Harmonic Drive®
CSF-GH Standard Series

Size
14, 20, 32, 45, 65

Peak torque
18Nm to 2630Nm

Reduction ratio
50:1 to 160:1

Zero backlash

High Accuracy
Repeatability ±4 to ±10 arc-sec

High Load Capacity Output Bearing
A Cross Roller bearing is integrated with the output flange to provide high moment stiffness, high load capacity and precise positioning accuracy.

Easy mounting to a wide variety of servomotors
Quick Connect® motor adaptation system includes a clamshell style servo coupling and piloted adapter flange.

Motor Code

<table>
<thead>
<tr>
<th>Model Name</th>
<th>Size</th>
<th>Reduction Ratio</th>
<th>Model</th>
<th>Output Configuration</th>
<th>Input Configuration</th>
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<td>HarmonicDrive® CSF Standard</td>
<td>14</td>
<td>50, 80, 100</td>
<td>GH: Gearhead</td>
<td>F0: Flange output</td>
<td>This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.</td>
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<tr>
<td></td>
<td>20</td>
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<td>J2: Shaft output without key</td>
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Gearhead Construction

Figure 096-1

(THE  FIGURE INDICATES OUTPUT SHAFT TYPE.)
## Rating Table  CSF-GH

<table>
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<tr>
<th>Size</th>
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<th>Rated Torque at 2000 rpm</th>
<th>Rated Torque at 3000 rpm</th>
<th>Limit for Average Torque</th>
<th>Limit for Repeated Peak Torque</th>
<th>Limit for Momentary Torque</th>
<th>Max. Average Input Speed</th>
<th>Mac. Input Speed</th>
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*1: Rated torque is based on L10 life of 7,000 hours when input speed is 2000 rpm.
*2: Rated torque is based on L10 life of 7,000 hours when input speed is 3000 rpm, input speed for size 65 is 2800 rpm.
*3: Average load torque calculated based on the application motion profile must not exceed values shown in the table. See p.110.
*4: The limit for torque during start and stop cycles.
*5: The limit for torque during emergency stops or from external shock loads. Always operate below this value.
*6: Max value of average input rotational speed during operation.
*7: Maximum instantaneous input speed.
*8: The mass is for the gearhead only (without input shaft coupling & motor flange). Please contact us for the mass of your specific configuration.

## Ratcheting Torque  CSF-GH

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### Buckling Torque  CSF-GH

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<th>Starting torque</th>
<th>Backdriving torque</th>
<th>No-load running torque</th>
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</table>

*1: Accuracy values represent the difference between the theoretical angle and the actual angle of output for any given input. The values shown in the table are maximum values.

*2: The repeatability is measured by moving to a given theoretical position seven times, each time approaching from the same direction. The actual position of the output shaft is measured each time and repeatability is calculated as the 1/7 of the maximum difference of the seven data points. Measured values are indicated in angles (arc-sec) prefixed with "±". The values in the table are maximum values.

*3: Starting torque is the torque value applied to the input side at which the output first starts to rotate. The values in the table are maximum values.

*4: Backdriving torque is the torque value applied to the output side at which the input first starts to rotate. The values in the table are maximum values.

*5: No-load running torque is the torque required at the input to operate the gearhead at a given speed under a no-load condition. The values in the table are average values.
## Torsional Stiffness  CSF-GH

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<th>Symbol</th>
<th>Size</th>
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<td>7.6</td>
<td>—</td>
</tr>
<tr>
<td>( \phi_1 )</td>
<td>arc min</td>
<td>5.6</td>
<td>5.2</td>
<td>5.5</td>
<td>5.2</td>
<td>—</td>
</tr>
<tr>
<td>( \phi_2 )</td>
<td>arc min</td>
<td>2.0</td>
<td>1.8</td>
<td>1.9</td>
<td>1.8</td>
<td>—</td>
</tr>
<tr>
<td>( \phi_3 )</td>
<td>arc min</td>
<td>16</td>
<td>15.4</td>
<td>15.7</td>
<td>15.1</td>
<td>—</td>
</tr>
</tbody>
</table>

* The values in this table are average values. See page 108 for more information about torsional stiffness.

## Hysteresis Loss  CSF-GH

Reduction ratio 50: Approx. 5.8\( \times 10^4 \) rad (2arc min)
Reduction ratio 80 or more: Approx. 2.9\( \times 10^4 \) rad (1arc min)
CSF-GH-14 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

<table>
<thead>
<tr>
<th>Flange Type I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flange Type II</td>
</tr>
<tr>
<td>Output shaft shape: J2 (Shaft output without key)</td>
</tr>
<tr>
<td>J6 (Shaft output with key and center tapped hole)</td>
</tr>
</tbody>
</table>

(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

### Dimension Table

<table>
<thead>
<tr>
<th>Flange</th>
<th>Coupling</th>
<th>A (H7)</th>
<th>B</th>
<th>C</th>
<th>F (H7)</th>
<th>G</th>
<th>H</th>
<th>Moment of Inertia</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I</td>
<td>1</td>
<td>30</td>
<td>50</td>
<td>6.5</td>
<td>35</td>
<td>55</td>
<td>6.0</td>
<td>8</td>
<td>20.5</td>
</tr>
<tr>
<td>Type II</td>
<td>1</td>
<td>30</td>
<td>55</td>
<td>7</td>
<td>55</td>
<td>75</td>
<td>6.0</td>
<td>8</td>
<td>20.5</td>
</tr>
</tbody>
</table>

Refer to the confirmation drawing for detailed dimensions. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.

*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for mounting screw.
CSF-GH-20 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

<table>
<thead>
<tr>
<th>Dimension Table</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Flange</th>
<th>Coupling</th>
<th>A (mm)</th>
<th>B (mm)</th>
<th>C (mm)</th>
<th>F (mm)</th>
<th>G (mm)</th>
<th>H (mm)</th>
<th>Moment of Inertia (kgf·mm²)</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>28.5</td>
<td>140.5</td>
</tr>
<tr>
<td>Type II</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>45°</td>
<td>0.28</td>
</tr>
<tr>
<td>Type III</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>45°</td>
<td>0.42</td>
</tr>
</tbody>
</table>

Refer to the confirmation drawing for detailed dimensions. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.

*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.
**CSF-GH-32 Outline Dimensions**

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

<table>
<thead>
<tr>
<th>Flange Type I</th>
<th>Flange Type II</th>
</tr>
</thead>
</table>

- **Flange Type I**
  - Grease filling port
  - 2 locations (symmetrical locations)
  - M6 P=1
  - * Output dimensions are the same as flange type III

- **Flange Type II**
  - Grease filling port
  - 2 locations (symmetrical locations)
  - M6 P=1
  - * Output dimensions are the same as flange type III

- **Flange Type III**
  - Output shaft shape: J2 (Shaft output without key)
  - J6 (Shaft output with key and center tapped hole)

(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

### Dimension Table

(Unit: mm) Table 102-1

<table>
<thead>
<tr>
<th>Flange</th>
<th>Coupling</th>
<th>A (H7)</th>
<th>B</th>
<th>C</th>
<th>F (H7)</th>
<th>G</th>
<th>H</th>
<th>Moment of Inertia</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Min.</td>
<td>Max.</td>
<td>Max.</td>
<td>Min.</td>
<td>Max.</td>
<td>Min.</td>
<td>Max.</td>
<td>102 (kg-m)</td>
</tr>
<tr>
<td>Type I</td>
<td>1</td>
<td>50</td>
<td>105</td>
<td>10</td>
<td>55</td>
<td>100</td>
<td>10.8</td>
<td>19.6</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.8</td>
<td>19.6</td>
<td>27</td>
</tr>
<tr>
<td>Type II</td>
<td>2</td>
<td>60</td>
<td>175</td>
<td>5</td>
<td>70</td>
<td>225</td>
<td>16</td>
<td>25.8</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6.4</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Type III</td>
<td>1</td>
<td>35</td>
<td>130</td>
<td>7</td>
<td>40</td>
<td>135</td>
<td>10.8</td>
<td>19.6</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.8</td>
<td>19.6</td>
<td>35</td>
</tr>
</tbody>
</table>

Refer to the confirmation drawing for detailed dimensions. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.

*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.
Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

**CSF-GH-45 Outline Dimensions**

Output shaft shape: J2 (Shaft output without key) J6 (Shaft output with key and center tapped hole)

(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

**Dimension Table**

<table>
<thead>
<tr>
<th>Flange</th>
<th>Coupling</th>
<th>A (H7)</th>
<th>B</th>
<th>C</th>
<th>F (H7)</th>
<th>G</th>
<th>H</th>
<th>Moment of Inertia</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
<td>Typical (10^3kg-m²)</td>
<td>Shaft</td>
</tr>
<tr>
<td>Type I</td>
<td>1</td>
<td>70</td>
<td>119</td>
<td>7</td>
<td>80</td>
<td>157</td>
<td>14.0</td>
<td>29.4</td>
<td>30.5</td>
</tr>
<tr>
<td>Type I</td>
<td>2</td>
<td>70</td>
<td>119</td>
<td>7</td>
<td>80</td>
<td>157</td>
<td>19.0</td>
<td>41</td>
<td>30.5</td>
</tr>
<tr>
<td>Type II</td>
<td>1</td>
<td>70</td>
<td>175</td>
<td>6.5</td>
<td>80</td>
<td>225</td>
<td>14.0</td>
<td>29.4</td>
<td>44.5</td>
</tr>
<tr>
<td>Type II</td>
<td>2</td>
<td>70</td>
<td>175</td>
<td>6.5</td>
<td>80</td>
<td>225</td>
<td>19.0</td>
<td>41</td>
<td>44.5</td>
</tr>
</tbody>
</table>

Refer to the confirmation drawing for detailed dimensions.

Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.

* May vary depending on motor interface dimensions.

*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.

*3 Tapped hole for motor mounting screw.
CSF-GH-65 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

![Flange Type I Diagram](image)

**Flange Type I**
Output shaft shape: J2 (Shaft output without key)
J6 (Shaft output with key and center tapped hole)

![Flange Type II Diagram](image)

**Flange Type II**

(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

### Dimension Table

![Dimension Table](image)

<table>
<thead>
<tr>
<th>Flange</th>
<th>Coupling</th>
<th>A (H7)</th>
<th>B</th>
<th>C</th>
<th>F (H7)</th>
<th>G</th>
<th>H</th>
<th>Moment of Inertia</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I</td>
<td>1</td>
<td>95</td>
<td>110</td>
<td>10</td>
<td>105</td>
<td>125</td>
<td>19</td>
<td>39.3</td>
<td>32.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>72</td>
<td>201.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>51</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>36.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>27.6</td>
</tr>
<tr>
<td>Type II</td>
<td>1</td>
<td>70</td>
<td>215</td>
<td>6.5</td>
<td>80</td>
<td>260</td>
<td>19</td>
<td>39.3</td>
<td>44.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>84.5</td>
<td>214</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>51</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>38.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>29.7</td>
</tr>
</tbody>
</table>

Refer to the confirmation drawing for detailed dimensions.
Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.

*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.
The Wave Generator is a thin raced ball bearing fitted onto an elliptical hub. This serves as a high efficiency torque converter and is generally mounted onto the input or motor shaft.

The Flexspline is a non-rigid, thin cylindrical cup with external teeth on the open end of the cup. The Flexspline fits over the Wave Generator and takes on its elliptical shape. The Flexspline is generally used as the output of the gear.

The Circular Spline is a rigid ring with internal teeth. It engages the teeth of the Flexspline across the major axis of the Wave Generator ellipse. The Circular Spline has two more teeth than the Flexspline and is generally mounted onto a housing.

The Flexspline is slightly smaller in diameter than the Circular Spline and usually has two fewer teeth than the Circular Spline. The elliptical shape of the Wave Generator causes the teeth of the Flexspline to engage the Circular Spline at two opposite regions across the major axis of the ellipse.

