radial load is applied, the shaft will bend. This bending change the number of carrying balls.

- $\leq 5'$: $f_2 = 1$
- $5' < \leq 10'$: $f_2 = 0.8$
- $10' < \leq 15'$: $f_2 = 0.4$

Coefficient $f_3$

If the distance of displacement is less than twice the width of the bearing, the coefficient $f_3$ must be determined. Consequently, it is possible to take into account the premature wear caused by running on a small zone.

- $(\text{course/width B}) \geq 2$: $f_3 = 1$
- $1 \leq (\text{course/width B}) < 2$: $f_3 = 0.8$
- $(\text{course/width B}) < 1$: $f_3 = 0.5$

Coefficient $f_4$

If the hardness of the shaft is lower than 58 HRC, the life expectancy will be decreased exponentially. It is therefore important to choose materials with hardness near 58 HRC, especially when using stainless steel.

- Hardness of the shaft $\geq 58$: $f_4 = 1$
- $55 \leq \text{hardness of the shaft} < 58$: $f_4 = 0.7$
- $50 \leq \text{hardness of the shaft} < 55$: $f_4 = 0.5$

Coefficient $f_5$

As soon the temperature of use higher than 25°C, the life expectancy of the bearing decreases. Therefore it is necessary to define the coefficient $f_5$.

- $T < 25^\circ C$: $f_5 = 1$
- $25^\circ C \leq T < 40^\circ C$: $f_5 = 0.7$
- $40^\circ C \leq T < 60^\circ C$: $f_5 = 0.35$

Coefficient $F_i$

In most applications, linear bearings are not mounted separately. They are often mounted in block forming compact guiding units. Because of the difference of tolerances, it has been noticed that the starting conditions are not the same for each mounted bearing. Based on several tests, a formula can be determined taking into account these particular conditions. The coefficient $F_i$ is calculated as follows:

$$F_i = \frac{0.7}{i}$$

- $i$: Number of ball bushings in the nuts

Coefficient $C_{\text{eff}}$

The formula which takes into account the effective load capacity ($C_{\text{eff}}$) and the two correction factors is as follows:

$$L_n = \left( \frac{C_{\text{eff}}}{P} \right)^{1.05}$$

- $L_n$: Nominal life expectancy in meters [m]
- $C_{\text{eff}}$: Effective dynamic load capacity [N]
- $P$: Equivalent dynamic load [N]
Miniature precision linear bearings for linear motion
Automation, medical instrumentation, military and defense industry, space industry

**Advantages**
- High precision
- Low noise
- Low friction
- Cost effective
- Corrosion resistant

### Load ratings

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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<th></th>
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<tbody>
<tr>
<td>DBL 307X</td>
<td>3</td>
<td>7</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>1.0</td>
<td>0.0</td>
<td>0.75</td>
<td>27</td>
<td>26</td>
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<tr>
<td>DBL 408X</td>
<td>4</td>
<td>8</td>
<td>12</td>
<td>-</td>
<td>-</td>
<td>1.0</td>
<td>0.0</td>
<td>0.9</td>
<td>50</td>
<td>44</td>
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<td>10</td>
<td>15</td>
<td>-</td>
<td>-</td>
<td>1.2</td>
<td>0.1</td>
<td>1.0</td>
<td>84</td>
<td>72</td>
</tr>
<tr>
<td>DBL 612X</td>
<td>6</td>
<td>12</td>
<td>19</td>
<td>-</td>
<td>-</td>
<td>1.0</td>
<td>0.0</td>
<td>1.0</td>
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<td>114</td>
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<td>8</td>
<td>15</td>
<td>24</td>
<td>1.1</td>
<td>23</td>
<td>1.5</td>
<td>0.85</td>
<td>1.0</td>
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<tr>
<td>DBL 1017X</td>
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<td>17</td>
<td>26</td>
<td>1.1</td>
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<td>0.85</td>
<td>1.2</td>
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<td>DBL 1219X</td>
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<td>19</td>
<td>28</td>
<td>1.3</td>
<td>26.4</td>
<td>1.5</td>
<td>1.25</td>
<td>1.2</td>
<td>257</td>
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<table>
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<tbody>
<tr>
<td>DBL 1222X (-JR)</td>
<td>12</td>
<td>22</td>
<td>32</td>
<td>1.3</td>
<td>22.60</td>
<td>1.3</td>
<td>22.60</td>
<td></td>
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<tr>
<td>DBL 1626X (-JR)</td>
<td>16</td>
<td>26</td>
<td>36</td>
<td>1.3</td>
<td>24.60</td>
<td>1.3</td>
<td>24.60</td>
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<tr>
<td>DBL 2032X (-JR)</td>
<td>20</td>
<td>32</td>
<td>45</td>
<td>1.6</td>
<td>31.20</td>
<td>1.6</td>
<td>31.20</td>
<td></td>
<td></td>
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<tr>
<td>DBL 2540X (-JR)</td>
<td>25</td>
<td>40</td>
<td>58</td>
<td>1.85</td>
<td>43.70</td>
<td>1.85</td>
<td>43.70</td>
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</tbody>
</table>

**Example of part number definition**
- DBL 307X: precision linear bearing
- Dimension: first digit bore = 3 [mm]
- DBL 307X: second 2 digits outer diameter = 7 [mm]
- DBL 307X: indicates stainless steel
- Housing: polyamide
- Lubrication: balls and needles; stainless steel standard: Winsor Lubric 245X (other oil on request)

Bearings are available with wipers on both sides. Please, indicate -JR on the part number (e.g. 1219X-JR).