As the Wave Generator rotates the teeth of the Flexspline engage with the Circular Spline at the major axis.

For every 180 degree clockwise movement of the Wave Generator the Flexspline rotates counterclockwise by one tooth in relation to the Circular Spline.

Each complete clockwise rotation of the Wave Generator results in the Flexspline moving counter-clockwise by two teeth from its original position relative to the Circular Spline. Normally, this motion is taken out as output.

The Harmonic Drive® gear utilizes a unique gear tooth profile for optimized tooth engagement. Unlike an involute tooth profile, this tooth profile ("S tooth") enables about 30% of the total number of teeth to be engaged simultaneously. This technological innovation results in high torque, high torsional stiffness, long life and smooth rotation.

Tooth behavior and engagement operating principles:

Operating Principle Gearheads™

A simple tree element construction combined with the unique operating principle puts extremely high reduction ratio capabilities into a very compact and lightweight package. The high performance attributes of this gearing technology including zero backlash, high torque, compact size, and excellent positional accuracy are a direct result of the unique operating principles.
### Rating Table Definitions

See the corresponding pages of each series for values from the ratings.

**Rated torque**
Rated torque indicates allowable continuous load torque at input speed.

**Limit for Repeated Peak Torque**
(see Graph 106-1)
During acceleration and deceleration the Harmonic Drive® gear experiences a peak torque as a result of the moment of inertia of the output load. The table indicates the limit for repeated peak torque.

**Limit for Average Torque**
In cases where load torque and input speed vary, it is necessary to calculate an average value of load torque. The table indicates the limit for average torque. The average torque calculated must not exceed this limit. (calculation formula: Page 111)

**Limit for Momentary Torque**
(see Graph 106-1)
The gear may be subjected to momentary torques in the event of a collision or emergency stop. The magnitude and frequency of occurrence of such peak torques must be kept to a minimum and they should, under no circumstance, occur during normal operating cycle. The allowable number of occurrences of the momentary torque may be calculated by using the formula on page 111.

**Maximum Average Input Speed**

**Maximum Input Speed**
Do not exceed the allowable rating. (calculation formula of the average input speed: Page 111).

**Inertia**
The rating indicates the moment of inertia reflected to the gear input.

### Life

**Life of the wave generator**
The life of a gear is determined by the life of the wave generator bearing. The life may be calculated by using the input speed and the output load torque.

<table>
<thead>
<tr>
<th>Series name</th>
<th>Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSF-GH</td>
<td>7,000 hours</td>
</tr>
<tr>
<td>CSG-GH</td>
<td>10,000 hours</td>
</tr>
</tbody>
</table>

*L*<sub>in</sub> (average life)

| CSF-GH | 35,000 hours |
| CSG-GH | 50,000 hours |

*Life is based on the input speed and output load torque from the ratings.

**Calculation formula for Rated Lifetime**
Formula 106-1

\[
L_h = \frac{L_n}{\left(\frac{T_r}{T_{av}}\right) \cdot \left(\frac{N_r}{N_{av}}\right)}
\]

*See the corresponding pages of each series for ratcheting torque values.*

**Caution**
If the number of occurrences is exceeded, the Flexspline to become non-concentric with the Circular Spline. Contact us for details of the ratcheting torque.

**Figure 099-1.** Operating the drive in this condition will cause vibration and damage the flexspline.

<table>
<thead>
<tr>
<th><strong>Relative Torque Rating</strong></th>
<th>Graph 106-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load torque (when the rated torque is 1)</td>
<td></td>
</tr>
<tr>
<td>Momentary peak torque</td>
<td></td>
</tr>
<tr>
<td>Repeated peak torque</td>
<td></td>
</tr>
<tr>
<td>Fatigue strength of the flexspline</td>
<td></td>
</tr>
<tr>
<td>Buckling torque</td>
<td></td>
</tr>
<tr>
<td>Ratcheting torque</td>
<td></td>
</tr>
<tr>
<td>Life of wave generator (L&lt;sub&gt;s&lt;/sub&gt;)</td>
<td></td>
</tr>
</tbody>
</table>

* Lubricant life not taken into consideration in the graph described above.
* Use the graph above as reference values.


## Torque Limits

### Strength of flexspline

The Flex spline is subjected to repeated deflections, and its strength determines the torque capacity of the Harmonic Drive® gear. The values given for Rated Torque at Rated Speed and for the allowable Repeated Peak Torque are based on an infinite fatigue life for the Flex spline.

The torque that occurs during a collision must be below the momentary torque (impact torque). The maximum number of occurrences is given by the equation below.

**Calculation formula**

\[
N = \frac{1.0 \times 10^6}{2 \times \frac{n \times 60}{x}}
\]

**Formula 107-1**

<table>
<thead>
<tr>
<th>Permissible occurrences</th>
<th>N occurrences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time that impact torque is applied</td>
<td>t sec</td>
</tr>
<tr>
<td>Rotational speed of the wave generator</td>
<td>n rpm</td>
</tr>
</tbody>
</table>

The torque that occurs during a collision must be below the momentary torque (impact torque). The maximum number of occurrences is given by the equation below.

- **Allowable limit of the bending cycles of the flexspline during rotation of the wave generator while the impact torque is applied:** \(1.0 \times 10^4 \) (cycles)

### Ratcheting torque

When excessive torque (8 to 9 times rated torque) is applied while the gear is in motion, the teeth between the Circular Spline and Flex spline may not engage properly. This phenomenon is called ratcheting and the torque at which this occurs is called ratcheting torque. Ratcheting may cause the Flex spline to become non-concentric with the Circular Spline. Operating in this condition may result in shortened life and a Flex spline fatigue failure.

* See the corresponding pages of each series for ratcheting torque values.

### Buckling torque

When a highly excessive torque (16 to 17 times rated torque) is applied to the output with the input stationary, the flexspline may experience elastic deformation. This is defined as buckling torque.

* See the corresponding pages of each series for buckling torque values.

### Warning

When the flexspline buckles, early failure of the Harmonic Drive® gear may occur.

* See the corresponding pages of each series for buckling torque values.
### Torsional Stiffness

Stiffness and backlash of the drive system greatly affects the performance of the servo system. Please perform a detailed review of these items before designing your equipment and selecting a model number.

#### Stiffness

Fixing the input side (wave generator) and applying torque to the output side (flexspline) generates torsion almost proportional to the torque on the output side. Figure 106-1 shows the torsional angle at the output side when the torque applied on the output side starts from zero, increases up to +T0 and decreases down to −T0. This is called the “Torque – torsion angle diagram,” which normally draws a loop of 0 – A – B – A’ – B’ – A. The slope described in the “Torque – torsion angle diagram” is represented as the spring constant for the stiffness of the HarmonicDrive® gear (unit: Nm/rad).

As shown in Figure 108-2, this “Torque – torsional angle diagram” is divided into 3 regions, and the spring constants in the area are represented by K1, K2 and K3.

- **K1**: The spring constant when the torque changes from [zero] to [T1]
- **K2**: The spring constant when the torque changes from [T1] to [T2]
- **K3**: The spring constant when the torque changes from [T2] to [T3]

#### Example for calculating the torsion angle

The torsion angle (θ) is calculated here using CSG-32-100-GH as an example:

- **T1** = 29 Nm
- **T2** = 108 Nm
- **K1** = 11 x 10^4 Nm/rad
- **K2** = 12 x 10^4 Nm/rad
- **K3** = 6.7 x 10^4 Nm/rad

When the applied torque is **T1** or less, the torsion angle **θ1** is calculated as follows:

**When the load torque T1=6.0 Nm**

θ1 = T1 / K1  
= 6.0 / 11 x 10^4  
= 6.0 x 10^-4 rad (0.31 arc min)

**When the applied torque is between **T1** and **T2**, the torsion angle **θ2** is calculated as follows**:

When the load torque is T2=50 Nm

θ2 = θ1 + (T2−T1)/K2  
= 4.4 x 10^-4 + (50−29) / 11 x 10^4  
= 4.4 x 10^-4 + 1.1 x 10^-4  
= 5.5 x 10^-4 rad (2.17 arc min)

**When the applied torque is greater than **T2**, the torsion angle **θ3** is calculated as follows**:

When the load torque is T3=178 Nm

θ3 = θ2 + θ3 / (T3−T2)/K3  
= 4.4 x 10^-4 + 11.6 x 10^-4 + (178−108) / 6.7 x 10^4  
= 4.4 x 10^-4 + 11.6 x 10^-4 + 7.0 x 10^-4  
= 2.18 x 10^-3 rad (7.5 arc min)

When a bidirectional load is applied, the total torsion angle will be 2 x θ + hysteresis loss.

* The torsion angle calculation is for the gear component set only and does not include any torsional windup of the output shaft.

#### Hysteresis loss

As shown in Figure 106-1, when the applied torque is increased to the rated torque and is brought back to [zero], the torsional angle does not return exactly back to the zero point. This small difference (B – B') is called hysteresis loss.

See the appropriate page for each model series for the hysteresis loss value.

#### Backlash

Hysteresis loss is primarily caused by internal friction. It is a very small value and will vary roughly in proportion to the applied load. Because HarmonicDrive® gearheads have zero backlash, the only true backlash is due to the clearance in the Oldham coupling, a self-aligning mechanism used on the wave generator. Since the Oldham coupling is used on the input, the backlash measured at the output is extremely small (arc-seconds) since it is divided by the gear reduction ratio.
Vibration

The primary frequency of the transmission error of the HarmonicDrive® gear may rarely cause a vibration of the load inertia. This can occur when the driving frequency of the servo system including the HarmonicDrive® gear is at, or close to the resonant frequency of the system. Refer to the design guide of each series.

The primary component of the transmission error occurs twice per input revolution of the input. Therefore, the frequency generated by the transmission error is 2x the input frequency (rev / sec).

If the resonant frequency of the entire system, including the HarmonicDrive® gear, is F=15 Hz, then the input speed (N) which would generate that frequency could be calculated with the formula below.

\[ N = \frac{15}{2} \cdot 60 = 450 \text{ rpm} \]

The resonant frequency is generated at an input speed of 450 rpm.

Efficiency

The efficiency will vary depending on the following factors:

- Reduction ratio
- Input speed
- Load torque
- Temperature
- Lubrication condition (Type of lubricant and the quantity)

### How to calculate resonant frequency of the system

\[ f = \frac{1}{2\pi} \sqrt{\frac{K}{J}} \]

**Formula variables**

<table>
<thead>
<tr>
<th>f</th>
<th>Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>Nm/rad</td>
</tr>
<tr>
<td>J</td>
<td>kgm²</td>
</tr>
</tbody>
</table>

See pages of each series.
**Product Sizing & Selection**

In general, a servo system rarely operates at a continuous load and speed. The input rotational speed, load torque change and comparatively large torque are applied at start and stop. Unexpected impact torque may be applied. These fluctuating load torques should be converted to the average load torque when selecting a model number.

As an accurate cross roller bearing is built in the direct external load support (output flange), the maximum moment load, life of the cross roller bearing and the static safety coefficient should also be checked.

(Note) If HarmonicDrive® CSG-GH or CSF-GH series is installed vertically with the output shaft facing downward (motor mounted above it) and continuously operated in one direction under the constant load state, lubrication failure may occur. In this case, please contact us for details.

### Flowchart for selecting a size

Please use the flowchart shown below for selecting a size. Operating conditions must not exceed the performance ratings.

1. Calculate the average load torque applied on the output side from the load torque pattern. $T_{av}$ (Nm).
   
   $$T_{av} = \frac{n_1 \cdot T_1 + n_2 \cdot T_2 + \cdots + n_N \cdot T_N}{n_1 + n_2 + \cdots + n_N}$$

2. Make a preliminary model selection with the following conditions.
   $T_{av} \leq$ Limit for average torque
   (See the ratings of each series).

3. Calculate the average output speed: $n_{av}$ (rpm).
   
   $$n_{av} = \frac{n_1 \cdot T_1 + n_2 \cdot T_2 + \cdots + n_N \cdot T_N}{n_1 + n_2 + \cdots + n_N}$$

4. Obtain the reduction ratio (R). A limit is placed on “$n_{max}$” by motors.

5. Calculate the average input rotational speed from the average output rotational speed ($n_{av}$) and the reduction ratio (R): $n_i = n_{av} \cdot R$.

6. Calculate the maximum input rotational speed from the max. output rotational speed ($n_{max}$) and the reduction ratio (R): $n_i = n_{max} \cdot R$.

7. Check whether the preliminary selected model number satisfies the following condition from the ratings:
   
   $n_i \leq n_{max}$ Limit for average speed (rpm)
   
   $n_i \leq n_{max}$ Limit for maximum speed (rpm)

8. Check whether $T_1$ and $T_3$ are equal to or less than the repeated peak torque specification.

9. Check whether $T_4$ is equal to or less than the momentary torque specification.

10. Calculate the lifetime:
    
    $$L_{10} = \frac{7,000 \cdot \left( \frac{T_1}{n_{av}} \right)^2}{T_{av} \cdot \frac{n_r}{n_{av}}} \text{ (hours)}$$

11. Check whether the calculated lifetime is equal to or more than the life of the wave generator (see Page 106).

The model number is confirmed.

### Application Motion Profile

Review the application motion profile. Check the specifications shown in the figure below.

**Graph 110-1**

- $T_1$, $T_2$, $T_3$, $T_4$, $T_5$, $T_6$ indicate the average values.

Obtain the value of each application motion profile.

<table>
<thead>
<tr>
<th>Load torque</th>
<th>Time</th>
<th>Output rotational speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_n$ (Nm)</td>
<td>$t_n$ (sec)</td>
<td>$n_0$ (rpm)</td>
</tr>
</tbody>
</table>

**Normal operation pattern**

- Starting (acceleration): $T_1$, $t_1$, $n_1$
- Steady operation (constant velocity): $T_2$, $t_2$, $n_2$
- Stopping (deceleration): $T_3$, $t_3$, $n_3$
- Idle: $T_4$, $t_4$, $n_4$

**Maximum rotational speed**

- Max. output speed: $n_{max}$
- Max. input rotational speed: $n_{max}$ (Restricted by motors)

**Emergency stop torque**

When impact torque is applied: $T_s$, $t_s$, $n_s$

**Required life**

$L_{10} = L$ (hours)
### Example of model number selection

<table>
<thead>
<tr>
<th>Load torque ( T_i ) (Nm)</th>
<th>Time ( t_i ) (sec)</th>
<th>Output rotational speed ( n_i ) (rpm)</th>
<th>Maximum rotational speed</th>
<th>Minimum output rotational speed</th>
<th>Minimum input rotational speed</th>
<th>Emergency stop torque</th>
<th>Required life</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 400 )</td>
<td>( 0.3 )</td>
<td>( 7 )</td>
<td>( 14 ) rpm</td>
<td>( 1800 ) rpm</td>
<td>( 14 ) rpm</td>
<td>( 500 ) Nm ( t_s = 0.15 ) sec, ( n_s = 14 ) rpm</td>
<td>( 7000 ) (hours)</td>
</tr>
<tr>
<td>( 320 )</td>
<td>( 3 )</td>
<td>( 7 )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( 200 )</td>
<td>( 4 )</td>
<td>( 7 )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( 0 )</td>
<td>( 2 )</td>
<td>( 0 )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Graph 110-1

![Graph](image)

- Calculate the average load torque applied on the output side of the Harmonic Drive® gear from the load torque pattern. \( T_{av} \) (Nm).
- Make a preliminary model selection with the following conditions. \( T_{av} = \frac{320 Nm}{3 + 7 rpm - 0.4 sec} = 12 rpm \)
- Thus, CSF-45-120-GH is tentatively selected.

#### Calculation Details

- \( T_{av} = \frac{3(7 rpm \cdot 0.3 sec + 14 rpm \cdot 3 sec + 320 Nm + 7 rpm \cdot 0.4 sec + 200 Nm)}{7 rpm \cdot 0.3 sec + 14 rpm \cdot 3 sec + 7 rpm \cdot 0.4 sec} \)
- \( ni_{max} = 14 \) rpm \( \cdot 120 = 1680 \) rpm

#### Operation Conditions and Model Number

- Check whether the preliminary selected model number satisfies the following conditions from the ratings. \( ni_{max} = 1680 \) rpm \( \leq 3800 \) rpm (Max input speed of size 45)
- \( ni = 1440 \) rpm \( \leq 3000 \) rpm (Max average input speed of size 45)
- \( n_s = 14 \) rpm \( \leq 40 \) rpm (Limit of repeated peak torque of size 45)

#### Notes

- \( n_{max} = 14 \) rpm \( \cdot 120 = 1680 \) rpm
- \( n_{max} = 14 \) rpm \( \cdot 120 = 1680 \) rpm
- \( n_{max} = 14 \) rpm \( \cdot 120 = 1680 \) rpm

#### Conclusion

The selection of model number CSF-45-120-GH is confirmed from the above calculations.
The rated value and performance vary depending on the product series. Be sure to check the usage conditions and refer to the items conforming to the related product.
## Efficiency

In general, the efficiency of a speed reducer depends on the reduction ratio, input rotational speed, load torque, temperature and lubrication condition. The efficiency of each series under the following measurement conditions is plotted in the graphs on the next page. The values in the graph are average values.

### Measurement condition

<table>
<thead>
<tr>
<th>Input rotational speed</th>
<th>HPGP / HPG / HPF / HPN: 3000rpm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CSG-GH / CSF-GH: Indicated on each efficiency graph.</td>
</tr>
<tr>
<td>Ambient temperature</td>
<td>25°C</td>
</tr>
<tr>
<td>Lubricant</td>
<td>Use standard lubricant for each model. (See pages 163-164 for details.)</td>
</tr>
</tbody>
</table>

### Efficiency compensated for low temperature

Calculate the efficiency at an ambient temperature of 25°C or less by multiplying the efficiency at 25°C by the low-temperature efficiency correction value. Obtain values corresponding to an ambient temperature and to an input torque (TRi) from the following graphs when calculating the low-temperature efficiency correction value.

* TRi is an input torque corresponding to output torque at 25°C.

**Graph 134-1**

**Graph 134-2**

---

* * *
**Input Bearing Specifications and Checking Procedure**

### Size 11: Gearhead

**HPGP**

**Reduction Ratio = 5**

![Graph 135-1](image)

**Reduction Ratio = 21**

![Graph 135-2](image)

**Reduction Ratio = 37, 45**

![Graph 135-3](image)

### Size 14: Gearhead

**HPGP**

**Reduction Ratio = 5**

![Graph 135-4](image)

**Reduction Ratio = 11**

![Graph 135-5](image)

**Reduction Ratio = 15, 21**

![Graph 135-6](image)

**Reduction Ratio = 33, 45**

![Graph 135-7](image)

---

**Note**

*1* The allowable axial load is the value of an axial load applied along the axis of rotation.

*2* The allowable radial load of HPG series is the value of a radial load applied to the point of 20 mm from the shaft edge (input flange edge).

---

**Technical Data**

- **Input bearing specifications**
- **Checking maximum load**
  - Check the maximum load and life of the bearing on the input side if the reducer is an HPG input shaft unit or an HPF hollow specification of input shaft bearing.

---

**Input torque corresponding to output torque**

- Gearhead with D bearing (double sealed)

---

**Efficiency correction coefficient**

- See Table 157-2 and 157-4

---

**Input speed**

- Calculate the life and check it.

---

**Reduction ratio**

- See Formula 158-4

---

**Technical Information / Handling Explanation**

- See Table 157-1 and -3
- See Table 158-1 and -2
**Technical Data**

**Size 20 : Gearhead**

**HPGP**

**Reduction ratio = 5**

- Gearhead (standard item)
- Gearhead with D bearing (double sealed)

**Reduction ratio = 15, 21**

- Gearhead with D bearing (double sealed)

**Reduction ratio = 33, 45**

- Gearhead with D bearing (double sealed)

**Size 32 : Gearhead**

**HPGP**

**Reduction ratio = 5 \(^*1\)**

- Gearhead (standard item)

**Reduction ratio = 15, 21**

- Gearhead with D bearing (double sealed)

**Reduction ratio = 33, 45**

- Gearhead with D bearing (double sealed)

\(^*1\) Only one line is shown because the difference between the gearhead and a bearing assembled on the input side is small.
Checking maximum load
shaft unit.

Check the maximum load and life of the bearing on the input side if the reducer is an HPG input shaft unit or an HPF hollow

**Specification of input bearing**

<table>
<thead>
<tr>
<th>Gearhead (standard item)</th>
<th>Input torque corresponding to output torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRi</td>
<td>Nm</td>
</tr>
<tr>
<td>TRi</td>
<td>Nm</td>
</tr>
<tr>
<td>TRi</td>
<td>Nm</td>
</tr>
<tr>
<td>TRi</td>
<td>Nm</td>
</tr>
</tbody>
</table>

**Reduction ratio = 15, 21**

- Gearhead (standard item)
- Gearhead with D bearing (double sealed)
- Input torque corresponding to output torque

**Reduction ratio = 33, 45**

- Gearhead (standard item)
- Gearhead with D bearing (double sealed)
- Input torque corresponding to output torque

**Technical Data**

- **Size 50**: Gearhead
- **Size 65**: Gearhead

* Only one line is shown because the difference between the gearhead and a bearing assembled on the input side is small.

**Formula 158-1**

\[
	ext{Efficiency} \% = \frac{T_{in} \times n_{in}}{T_{out} \times n_{out}}
\]

**Formula 158-2**

\[
	ext{Efficiency} \% = \frac{T_{in} \times n_{in}}{T_{out} \times n_{out}}
\]

**Formula 158-3**

\[
	ext{Efficiency} \% = \frac{T_{in} \times n_{in}}{T_{out} \times n_{out}}
\]

**Formula 158-4**

\[
	ext{Efficiency} \% = \frac{T_{in} \times n_{in}}{T_{out} \times n_{out}}
\]
Technical Data

**Gearhead (standard item)**

Input torque corresponding to output torque

Reduction ratio = 11

Note

*1 The allowable axial load is the value of an axial load applied along the axis of rotation.

*2 The allowable radial load of HPG series is the value of a radial load applied at the mid-point of the input shaft.