**Material**: stainless steel / polyamide
<table>
<thead>
<tr>
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<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>307</td>
<td>0/+6</td>
<td>0/+9</td>
<td>0/-4</td>
<td>0/-6</td>
<td>0/6</td>
<td>0/16</td>
<td>0/21</td>
</tr>
<tr>
<td>408</td>
<td>0/+6</td>
<td>0/+9</td>
<td>0/-5</td>
<td>0/-8</td>
<td>0/6</td>
<td>0/17</td>
<td>0/23</td>
</tr>
<tr>
<td>510</td>
<td>0/+6</td>
<td>0/+9</td>
<td>0/-5</td>
<td>0/-8</td>
<td>0/6</td>
<td>0/17</td>
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<tr>
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<td>0/+8</td>
<td>0/+11</td>
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<td>0/-8</td>
<td>0/6</td>
<td>0/19</td>
<td>0/25</td>
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<tr>
<td>815</td>
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<td>0/+11</td>
<td>0/-6</td>
<td>0/-9</td>
<td>0/6</td>
<td>0/20</td>
<td>0/26</td>
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<tr>
<td>1017</td>
<td>0/+8</td>
<td>0/+11</td>
<td>0/-6</td>
<td>0/-9</td>
<td>0/6</td>
<td>0/20</td>
<td>0/26</td>
</tr>
<tr>
<td>1219</td>
<td>0/+9</td>
<td>0/+13</td>
<td>0/-8</td>
<td>0/-11</td>
<td>0/6</td>
<td>0/23</td>
<td>0/30</td>
</tr>
<tr>
<td>1222</td>
<td>0/+9</td>
<td>0/+13</td>
<td>0/-8</td>
<td>0/-11</td>
<td>0/6</td>
<td>0/23</td>
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<td>1626</td>
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<td>0/-8</td>
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<td>0/-13</td>
<td>0/7</td>
<td>0/27</td>
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</table>
Miniature ball screws high-precision
Automation, medical instrumentation, military and defense industry, space industry

<table>
<thead>
<tr>
<th>Nut</th>
<th>Screw</th>
<th>Axial load rating</th>
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<tbody>
<tr>
<td>ED 410X</td>
<td>10</td>
<td>10</td>
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<tr>
<td>V404X</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>ED 513X</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>V501X</td>
<td>22</td>
<td>18</td>
</tr>
<tr>
<td>ED 616X</td>
<td>28</td>
<td>22</td>
</tr>
<tr>
<td>V601X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ED 822X</td>
<td></td>
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<tr>
<td>V801X</td>
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<td>ED 1028X</td>
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<tr>
<td>V1001X</td>
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</tr>
</tbody>
</table>

Example of part number definition

- **ED 513X/501X**: ball nut. (EDD = two ball nuts)
- **ED 513X/501X**: 4 x pitch of ball nut thread
- **ED 513X/501X**: outer diameter of ball nut
- **ED 513X/501X**: ball nut in stainless steel material
- **ED 513X/501X**: ground precision screw
- **ED 513X/501X**: 4 x pitch of screw thread
- **ED 513X/501X**: screw drawing number
- **ED 513X/501X**: screw in stainless steel material

- **Housing**: stainless steel AISI 440C
- **Ball nuts ED/ES**: stainless steel AISI 440C
- **Shields**: stainless steel AISI 302 or AISI 303
- **Balls**: stainless steel AISI 440C
- **Lubrication**: Standard: L23ar

- **Special**: The maximum length of a special screw will not exceed 1.5x the length of a standard screw. Nevertheless, each case must be examined individually.