Table 157-1

<table>
<thead>
<tr>
<th>Gearhead Size</th>
<th>Reduction Ratio</th>
<th>Input Torque (Nm)</th>
<th>Efficiency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>5</td>
<td>0.016</td>
<td>96.9</td>
</tr>
<tr>
<td>32</td>
<td>9</td>
<td>0.21</td>
<td>59.2</td>
</tr>
<tr>
<td>32</td>
<td>11</td>
<td>0.32</td>
<td>48.5</td>
</tr>
<tr>
<td>32</td>
<td>15</td>
<td>0.63</td>
<td>39.4</td>
</tr>
<tr>
<td>32</td>
<td>21</td>
<td>1.27</td>
<td>32.3</td>
</tr>
<tr>
<td>32</td>
<td>33</td>
<td>2.54</td>
<td>27.5</td>
</tr>
<tr>
<td>32</td>
<td>45</td>
<td>5.08</td>
<td>23.1</td>
</tr>
<tr>
<td>32</td>
<td>60</td>
<td>10.15</td>
<td>18.7</td>
</tr>
</tbody>
</table>

Table 157-2

<table>
<thead>
<tr>
<th>Gearhead Size</th>
<th>Reduction Ratio</th>
<th>Input Torque (Nm)</th>
<th>Efficiency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>5</td>
<td>0.016</td>
<td>96.9</td>
</tr>
<tr>
<td>32</td>
<td>9</td>
<td>0.21</td>
<td>59.2</td>
</tr>
<tr>
<td>32</td>
<td>11</td>
<td>0.32</td>
<td>48.5</td>
</tr>
<tr>
<td>32</td>
<td>15</td>
<td>0.63</td>
<td>39.4</td>
</tr>
<tr>
<td>32</td>
<td>21</td>
<td>1.27</td>
<td>32.3</td>
</tr>
<tr>
<td>32</td>
<td>33</td>
<td>2.54</td>
<td>27.5</td>
</tr>
<tr>
<td>32</td>
<td>45</td>
<td>5.08</td>
<td>23.1</td>
</tr>
<tr>
<td>32</td>
<td>60</td>
<td>10.15</td>
<td>18.7</td>
</tr>
</tbody>
</table>

Table 157-3

<table>
<thead>
<tr>
<th>Gearhead Size</th>
<th>Reduction Ratio</th>
<th>Input Torque (Nm)</th>
<th>Efficiency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>5</td>
<td>0.016</td>
<td>96.9</td>
</tr>
<tr>
<td>32</td>
<td>9</td>
<td>0.21</td>
<td>59.2</td>
</tr>
<tr>
<td>32</td>
<td>11</td>
<td>0.32</td>
<td>48.5</td>
</tr>
<tr>
<td>32</td>
<td>15</td>
<td>0.63</td>
<td>39.4</td>
</tr>
<tr>
<td>32</td>
<td>21</td>
<td>1.27</td>
<td>32.3</td>
</tr>
<tr>
<td>32</td>
<td>33</td>
<td>2.54</td>
<td>27.5</td>
</tr>
<tr>
<td>32</td>
<td>45</td>
<td>5.08</td>
<td>23.1</td>
</tr>
<tr>
<td>32</td>
<td>60</td>
<td>10.15</td>
<td>18.7</td>
</tr>
</tbody>
</table>

Table 157-4

<table>
<thead>
<tr>
<th>Gearhead Size</th>
<th>Reduction Ratio</th>
<th>Input Torque (Nm)</th>
<th>Efficiency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>5</td>
<td>0.016</td>
<td>96.9</td>
</tr>
<tr>
<td>32</td>
<td>9</td>
<td>0.21</td>
<td>59.2</td>
</tr>
<tr>
<td>32</td>
<td>11</td>
<td>0.32</td>
<td>48.5</td>
</tr>
<tr>
<td>32</td>
<td>15</td>
<td>0.63</td>
<td>39.4</td>
</tr>
<tr>
<td>32</td>
<td>21</td>
<td>1.27</td>
<td>32.3</td>
</tr>
<tr>
<td>32</td>
<td>33</td>
<td>2.54</td>
<td>27.5</td>
</tr>
<tr>
<td>32</td>
<td>45</td>
<td>5.08</td>
<td>23.1</td>
</tr>
<tr>
<td>32</td>
<td>60</td>
<td>10.15</td>
<td>18.7</td>
</tr>
</tbody>
</table>

Graph 138-1

**Gearhead & Input Shaft Unit**

HPG

Reduction ratio = 5

Reduction ratio = 9

Reduction ratio = 21

Reduction ratio = 37

Reduction ratio = 45

Reduction ratio = 15

Reduction ratio = 11

Reduction ratio = 33

Reduction ratio = 45

--- Gearhead (standard item) --- Gearhead with D bearing (double sealed)

Input torque corresponding to output torque

--- Gearhead with D bearing (double sealed) --- Gearhead (standard item)
The allowable radial load of HPG series is the value of a radial load applied at the mid-point of the input shaft.

**Input Bearing Specifications and Checking Procedure**

**Technical Information / Handling Explanation**

<table>
<thead>
<tr>
<th>Size 20</th>
<th>Gearhead &amp; Input Shaft Unit</th>
<th>HPG</th>
</tr>
</thead>
</table>

**Reduction ratio = 3, 5**

**Reduction ratio = 15, 21**

**Reduction ratio = 33, 45**

**Reduction ratio = 11**

---

*1 Only one line is shown because the difference between the gearhead and a bearing assembled on the input side is small.
**Technical Data**

**Reduction ratio = 4, 5**

**Reduction ratio = 11**

**Reduction ratio = 15, 21**

**Reduction ratio = 33, 45**

**Size 50**: Gearhead & Input Shaft Unit

**Reduction ratio = 3, 5**

**Reduction ratio = 11**

**Reduction ratio = 15, 21**

**Reduction ratio = 33, 45**

**Size 65**: Gearhead & Input Shaft Unit

**Reduction ratio = 4, 5**

**Reduction ratio = 12**

**Reduction ratio = 15, 20**

**Reduction ratio = 25**

**Reduction ratio = 40**

**Reduction ratio = 50**

---

*Only one line is shown because the difference between the gearhead and a bearing assembled on the input side is small.*

---

*Only one line is shown because the difference between the gearhead and a bearing assembled on the input side is small.*
Note:  
*3 The allowable radial load of HPG series is the value of a radial load applied to the point of 20 mm from the shaft edge (input flange edge).

### Specification of Input Shaft Bearing

<table>
<thead>
<tr>
<th>Size</th>
<th>Torque (Nm)</th>
<th>Load (kgf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>65</td>
<td>2.1</td>
</tr>
<tr>
<td>25</td>
<td>50</td>
<td>5.1</td>
</tr>
<tr>
<td>32</td>
<td>11</td>
<td>0.16</td>
</tr>
</tbody>
</table>

### Checking Procedure

1. **Calculate:**
   - Average input speed ($N_{i\text{av}}$)
   - Average axial load ($F_{a\text{av}}$)
   - Average moment load ($M_{i\text{av}}$)

2. **Allowable:**
   - Allowable radial load ($F_{r\text{c}}$)
   - Allowable axial load ($F_{a\text{c}}$)
   - Allowable moment load ($M_{c}$)

3. **Maxima:**
   - Maximum radial load ($F_{r\text{max}}$)
   - Maximum axial load ($F_{a\text{max}}$)
   - Maximum moment load ($M_{i\text{max}}$)

### Table 157-3

<table>
<thead>
<tr>
<th>Gearhead</th>
<th>Torque (Nm)</th>
<th>Load (kgf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPG</td>
<td>5800</td>
<td>0.016</td>
</tr>
<tr>
<td>HPF</td>
<td>1930</td>
<td>0.019</td>
</tr>
</tbody>
</table>

### Table 157-2

<table>
<thead>
<tr>
<th>Gearhead</th>
<th>Torque (Nm)</th>
<th>Load (kgf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPG</td>
<td>3285</td>
<td>0.025</td>
</tr>
<tr>
<td>HPF</td>
<td>966</td>
<td>0.007</td>
</tr>
</tbody>
</table>
**Technical Data**

**Gearhead with D bearing (double sealed)**

**Input torque corresponding to output torque**

---

### Technical Information / Handling Explanation

* The allowable radial load of HPG series is the value of a radial load applied at the mid-point of the input shaft.

* The allowable axial load is the value of an axial load applied along the axis of rotation.

---

### Specification of input shaft bearing

<table>
<thead>
<tr>
<th>Size 20</th>
<th>Gearhead</th>
<th>HPG-Helical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction ratio = 3, 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduction ratio = 7, 8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduction ratio = 9, 10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Size 32</th>
<th>Gearhead</th>
<th>HPG-Helical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction ratio = 3, 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduction ratio = 7, 8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduction ratio = 9, 10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

### Input Bearing Specifications and Checking Procedure

1. **General—Checking maximum load**

   Check the maximum load and life of the bearing on the input side if the reducer is an HPG input shaft unit or an HPF hollow shaft unit.

2. **Calculating maximum moment load ON input shaft**

   Calculate:

   \[ \text{Allowable moment load } M_{cl} = 0.041 \times M_i \]  

   \[ \text{Allowable axial load } F_{ai} = 1.232 \times F_i \]  

   \[ \text{Allowable radial load } F_{rc} = 2.7 \times F_i \]  

   \[ \text{Basic dynamic load rating } C_r = 0.548 \times M_i \]  

   \[ \text{Basic static load rating } C_o = 2.1 \times F_i \]  

   \[ \text{Basic load rating } C_{tr} = 0.016 \times \text{output torque} \]  

   \[ \text{Basic load rating } C_{tr} = 0.016 \times \text{output torque} \]  

   \[ \text{Basic load rating } C_{tr} = 0.016 \times \text{output torque} \]  

   \[ \text{Basic load rating } C_{tr} = 0.016 \times \text{output torque} \]  

---

### Table 157-1 and -3

See Table 157-1 and -3 for the following:

- **Allowable moment load**
- **Allowable axial load**
- **Allowable radial load**
- **Input Bearing Specifications**
- **Checking Procedure**

---

### Note

* The allowable radial load of HPG series is the value of a radial load applied at the mid-point of the input shaft.

* The allowable axial load is the value of an axial load applied along the axis of rotation.
The allowable radial load of HPG series is the value of a radial load applied at the mid-point of the input shaft.

**Input Bearing Specifications and Checking Procedure**

1. Checking maximum load
2. Checking the life

**Checking procedure**

Average input speed ($N_{i}$)

Reduction ratio = 15, 21

Efficiency %

Reduction ratio = 3, 21

**Gearhead & Input Shaft Unit**

Reduction ratio = 5

Efficiency %

Reduction ratio = 11

**Allowable moment load (Mc)**

Reduction ratio = 33

Table 157-3

Table 157-4

TRi TRi

Size 50 RA3  : Right Angle Gearhead

HPG

Reduction ratio = 15, 21

TRi TRi

Reduction ratio = 33

External load influence diagram

See Fig. 158-1.

Graph 158-1

Dynamic equivalent load

See Formula 158-3

Average axial load N (kgf)

Reduction ratio = 33

Reduction ratio = 45

Reduction ratio = 21

Reduction ratio = 15

Reduction ratio = 33

Reduction ratio = 45

Average axial load N (kgf)    See Formula 158-3

TRi TRi

TRi TRi

TRi TRi

TRi TRi

TRi TRi

TRi TRi

TRi TRi

TRi TRi

TRi TRi

TRi TRi

TRi TRi
### Technical Data

#### Size 50 RA5: Right Angle Gearhead - HPG

**Reduction ratio = 5**

[Graph 144-1]

**Reduction ratio = 11**

[Graph 144-2]

**Reduction ratio = 15, 21**

[Graph 144-3]

**Reduction ratio = 33, 45**

[Graph 144-4]

**Input torque Nm**

**Efficiency %**

---

**Reduction ratio = 12, 15**

[Graph 144-6]

**Reduction ratio = 20, 25**

[Graph 144-7]

**Reduction ratio = 40, 50**

[Graph 144-8]

**Input torque Nm**

**Efficiency %**

---

**Input torque corresponding to output torque**

---

The allowable radial load of HPG series is the value of a radial load applied at the mid-point of the input shaft.

(1) Checking maximum load

- **Maximum axial load (F_{a\text{ax}})**
- **Maximum moment load (M_{i\text{m}})**
- **Average axial load (F_{a\text{av}})**

**Reduction ratio** = 15, 21

**Reduction ratio** = 33, 45

<table>
<thead>
<tr>
<th>Size</th>
<th>Input torque (Nm)</th>
<th>Moment load (Nm)</th>
<th>Axial load (kgf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>65</td>
<td>100</td>
<td>22500</td>
<td>20</td>
</tr>
<tr>
<td>25</td>
<td>100</td>
<td>2030</td>
<td>60</td>
</tr>
<tr>
<td>10</td>
<td>100</td>
<td>966</td>
<td>70</td>
</tr>
</tbody>
</table>

**Reduction ratio** = 12, 15

**Reduction ratio** = 5

**Reduction ratio** = 15

**Reduction ratio** = 20

**Reduction ratio** = 40

**Reduction ratio** = 50

---

See Table 158-1 and -2

---

See Formula 158-3

---

Formula 158-4

---

Formula 158-5

---

How to calculate average load:

\[
F_{a\text{av}} = 0.041 \times M_{i\text{m}} + 0.109 \times F_{a\text{ax}} + 0.444 \times F_{a\text{av}} + 2.7 \times F_{a\text{av}}
\]

---

Calculating life of input bearing:

- **Basic load rating**
- **Life**

---

Input speed Moment load
The allowable radial load of HPG series is the value of a radial load applied to the point of 20 mm from the shaft edge (input flange edge).

The allowable axial load is the value of an axial load applied along the axis of rotation.

1. Checking maximum load
2. Checking the life

Shaft unit.

Check the maximum load and life of the bearing on the input side if the reducer is an HPG input shaft unit or an HPF hollow shaft unit.

**Input Bearing Specifications and Checking Procedure**

<table>
<thead>
<tr>
<th>Size 11</th>
<th>HPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Reduction ratio = 4]</td>
<td>Graph 145-1</td>
</tr>
<tr>
<td>[Reduction ratio = 5]</td>
<td>Graph 145-2</td>
</tr>
<tr>
<td>[Reduction ratio = 7]</td>
<td>Graph 145-3</td>
</tr>
<tr>
<td>[Reduction ratio = 10]</td>
<td>Graph 145-4</td>
</tr>
<tr>
<td>[Reduction ratio = 15]</td>
<td>Graph 145-5</td>
</tr>
<tr>
<td>[Reduction ratio = 20, 25]</td>
<td>Graph 145-6</td>
</tr>
<tr>
<td>[Reduction ratio = 30, 35]</td>
<td>Graph 145-7</td>
</tr>
<tr>
<td>[Reduction ratio = 40, 45, 50]</td>
<td>Graph 145-8</td>
</tr>
</tbody>
</table>

**Input Bearing Specifications and Checking Procedure**

<table>
<thead>
<tr>
<th>Size 14</th>
<th>HPN</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>[Reduction ratio = 4]</td>
<td>Graph 145-2</td>
</tr>
<tr>
<td>[Reduction ratio = 5]</td>
<td>Graph 145-3</td>
</tr>
<tr>
<td>[Reduction ratio = 7]</td>
<td>Graph 145-4</td>
</tr>
<tr>
<td>[Reduction ratio = 10]</td>
<td>Graph 145-5</td>
</tr>
<tr>
<td>[Reduction ratio = 15]</td>
<td>Graph 145-6</td>
</tr>
<tr>
<td>[Reduction ratio = 20, 25]</td>
<td>Graph 145-7</td>
</tr>
<tr>
<td>[Reduction ratio = 30, 35]</td>
<td>Graph 145-8</td>
</tr>
<tr>
<td>[Reduction ratio = 40, 45, 50]</td>
<td>Graph 145-9</td>
</tr>
</tbody>
</table>
The allowable radial load of HPG series is the value of a radial load applied at the mid-point of the input shaft.

Checking the life
Check the maximum load and life of the bearing on the input side if the reducer is an HPG input shaft unit or an HPF hollow specification of input shaft bearing.

Table 157-2 and 157-4

Checking procedure

- Maximum radial load (Fri_{max})
- Maximum axial load (Fai_{max})
- Maximum moment load (Mi_{max})

Calculate:

- Average input speed (Ni_{av})
- Average moment load (Mi_{av})
- Average axial load (Fai_{av})

See Table 157-1 and -3
See Table 158-1 and -2

Input Bearing Specifications and Checking Procedure

- Gearheads
- Technical Data
- Technical Information / Handling Explanation
**Technical Data**

**Size 25**  
Hollow Shaft Unit  
**HPF**

**Reduction ratio = 11**

![Graph 148-1](image)

**Size 32**  
Hollow Shaft Unit  
**HPF**

**Reduction ratio = 11**

![Graph 148-2](image)
Note
(1) Checking maximum load
(2) Checking the life
Check the maximum load and life of the bearing on the input side if the reducer is an HPG input shaft unit or an HPF hollow

Specification of input bearing

<table>
<thead>
<tr>
<th>Size</th>
<th>Max. radial load (F_r)</th>
<th>Max. axial load (F_a)</th>
<th>Max. moment load (M_i)</th>
</tr>
</thead>
<tbody>
<tr>
<td>65</td>
<td>14800 N</td>
<td>157 kgf</td>
<td>100 kgf</td>
</tr>
<tr>
<td>20</td>
<td>320 N</td>
<td>1030 kgf</td>
<td>320 kgf</td>
</tr>
<tr>
<td>25</td>
<td>5600 N</td>
<td>157 kgf</td>
<td>320 kgf</td>
</tr>
<tr>
<td>32</td>
<td>1270 N</td>
<td>1030 kgf</td>
<td>320 kgf</td>
</tr>
</tbody>
</table>

If moment load and axial load fluctuate, they should be converted into the average load to check the life of the bearing.

How to calculate average load

$$
\begin{align*}
\text{Average moment load (Nm) & (kgf)} &= \text{See Formula 158-2} \\
\text{Combined load influence diagram} &= 20 \times M_i \\
\text{Input torque} &= P_i \\
\end{align*}
$$

Technical Data

Efficiency %

Graph 149-1

Graph 149-2

Graph 149-3

Graph 149-4

Graph 149-5

Graph 149-6

Graph 149-7

Graph 149-8

Input rotational speed

- 500 rpm
- 1000 rpm
- 2000 rpm
- 3500 rpm
### Technical Data

#### Size 32: Gearhead  
**CSG-GH  CSF-GH**

**Reduction ratio = 50**

Graph 150-1

**Reduction ratio = 80**

Graph 150-2

**Reduction ratio = 100**

Graph 150-3

Input rotational speed  
- 500 rpm
- 1000 rpm
- 2000 rpm
- 3500 rpm

#### Size 45: Gearhead  
**CSG-GH  CSF-GH**

**Reduction ratio = 50**

Graph 150-6

**Reduction ratio = 80**

Graph 150-7

**Reduction ratio = 100**

Graph 150-8

Input rotational speed  
- 500 rpm
- 1000 rpm
- 2000 rpm
- 3500 rpm

**Note**
- *1 The allowable axial load is the value of an axial load applied along the axis of rotation.
- *2 The allowable radial load of HPG series is the value of a radial load applied to the point of 20 mm from the shaft edge (input flange edge).

### Specification of Input Shaft Bearing

**Size 45**

**Reduction ratio = 50**

Graph 150-9

**Reduction ratio = 80**

Graph 150-10

Input rotational speed  
- 500 rpm
- 1000 rpm
- 2000 rpm
- 3500 rpm
Technical Data

**Input Bearing Specifications and Checking Procedure**

- **Size**: 65
- **Type**: Gearhead
- **Gearheads**:
  - **CSG-GH**
  - **CSF-GH**

**Maximum axial load (F_{a_{max}})**

**Maximum moment load (M_{i_{max}})**

**Average input speed (N_{i_{av}})**

- **Allowable moment load (M_{c})**
- **Allowable axial load (F_{a_{c}})**
- **Allowable radial load (F_{r_{c}})**

**Calculating maximum moment load on input shaft**

**Calculating life of input bearing**

**Reduction ratio = 80**

**Reduction ratio = 100**

**Reduction ratio = 120**

**Reduction ratio = 160**

**Input rotational speed**
- 500 rpm
- 1000 rpm
- 2000 rpm
- 3500 rpm

**Graphs 151-1 to 151-4**

See Table 157-1 and -3

See Table 158-1 and -2

See Formula 158-4

See Fig. 158-1.
Output Shaft Bearing Load Limits

HPN uses deep groove ball bearings to support the output shaft. Please use the curve on the graph for the appropriate load coefficient (fw) that represents the expected operating condition.

Output shaft speed - 100 rpm, bearing life is based on 20,000 hours. The load-point is based on shaft center of radial load and axial load.
Output Bearing Specifications and Checking Procedure

HPGP, HPG, HPG Helical, CSF-GH, CSG-GH, HPF, and HPG-U1 are equipped with cross roller bearings. A precision cross roller bearing supports the external load (output flange). Check the maximum load, moment load, life of the bearing and static safety coefficient to maximize performance.

Checking procedure

1. Checking the maximum moment load \( M_{\text{max}} \)
   - Calculate the maximum moment load \( M_{\text{max}} \).
   - Maximum moment load \( M_{\text{max}} \leq \) Permissible moment \( M_{c} \)

2. Checking the life
   - Calculate the average radial load \( F_{\text{av}} \) and the average axial load \( F_{\text{ay}} \).
   - Calculate the radial load coefficient \( X \) and the axial load coefficient \( Y \).
   - Calculate the life and check it.

3. Checking the static safety coefficient
   - Calculate the equivalent radial load coefficient \( P_{0} \).
   - Check the static safety coefficient \( (fs) \).

Specification of output bearing

HPG/HPG Series Tables 153-1, -2 and -3 indicate the cross roller bearing specifications for in-line, right angle and input shaft gears.

### Table 153-1

<table>
<thead>
<tr>
<th>Size</th>
<th>Pitch circle dp</th>
<th>Offset amount R</th>
<th>Basic dynamic load rating ( C )</th>
<th>Basic static load rating ( Co )</th>
<th>Allowable moment load ( M_{c} )</th>
<th>Moment stiffness ( K_{m} )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nm</td>
<td>m</td>
<td>N</td>
<td>Kgfm</td>
<td>Nm/arc min</td>
<td>Kgfm/arc min</td>
</tr>
<tr>
<td>11</td>
<td>0.0275</td>
<td>0.006</td>
<td>3116</td>
<td>318</td>
<td>4087</td>
<td>417</td>
</tr>
<tr>
<td>14</td>
<td>0.0405</td>
<td>0.011</td>
<td>5110</td>
<td>521</td>
<td>7060</td>
<td>720</td>
</tr>
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<td>20</td>
<td>0.064</td>
<td>0.015</td>
<td>10600</td>
<td>1062</td>
<td>17300</td>
<td>1765</td>
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<td>32</td>
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<td>2092</td>
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<td>50</td>
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<td>0.019</td>
<td>41600</td>
<td>4245</td>
<td>76000</td>
<td>7755</td>
</tr>
<tr>
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<td>0.023</td>
<td>90600</td>
<td>9245</td>
<td>148000</td>
<td>15102</td>
</tr>
</tbody>
</table>

### Table 153-2

<table>
<thead>
<tr>
<th>Size</th>
<th>Reduction ratio</th>
<th>Allowable radial load ( R )</th>
<th>Allowable axial load ( A )</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Kgfm</td>
<td>Kgfm</td>
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<tr>
<td>11</td>
<td>5</td>
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<td>440</td>
<td>660</td>
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<td>700</td>
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<td>890</td>
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<td>980</td>
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<td></td>
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<td>1890</td>
<td>2830</td>
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### Table 153-3

<table>
<thead>
<tr>
<th>Size</th>
<th>Reduction ratio</th>
<th>Allowable radial load ( R )</th>
<th>Allowable axial load ( A )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Kgfm</td>
<td>Kgfm</td>
</tr>
<tr>
<td>32</td>
<td>3</td>
<td>3700</td>
<td>5570</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>4350</td>
<td>6490</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>5500</td>
<td>8220</td>
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<tr>
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<td>6050</td>
<td>9030</td>
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<td>9980</td>
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<td>9030</td>
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<td></td>
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</tr>
<tr>
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<td>33</td>
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<td>11400</td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>8400</td>
<td>12500</td>
</tr>
</tbody>
</table>

* The ratio specified in parentheses is for the HPG Series.

(Note: Table 153-1, -2 and -3 Table 154-1 and -2)

1. The basic dynamic load rating means a certain static radial load so that the basic dynamic rated life of the roller bearing is a million rotations.
2. The basic static load rating means a static load that gives a certain level of contact stress (4kN/mm²) in the center of the contact area between rolling element receiving the maximum load and orbit.
3. The allowable moment load is a maximum moment load applied to the bearing. Within the allowable range, basic performance is maintained and the bearing is operable. Check the bearing life based on the calculations shown on the next page.
4. The value of the moment stiffness is the average value.
5. The allowable radial load and allowable axial load are the values that satisfy the life of a speed reducer when a pure radial load or an axial load applies to the main bearing. (\( L_r + R = 0 \) mm for radial load and \( L_a = 0 \) mm for axial load) If a compound load applies, refer to the calculations shown on the next page.