- **Temperature**: -40°C and +80°C or more with the appropriate lubricant

Left hand thread ball screws with left hand thread are available upon request.
### Technical Data

<table>
<thead>
<tr>
<th></th>
<th>ED 410X</th>
<th>ED 513X</th>
<th>ED 616X</th>
<th>ED 822X</th>
<th>ED 1028X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tolerance of outside diameter of nut</td>
<td>μm</td>
<td>0 / -6</td>
<td>0 / -6</td>
<td>0 / -9</td>
<td>0 / -9</td>
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<tr>
<td>Tolerance of the bearing shaft diameter</td>
<td>d2 / μm</td>
<td>0 / -8</td>
<td>0 / -8</td>
<td>0 / -8</td>
<td>0 / -8</td>
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<tr>
<td>Max. pitch variation per L1*</td>
<td>rPL1 / μm</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Max. band width</td>
<td>rPB / μm</td>
<td>5</td>
<td>5</td>
<td>5</td>
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<tr>
<td>Max. eccentricity of the nut on the screw</td>
<td>μm</td>
<td>10</td>
<td>10</td>
<td>12</td>
<td>14</td>
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<tr>
<td>Average efficiency</td>
<td>%</td>
<td>80-85</td>
<td>80-87</td>
<td>80-89</td>
<td>81-91</td>
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<tr>
<td>Standard axial play</td>
<td>μm</td>
<td>0-5</td>
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<tr>
<td>Zero backlash</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>on request</td>
</tr>
</tbody>
</table>

* Above are standard specifications. The precision can be increased on request. Special executions are available on request.

**Note:** The nut must not be removed from the shaft.

**Material:** Stainless steel

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### Ball Screws Calculations - General Formulas

The theoretical life expectancy is generally expressed by the total number of revolutions. The total rotation in hours or total travel distance may also be used to express life. The fatigue life is calculated as follows:

- \( L = \left( \frac{C}{F_{nm}} \right)^3 \cdot 10^6 \)
- \( Lh = \frac{L}{nm \cdot 60} \)

- \( L \): Life expectancy in millions of revolutions [min⁻¹]
- \( Lh \): Life expectancy in hours [h]
- \( C \): Dynamic load rating [N]
- \( F_{nm} \): Axial load (N)
- \( nm \): Rotating speed [min⁻¹]
Four-point contact bearings
Watch industry, micromotors, medical technology

<table>
<thead>
<tr>
<th>Reference</th>
<th>Shaft bearing for micromotors</th>
<th>Bearing for oscillating mass</th>
<th>Biocompatible bearing</th>
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<tbody>
<tr>
<td></td>
<td>20/112</td>
<td>30/130</td>
<td>40/210</td>
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<tr>
<td>d (mm)</td>
<td>0.32</td>
<td>0.60</td>
<td>1.00</td>
</tr>
<tr>
<td>D (mm)</td>
<td>1.60</td>
<td>2.40</td>
<td>3.00</td>
</tr>
<tr>
<td>B (mm)</td>
<td>0.40</td>
<td>0.82</td>
<td>1.00</td>
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<tr>
<td>Ball Ø (mm)</td>
<td>0.20</td>
<td>0.30</td>
<td>0.40</td>
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<tr>
<td>Tilt angle [°]</td>
<td>&lt; 1.6</td>
<td>&lt; 1.3</td>
<td>&lt; 0.8</td>
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</table>

The above dimensions only give a view of the dimensional range which can be produced. There is no standard design for these types of high-end bearings. Each bearing is developed and adapted to a specific application. If you would like to know the available sizes and specifications fitting your requirements, please contact:
watch@mpsag.com
example of calculations: load capacity

These tables are valid for steel ring only.
Specific calculations are available at our engineering department.
Please contact: watch@mpsag.com
Miniature precision balls
Watch industry, linear bearings, ball screws

<table>
<thead>
<tr>
<th>Tolerances</th>
<th>Stainless steel</th>
<th>myrox®</th>
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<td>Spherical variation</td>
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<td>Diameter variation of one lot*</td>
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<tr>
<td>Density</td>
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<td>6.0 g/cm³</td>
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<td>Hardness</td>
<td>min. 720 HV</td>
<td>1150-1200 HV</td>
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<td>E-modules</td>
<td>21 400 Mpa</td>
<td>220 000 Mpa</td>
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<tr>
<td>Linear coefficient of thermal expansion</td>
<td>10.4 x 10^-6 K^-1</td>
<td>11 x 10^-6 K^-1</td>
</tr>
<tr>
<td>Fracture toughness</td>
<td>-</td>
<td>10 Mpa m¹²</td>
</tr>
<tr>
<td>Bending strength</td>
<td>1930 Mpa</td>
<td>&gt;1800 Mpa</td>
</tr>
</tbody>
</table>

* other diameters are available on request.

### Example of part number definition

- **0.250X/G3**: Nominal ball diameter in [mm]
- **0.250X/G3**: Material: "X" for stainless steel
- **0.250X/G3**: Steel / "ZRY" for myrox®
- **0.250X/G3**: Precision quality ISO grade 3

### Material
- **myrox®**: Zirconium oxide (ZrO₂)
- **stainless steel**: AISI 440C

### Stainless steel [mm]
- 0.200X
- 0.250X
- 0.300X
- 0.397X
- 0.500X
- 0.600X
- 0.794X (1/32 inch)
- 1.000X
- 1.150X
- 1.250X
- 1.450X
- 1.500X
- 1.588X (1/16 inch)

### myrox® [mm]
- 0.700ZRY
- 1.000ZRY
- 1.000ZRY