Technical Information / Handling Explanation
**Technical Data**

### CSG-GH/CSF-GH Series

Table 154-1 indicates the specifications for cross roller bearing.

<table>
<thead>
<tr>
<th>Size</th>
<th>Pitch circle</th>
<th>Offset amount</th>
<th>Basic load rating</th>
<th>Allowable moment load Mc</th>
<th>Moment stiffness Km</th>
<th>Allowable axial load</th>
<th>Allowable axial load*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dp</td>
<td>R</td>
<td>C1</td>
<td>Co</td>
<td>x10⁴</td>
<td>Nm/rad</td>
<td>kgf/arc min</td>
</tr>
<tr>
<td>14</td>
<td>0.0405</td>
<td>0.011</td>
<td>5110</td>
<td>521</td>
<td>7060</td>
<td>720</td>
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<tr>
<td>20</td>
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<tr>
<td>32</td>
<td>0.085</td>
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<td>7755</td>
<td>797</td>
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<tr>
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<td>81600</td>
<td>8327</td>
<td>149000</td>
<td>15204</td>
<td>2166</td>
</tr>
</tbody>
</table>

### HPF Series

Table 154-2 indicates the specifications for cross roller bearing.

<table>
<thead>
<tr>
<th>Size</th>
<th>Pitch circle</th>
<th>Offset amount</th>
<th>Basic load rating</th>
<th>Allowable moment load Mc</th>
<th>Moment stiffness Km</th>
<th>Allowable radial load</th>
<th>Allowable axial load*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dp</td>
<td>R</td>
<td>C1</td>
<td>Co</td>
<td>x10⁴</td>
<td>Nm/rad</td>
<td>kgf/arc min</td>
</tr>
<tr>
<td>25</td>
<td>0.085</td>
<td>0.0153</td>
<td>11400</td>
<td>1163</td>
<td>20300</td>
<td>2071</td>
<td>410</td>
</tr>
<tr>
<td>32</td>
<td>0.1115</td>
<td>0.015</td>
<td>22500</td>
<td>2296</td>
<td>39900</td>
<td>4071</td>
<td>932</td>
</tr>
</tbody>
</table>

**Note:** Table 153-1, -2 and -3  Table 154-1 and -2

1. The basic dynamic load rating means a certain static radial load so that the basic dynamic rated life of the roller bearing is a million rotations.
2. The basic static load rating means a static load that gives a certain level of contact stress (4kN/mm²) in the center of the contact area between rolling element receiving the maximum load and orbit.
3. The allowable moment load is a maximum moment load applied to the bearing. Within the allowable range, basic performance is maintained and the bearing is operable. Check the bearing life based on the calculations shown on the next page.
4. The value of the moment stiffness is the average value.
5. The allowable radial load and allowable axial load are the values that satisfy the life of a speed reducer when a pure radial load or an axial load applies to the main bearing. (Lr + R = 0 mm for radial load and La = 0 mm for axial load) If a compound load applies, refer to the calculations shown on the next page.
How to calculate the maximum moment load

![HPG] ![HPG] ![CSF-GH] ![CSF-GH] ![HPF]

Maximum moment load \((M_{\text{max}})\) is obtained as follows. Make sure that \(M_{\text{max}} \leq M_c\).

\[
M_{\text{max}} = Fr_{\text{max}} (Lr+R) + Fa_{\text{max}} La
\]

| \(F_{r\text{max}}\) | Max. radial load \(N\) (kgf) | See Fig. 155-1. |
| \(F_{a\text{max}}\) | Max. axial load \(N\) (kgf) | See Fig. 155-1. |
| \(Lr, La\) | \(m\) | See Fig. 155-1. |
| \(R\) | Offset amount \(m\) | See Fig. 155-1. |
| \(dp\) | Circular pitch of roller \(m\) | See Fig. 155-1. |

How to calculate the radial and the axial load coefficient

![HPG] ![HPG] ![CSF-GH] ![CSF-GH] ![HPF]

The radial load coefficient \((X)\) and the axial load coefficient \((Y)\)

\[
F_{a\text{av}} = \begin{cases} \frac{Fr_{\text{av}} + 2(Fr_{\text{av}} + Fa_{\text{av}} + La)}{dp} & \leq 1.5 \\
\frac{Fr_{\text{av}} + 2(Fr_{\text{av}} - Fa_{\text{av}} - La)}{dp} & > 1.5
\end{cases}
\]

<table>
<thead>
<tr>
<th>Formula</th>
<th>(F_{a\text{av}})</th>
<th>(X)</th>
<th>(Y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\leq 1.5)</td>
<td>(1)</td>
<td>0.45</td>
<td></td>
</tr>
<tr>
<td>(&gt; 1.5)</td>
<td>0.67</td>
<td>0.67</td>
<td></td>
</tr>
</tbody>
</table>

Note:
- \(Fr_{\text{av}}\): Average radial load \(N\) (kgf) See “How to calculate the average load below.”
- \(Fa_{\text{av}}\): Average axial load \(N\) (kgf) See “How to calculate the average load below.”
- \(Lr, La\): \(m\) See Fig. 155-1.
- \(R\): Offset amount \(m\) See Fig. 155-1. |
- \(dp\): Circular pitch of roller \(m\) See Fig. 155-1. |

How to calculate the average load (Average radial load, average axial load, average output speed)

![HPG] ![HPG] ![CSF-GH] ![CSF-GH] ![HPF]

If the radial load and the axial load fluctuate, they should be converted into the average load to check the life of the cross roller bearing.

How to obtain the average radial load \((Fr_{\text{av}})\)

\[
Fr_{\text{av}} = \sqrt{n_0 \left[ (Fr_1)^{1.0} + n_1 \left( (Fr_1)^{1.0} + \cdots + n_{t_1} \left( (Fr_1)^{1.0} + \cdots \right) \right) \right]}/n_0 + n_1 + \cdots + n_{t_1}
\]

Note that the maximum radial load within the \(t_1\) section is \(Fr_1\) and the maximum radial load within the \(t_2\) section is \(Fr_2\).

How to obtain the average axial load \((Fa_{\text{av}})\)

\[
Fa_{\text{av}} = \sqrt{n_0 \left[ (Fa_1)^{1.0} + n_1 \left( (Fa_1)^{1.0} + \cdots + n_{t_1} \left( (Fa_1)^{1.0} + \cdots \right) \right) \right]}/n_0 + n_1 + \cdots + n_{t_1}
\]

Note that the maximum axial load within the \(t_1\) section is \(Fa_1\) and the maximum axial load within the \(t_2\) section is \(Fa_2\).

How to obtain the average output speed \((N_{\text{av}})\)

\[
N_{\text{av}} = \frac{n_0 \left[ (N_1)^{1/3} + n_1 \left( (N_1)^{1/3} + \cdots + n_{t_1} \left( (N_1)^{1/3} + \cdots \right) \right) \right]}/(n_0 + n_1 + \cdots + n_{t_1})
\]
Calculate the life of the cross roller bearing using Formula 156-1. You can obtain the dynamic equivalent load (Pc) using Formula 156-2.

\[
L = \frac{10^8}{60 \times N_{av}} \times \left( \frac{C}{f_w \times P_c} \right)^{1/3}
\]

Where:
- \( L \) = Life (hour)
- \( N_{av} \) = Ave. output speed (rpm)
- \( C \) = Basic dynamic load rating (N·kgf)
- \( P_c \) = Dynamic equivalent load (N·kgf)
- \( f_w \) = Load coefficient

How to calculate the average load (Average radial load, average axial load, average output speed)

1. **Average radial load**
   \[
   p_c = X \left( \frac{F_{rav} + \frac{2}{d\rho} (L_r + R) + F_{aav} \cdot L_a}{d\rho} \right) + Y \cdot F_{av}
   \]
   Where:
   - \( F_{rav} \) = Average radial load (N·kgf)
   - \( F_{aav} \) = Average axial load (N·kgf)
   - \( L_r \) = Offset amount
   - \( L_a \) = Offset amount
   - \( d\rho \) = Pitch Circle
   - \( X \) = Radial load coefficient
   - \( Y \) = Axial load coefficient

2. **Average axial load**
   \[
   \frac{Fa1}{dp} = \frac{Fr1}{av}\frac{t1}{t2} \frac{t2}{t3} \frac{t3}{t4}
   \]
   Note: The maximum axial load within the \( t1 \) section is \( Fa1 \) and the maximum axial load is \( Fa4 \).

3. **Average output speed**
   \[
   \frac{Circlar \ \ pitch \ of \ roller}{Lr+R} = \frac{Circlar \ \ pitch \ of \ roller}{Lr+R} + \frac{Offset \ amount}{av}
   \]

Load coefficient

<table>
<thead>
<tr>
<th>Load status</th>
<th>( f_w )</th>
</tr>
</thead>
<tbody>
<tr>
<td>During smooth operation without impact or vibration</td>
<td>1 to 1.2</td>
</tr>
<tr>
<td>During normal operation</td>
<td>1.2 to 1.5</td>
</tr>
<tr>
<td>During operation with impact or vibration</td>
<td>1.5 to 3</td>
</tr>
</tbody>
</table>

How to calculate the life during oscillating motion

Calculate the life of the cross roller bearing during oscillating motion by Formula 156-3.

\[
L_{oc} = \frac{10^8}{60 \times n1} \times \left( \frac{90}{\theta} \right) \times \left( \frac{C}{f_w \times P_c} \right)^{1/3}
\]

Where:
- \( L_{oc} \) = Rated life under oscillating motion (hour)
- \( n1 \) = No. of reciprocating oscillation per min. (rpm)
- \( C \) = Basic dynamic load rating (N·kgf)
- \( P_c \) = Dynamic equivalent load (N·kgf)
- \( f_w \) = Load coefficient
- \( \theta \) = Oscillating angle (deg.)

Note: When the oscillating angle is small (5° or less), it is difficult to generate an oil film on the contact surface of the orbit ring and the rolling element and fretting corrosion may develop.

How to calculate the static safety coefficient

In general, the basic static load rating \( (Co) \) is considered to be the permissible limit of the static equivalent load. However, obtain the limit based on the operating and required conditions. Calculate the static safety coefficient \( (fs) \) of the cross roller bearing using Formula 156-4.

\[
fs = \frac{Co}{Po}
\]

Where:
- \( Co \) = Basic static load (N·kgf)
- \( Po \) = Static equivalent load (N·kgf)

Static safety coefficient

<table>
<thead>
<tr>
<th>Load status</th>
<th>( fs )</th>
</tr>
</thead>
<tbody>
<tr>
<td>When high precision is required</td>
<td>≥ 3</td>
</tr>
<tr>
<td>When impact or vibration is expected</td>
<td>≥ 2</td>
</tr>
<tr>
<td>Under normal operating condition</td>
<td>≥ 1.5</td>
</tr>
</tbody>
</table>
Input Bearing Specifications and Checking Procedure

Check the maximum load and life of the bearing on the input side if the reducer is an HPG input shaft unit or an HPF hollow shaft unit.

### Checking procedure

#### (1) Checking maximum load

Calculate:
- Maximum moment load \( (M_{\text{imax}}) \)
- Maximum axial load \( (F_{\text{ai max}}) \)
- Maximum radial load \( (F_{\text{r max}}) \)

Maximum moment load \( (M_{\text{imax}}) \) \( \leq \) Allowable moment load \( (M_{\text{a}}) \)
Maximum axial load \( (F_{\text{ai max}}) \) \( \leq \) Allowable axial load \( (F_{\text{a}}) \)
Maximum radial load \( (F_{\text{r max}}) \) \( \leq \) Allowable radial load \( (F_{\text{r}}) \)

#### (2) Checking the life

Calculate:
- Average moment load \( (M_{\text{av}}) \)
- Average axial load \( (F_{\text{av}}) \)
- Average input speed \( (N_{\text{iav}}) \)

Calculate the life and check it.

### Specification of input bearing

#### Specification of input bearing

<table>
<thead>
<tr>
<th>Size (mm)</th>
<th>Basic dynamic load rating ( (C_r) )</th>
<th>Basic static load rating ( (C_o) )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( N )</td>
<td>( \text{kgf} )</td>
</tr>
<tr>
<td>11</td>
<td>2700</td>
<td>275</td>
</tr>
<tr>
<td>14</td>
<td>5800</td>
<td>590</td>
</tr>
<tr>
<td>20</td>
<td>9700</td>
<td>990</td>
</tr>
<tr>
<td>32</td>
<td>22500</td>
<td>2300</td>
</tr>
<tr>
<td>50</td>
<td>35500</td>
<td>3600</td>
</tr>
<tr>
<td>65</td>
<td>51000</td>
<td>5200</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Size (mm)</th>
<th>Allowable moment load ( (M_{a}) )</th>
<th>Allowable axial load ( (F_{a}) )</th>
<th>Allowable radial load ( (F_{r}) )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \text{Nm} )</td>
<td>( \text{kgf} \text{m} )</td>
<td>( N )</td>
</tr>
<tr>
<td>11</td>
<td>0.16</td>
<td>0.016</td>
<td>245</td>
</tr>
<tr>
<td>14</td>
<td>6.3</td>
<td>0.64</td>
<td>657</td>
</tr>
<tr>
<td>20</td>
<td>13.5</td>
<td>1.38</td>
<td>1206</td>
</tr>
<tr>
<td>32</td>
<td>44.4</td>
<td>4.53</td>
<td>3285</td>
</tr>
<tr>
<td>50</td>
<td>96.9</td>
<td>9.88</td>
<td>5540</td>
</tr>
<tr>
<td>65</td>
<td>210</td>
<td>21.4</td>
<td>8600</td>
</tr>
</tbody>
</table>

#### Specification of input shaft bearing

<table>
<thead>
<tr>
<th>Size (mm)</th>
<th>Basic dynamic load rating ( (C_r) )</th>
<th>Basic static load rating ( (C_o) )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( N )</td>
<td>( \text{kgf} \text{m} )</td>
</tr>
<tr>
<td>25</td>
<td>14500</td>
<td>1480</td>
</tr>
<tr>
<td>32</td>
<td>29700</td>
<td>3030</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Size (mm)</th>
<th>Allowable moment load ( (M_{a}) )</th>
<th>Allowable axial load ( (F_{a}) )</th>
<th>Allowable radial load ( (F_{r}) )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \text{Nm} )</td>
<td>( \text{kgf} \text{m} )</td>
<td>( N )</td>
</tr>
<tr>
<td>25</td>
<td>10</td>
<td>1.02</td>
<td>1538</td>
</tr>
<tr>
<td>32</td>
<td>19</td>
<td>1.93</td>
<td>3263</td>
</tr>
</tbody>
</table>

(Note: Table 157-2 and 157-4)

*1 The allowable axial load is the value of an axial load applied along the axis of rotation.
*2 The allowable radial load of HPG series is the value of a radial load applied at the mid-point of the input shaft.
*3 The allowable radial load of HPG series is the value of a radial load applied to the point of 20 mm from the shaft edge (input flange edge).
Technical Information / Handling Explanation

Note

*3 The allowable radial load of HPG series is the value of a radial load applied to the point of 20 mm from the shaft edge (input flange edge).

(1) Checking maximum load
Check the maximum load and life of the bearing on the input side if the reducer is an HPG input shaft unit or an HPF hollow.

(2) Checking the life
Check the maximum load and life of the bearing on the input side if the reducer is an HPG input shaft unit or an HPF hollow.

Specification of input bearing

<table>
<thead>
<tr>
<th>Size</th>
<th>50</th>
<th>32</th>
<th>25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formula</td>
<td>158-1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Technical Data**

<table>
<thead>
<tr>
<th>Size</th>
<th>50</th>
<th>32</th>
<th>25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic load rating</td>
<td>max</td>
<td>950</td>
<td>3600</td>
</tr>
<tr>
<td>Maximum moment load ((M_i))</td>
<td>max</td>
<td>3263</td>
<td>1538</td>
</tr>
<tr>
<td>Maximum axial load ((F_a))</td>
<td>max</td>
<td>116</td>
<td>329</td>
</tr>
<tr>
<td>Allowable moment load ((M_c))</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allowable axial load ((F_a))</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allowable radial load ((F_r))</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How to calculate average load
(Average moment load, average axial load, average input speed)

If moment load and axial load fluctuate, they should be converted into the average load to check the life of the bearing.

How to calculate the average input speed (\(n_{iav}\))

\[
N_{iav} = \sum_{t} \left( n_{i} \right) / \sum_{t} \cdot t
\]

How to calculate the average axial load (\(F_{a_{av}}\))

\[
F_{a_{av}} = \sum_{t} \left( F_{a_{i}} \right) / \sum_{t} \cdot t
\]

How to calculate the average moment load (\(M_{i_{av}}\))

\[
M_{i_{av}} = \sum_{t} \left( M_{i_{i}} \right) / \sum_{t} \cdot t
\]

Calculating life of input bearing
Calculate the bearing life according to Calculation Formula 158-5 and check the life.

\[
L_{i} = \frac{10^6}{60 \times N_{iav} \times \left( \frac{C_{r}}{Pci} \right)^3}
\]

<table>
<thead>
<tr>
<th>Size</th>
<th>11</th>
<th>14</th>
<th>20</th>
<th>32</th>
<th>50</th>
<th>65</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Pci)</td>
<td>av</td>
<td>av</td>
<td>av</td>
<td>av</td>
<td>av</td>
<td>av</td>
</tr>
<tr>
<td>Dynamic equivalent load</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Size</th>
<th>25</th>
<th>32</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Pci)</td>
<td>av</td>
<td>av</td>
</tr>
<tr>
<td>Dynamic equivalent load</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

HPG

**External load influence diagram**

Figure 158-1

**How to calculate average load
(Average moment load, average axial load, average input speed)**

If moment load and axial load fluctuate, they should be converted into the average load to check the life of the bearing.

How to calculate the average moment load (\(M_{i_{av}}\))

\[
M_{i_{av}} = \frac{\sum_{t} \left( M_{i_{i}} \right)}{\sum_{t}}
\]

How to calculate the average axial load (\(F_{a_{av}}\))

\[
F_{a_{av}} = \frac{\sum_{t} \left( F_{a_{i}} \right)}{\sum_{t}}
\]

How to calculate the average input speed (\(N_{iav}\))

\[
N_{iav} = \frac{\sum_{t} \left( n_{i} \right)}{\sum_{t}}
\]

Calculating life of input bearing
Calculate the bearing life according to Calculation Formula 158-5 and check the life.

\[
L_{i} = \frac{10^6}{60 \times N_{iav} \times \left( \frac{C_{r}}{Pci} \right)^3}
\]

<table>
<thead>
<tr>
<th>Size</th>
<th>11</th>
<th>14</th>
<th>20</th>
<th>32</th>
<th>50</th>
<th>65</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Pci)</td>
<td>av</td>
<td>av</td>
<td>av</td>
<td>av</td>
<td>av</td>
<td>av</td>
</tr>
<tr>
<td>Dynamic equivalent load</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

HPG

**External load influence diagram**

Figure 158-1

**How to calculate average load
(Average moment load, average axial load, average input speed)**

If moment load and axial load fluctuate, they should be converted into the average load to check the life of the bearing.

How to calculate the average moment load (\(M_{i_{av}}\))

\[
M_{i_{av}} = \frac{\sum_{t} \left( M_{i_{i}} \right)}{\sum_{t}}
\]

How to calculate the average axial load (\(F_{a_{av}}\))

\[
F_{a_{av}} = \frac{\sum_{t} \left( F_{a_{i}} \right)}{\sum_{t}}
\]

How to calculate the average input speed (\(N_{iav}\))

\[
N_{iav} = \frac{\sum_{t} \left( n_{i} \right)}{\sum_{t}}
\]

Calculating life of input bearing
Calculate the bearing life according to Calculation Formula 158-5 and check the life.

\[
L_{i} = \frac{10^6}{60 \times N_{iav} \times \left( \frac{C_{r}}{Pci} \right)^3}
\]

<table>
<thead>
<tr>
<th>Size</th>
<th>11</th>
<th>14</th>
<th>20</th>
<th>32</th>
<th>50</th>
<th>65</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Pci)</td>
<td>av</td>
<td>av</td>
<td>av</td>
<td>av</td>
<td>av</td>
<td>av</td>
</tr>
<tr>
<td>Dynamic equivalent load</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

HPG

**External load influence diagram**

Figure 158-1

**How to calculate average load
(Average moment load, average axial load, average input speed)**

If moment load and axial load fluctuate, they should be converted into the average load to check the life of the bearing.

How to calculate the average moment load (\(M_{i_{av}}\))

\[
M_{i_{av}} = \frac{\sum_{t} \left( M_{i_{i}} \right)}{\sum_{t}}
\]

How to calculate the average axial load (\(F_{a_{av}}\))

\[
F_{a_{av}} = \frac{\sum_{t} \left( F_{a_{i}} \right)}{\sum_{t}}
\]

How to calculate the average input speed (\(N_{iav}\))

\[
N_{iav} = \frac{\sum_{t} \left( n_{i} \right)}{\sum_{t}}
\]

Calculating life of input bearing
Calculate the bearing life according to Calculation Formula 158-5 and check the life.

\[
L_{i} = \frac{10^6}{60 \times N_{iav} \times \left( \frac{C_{r}}{Pci} \right)^3}
\]

<table>
<thead>
<tr>
<th>Size</th>
<th>11</th>
<th>14</th>
<th>20</th>
<th>32</th>
<th>50</th>
<th>65</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Pci)</td>
<td>av</td>
<td>av</td>
<td>av</td>
<td>av</td>
<td>av</td>
<td>av</td>
</tr>
<tr>
<td>Dynamic equivalent load</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

HPG

**External load influence diagram**

Figure 158-1

**How to calculate average load
(Average moment load, average axial load, average input speed)**

If moment load and axial load fluctuate, they should be converted into the average load to check the life of the bearing.

How to calculate the average moment load (\(M_{i_{av}}\))

\[
M_{i_{av}} = \frac{\sum_{t} \left( M_{i_{i}} \right)}{\sum_{t}}
\]

How to calculate the average axial load (\(F_{a_{av}}\))

\[
F_{a_{av}} = \frac{\sum_{t} \left( F_{a_{i}} \right)}{\sum_{t}}
\]

How to calculate the average input speed (\(N_{iav}\))

\[
N_{iav} = \frac{\sum_{t} \left( n_{i} \right)}{\sum_{t}}
\]

Calculating life of input bearing
Calculate the bearing life according to Calculation Formula 158-5 and check the life.

\[
L_{i} = \frac{10^6}{60 \times N_{iav} \times \left( \frac{C_{r}}{Pci} \right)^3}
\]

<table>
<thead>
<tr>
<th>Size</th>
<th>11</th>
<th>14</th>
<th>20</th>
<th>32</th>
<th>50</th>
<th>65</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Pci)</td>
<td>av</td>
<td>av</td>
<td>av</td>
<td>av</td>
<td>av</td>
<td>av</td>
</tr>
<tr>
<td>Dynamic equivalent load</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

HPG

**External load influence diagram**

Figure 158-1

**How to calculate average load
(Average moment load, average axial load, average input speed)**

If moment load and axial load fluctuate, they should be converted into the average load to check the life of the bearing.

How to calculate the average moment load (\(M_{i_{av}}\))

\[
M_{i_{av}} = \frac{\sum_{t} \left( M_{i_{i}} \right)}{\sum_{t}}
\]

How to calculate the average axial load (\(F_{a_{av}}\))

\[
F_{a_{av}} = \frac{\sum_{t} \left( F_{a_{i}} \right)}{\sum_{t}}
\]

How to calculate the average input speed (\(N_{iav}\))

\[
N_{iav} = \frac{\sum_{t} \left( n_{i} \right)}{\sum_{t}}
\]

Calculating life of input bearing
Calculate the bearing life according to Calculation Formula 158-5 and check the life.

\[
L_{i} = \frac{10^6}{60 \times N_{iav} \times \left( \frac{C_{r}}{Pci} \right)^3}
\]

<table>
<thead>
<tr>
<th>Size</th>
<th>11</th>
<th>14</th>
<th>20</th>
<th>32</th>
<th>50</th>
<th>65</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Pci)</td>
<td>av</td>
<td>av</td>
<td>av</td>
<td>av</td>
<td>av</td>
<td>av</td>
</tr>
<tr>
<td>Dynamic equivalent load</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Assembly

Assemble and mount your gearhead in accordance with these instructions to achieve the best performance. Be sure to use the recommended bolts and use a torque wrench to achieve the proper tightening torques as recommended in tables below.

Motor assembly procedure

To properly mount the motor to the gearhead, follow the procedure outlined below, refer to figure 159-1.

1. Turn the input shaft coupling and align the bolt head with the rubber cap hole.

2. With the speed reducer in an upright position as illustrated in the figure below, slowly insert the motor shaft into the coupling of speed reducer. Slide the motor shaft without letting it drop down. If the speed reducer cannot be positioned upright, slowly insert the motor shaft into the coupling of speed reducer, then tighten the motor bolts evenly until the motor flange and gearhead flange are in full contact. Exercise care to avoid tilting the motor when inserting it into the gear head.

3. Tighten the input shaft coupling bolt to the recommended torque specified in the table below. The bolt(s) or screw(s) is (are) already inserted into the input coupling when delivered. Check the bolt size on the confirmation drawing provided.

<table>
<thead>
<tr>
<th>Bolt tightening torque</th>
<th>Table 159-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolt size</td>
<td>M3</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-----</td>
</tr>
<tr>
<td>Tightening torque Nm</td>
<td>2.0</td>
</tr>
<tr>
<td>Tightening torque kgf</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Caution: Always tighten the bolts to the tightening torque specified in the table above. If the bolt is not tightened to the torque value recommended slippage of the motor shaft in the shaft coupling may occur. The bolt size will vary depending on the size of the gear and the shaft diameter of the mounted motor. Check the bolt size on the confirmation drawing provided.

Two setscrews need to be tightened on size 11. See the outline dimensions on page 22 (HPGP) and page 34 (HPG standard) and page 46 (HPF helical). Tighten the screws to the tightening torque specified below.

<table>
<thead>
<tr>
<th>Bolt tightening torque</th>
<th>Table 159-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolt size</td>
<td>M3</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-----</td>
</tr>
<tr>
<td>Tightening torque Nm</td>
<td>0.69</td>
</tr>
<tr>
<td>Tightening torque kgf</td>
<td>0.07</td>
</tr>
</tbody>
</table>

(4) Fasten the motor to the gearhead flange with bolts.

<table>
<thead>
<tr>
<th>Bolt tightening torque</th>
<th>Table 159-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolt size</td>
<td>M3</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-----</td>
</tr>
<tr>
<td>Tightening torque Nm</td>
<td>0.59</td>
</tr>
<tr>
<td>Tightening torque kgf</td>
<td>0.06</td>
</tr>
</tbody>
</table>

*Recommended bolt: JIS B 1176 Hexagon socket head bolt. Strength: JIS B 1051 12.9 or higher

Caution: Be sure to tighten the bolts to the tightening torques specified in the table.

(5) Insert the rubber cap provided. This completes the assembly. (Size 11: Fasten screws with a gasket in two places)
### Speed Reducer Assembly

Some right-angle gearhead models weigh as much as 60 kg. No thread for an eyebolt is provided because the mounting orientation varies depending on the customer's needs. When mounting the reducer, hoist it using a sling paying extreme attention to safety.

When assembling gearheads into your equipment, check the flatness of your mounting surface and look for any burrs on tapped holes. Then fasten the flange (Part A in the diagram below) using appropriate bolts.

#### Bolt Tightening Torque for Flange (Part A in the Diagram Below)

<table>
<thead>
<tr>
<th>Size</th>
<th>HPN</th>
<th>HPGP / HPG / CSG-GH / CSF-GH</th>
<th>HPF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>11</td>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>Number of bolts</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Bolt size</td>
<td>M3</td>
<td>M5</td>
<td>M6</td>
</tr>
<tr>
<td>Mounting PCD (mm)</td>
<td>50</td>
<td>70</td>
<td>100</td>
</tr>
<tr>
<td>Tightening torque (kgf·m)</td>
<td>1.4</td>
<td>6.3</td>
<td>10.7</td>
</tr>
<tr>
<td>Transmission torque (Nm)</td>
<td>27.9</td>
<td>110</td>
<td>223</td>
</tr>
<tr>
<td>Transmission torque (kgf·m)</td>
<td>2.85</td>
<td>11.3</td>
<td>22.8</td>
</tr>
</tbody>
</table>

*Recommended bolts: JIS B 1176 "Hexagon socket head bolts." Strength classification 12.9 or higher in JIS B 1051.

### Mounting the Load to the Output Flange

Follow the specifications in the table below when mounting the load onto the output flange.

#### Bolt Tightening Torque for Output Flange (Part B in the Figure 160-1)

<table>
<thead>
<tr>
<th>Size</th>
<th>HPGP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>11</td>
</tr>
<tr>
<td>Number of bolts</td>
<td>4</td>
</tr>
<tr>
<td>Bolt size</td>
<td>M4</td>
</tr>
<tr>
<td>Mounting PCD (mm)</td>
<td>18</td>
</tr>
<tr>
<td>Tightening torque (Nm)</td>
<td>4.5</td>
</tr>
<tr>
<td>Transmission torque (kgf·m)</td>
<td>0.46</td>
</tr>
</tbody>
</table>

*Recommended bolts: JIS B 1176 "Hexagon socket head bolts." Strength classification 12.9 or higher in JIS B 1051.

#### Output Flange Mounting Specifications

<table>
<thead>
<tr>
<th>Size</th>
<th>HPG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>11</td>
</tr>
<tr>
<td>Number of bolts</td>
<td>3</td>
</tr>
<tr>
<td>Bolt size</td>
<td>M4</td>
</tr>
<tr>
<td>Mounting PCD (mm)</td>
<td>18</td>
</tr>
<tr>
<td>Tightening torque (Nm)</td>
<td>4.5</td>
</tr>
<tr>
<td>Transmission torque (kgf·m)</td>
<td>0.46</td>
</tr>
</tbody>
</table>

*Recommended bolts: JIS B 1176 "Hexagon socket head bolts." Strength classification 12.9 or higher in JIS B 1051.
Mounting the load to the output flange

Bolt* tightening torque for output flange (Part B in Figure 160-1)  

### CSG-GH  

<table>
<thead>
<tr>
<th>Size</th>
<th>14</th>
<th>20</th>
<th>22</th>
<th>24</th>
<th>25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of bolts</td>
<td>8</td>
<td>8</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Bolt size</td>
<td>M4</td>
<td>M6</td>
<td>M8</td>
<td>M10</td>
<td>M16</td>
</tr>
<tr>
<td>Mounting PCD</td>
<td>mm</td>
<td>30</td>
<td>45</td>
<td>60</td>
<td>94</td>
</tr>
<tr>
<td>Tightening torque</td>
<td>Nm</td>
<td>4.5</td>
<td>15.3</td>
<td>37</td>
<td>128</td>
</tr>
<tr>
<td></td>
<td>kgf</td>
<td>0.46</td>
<td>1.56</td>
<td>3.8</td>
<td>3.1</td>
</tr>
<tr>
<td>Transmission torque</td>
<td>Nm</td>
<td>84</td>
<td>287</td>
<td>867</td>
<td>3067</td>
</tr>
<tr>
<td></td>
<td>kgf</td>
<td>8.6</td>
<td>29.3</td>
<td>88.5</td>
<td>313</td>
</tr>
</tbody>
</table>

### CSF-GH  

<table>
<thead>
<tr>
<th>Size</th>
<th>14</th>
<th>20</th>
<th>22</th>
<th>24</th>
<th>25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of bolts</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>Bolt size</td>
<td>M4</td>
<td>M6</td>
<td>M8</td>
<td>M8</td>
<td>M16</td>
</tr>
<tr>
<td>Mounting PCD</td>
<td>mm</td>
<td>30</td>
<td>45</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>Tightening torque</td>
<td>Nm</td>
<td>4.5</td>
<td>15.3</td>
<td>37.2</td>
<td>37.2</td>
</tr>
<tr>
<td></td>
<td>kgf</td>
<td>0.46</td>
<td>1.56</td>
<td>3.80</td>
<td>3.80</td>
</tr>
<tr>
<td>Transmission torque</td>
<td>Nm</td>
<td>83</td>
<td>215</td>
<td>524</td>
<td>2326</td>
</tr>
<tr>
<td></td>
<td>kgf</td>
<td>6.5</td>
<td>21.9</td>
<td>53.4</td>
<td>237</td>
</tr>
</tbody>
</table>

### HPF  

<table>
<thead>
<tr>
<th>Size</th>
<th>25</th>
<th>32</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of bolts</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Bolt size</td>
<td>M4</td>
<td>M5</td>
</tr>
<tr>
<td>Mounting PCD</td>
<td>mm</td>
<td>77</td>
</tr>
<tr>
<td>Tightening torque</td>
<td>Nm</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>kgf</td>
<td>0.46</td>
</tr>
<tr>
<td>Transmission torque</td>
<td>Nm</td>
<td>322</td>
</tr>
<tr>
<td></td>
<td>kgf</td>
<td>32.9</td>
</tr>
</tbody>
</table>

* Recommended bolts: JIS B 1176 "Hexagon socket head bolts." Strength classification 12.9 or higher in JIS B 1051.

Gearheads with an output shaft

Do not subject the output shaft to any impact when mounting a pulley, pinion or other parts. An impact to the output bearing may affect the speed reducer precision and may cause reduced life or failure.
Technical Information / Handling Explanation

Bolt* tightening torque for output flange failure.

Gearheads with an output shaft

Mounting PCD

Number of bolts

Tightening torque

Mounting PCD

Bolt size

Transmission torque

Table 161-1

Bolt* tightening torque for output flange (Part B in Figure 160-1)

Table 161-2

Table 157-1

Table 157-3

Table 162-1

Table 162-2

Table 162-3

Table 162-4

* T.I.R.: Total indicator reading

(T.I.R.* Unit: mm)

**1 The allowable axial load is the value of an axial load applied along the axis of rotation.

Calculation:

External load influence diagram

Check that the following formulas are established in all circumstances:

1. ** Fri max = 0.041 × Mi
2. ** Lai = 1.232 × Fai
3. ** Lri = 1.426 × Fai

If moment load and axial load fluctuate, they should be converted into the average load to check the life of the bearing.

** Fri max = 32.5 N (kgf)

Average input speed Ni

Average axial load N (kgf) av

Average moment load Mc

Allowable moment load Mc max

Allowable axial load Fa

Allowable radial load Fr

Maximum moment load L10

Calculating maximum moment load ON input shaft

Calculating life of input bearing

HPG HPF

CSG-GH CSF-GH

HPG

HPG

CSF-GH

Output Flange: F0 (flange)

Output shaft: J2 [J20], J6 [J60] (shaft output)

Size

Axial runout of output flange a

Radial runout of output flange pilot or output shaft b

Perpendicularity of mounting flange c

Concentricity of mounting flange d

11

0.020

0.030

0.050

0.040

14

0.020

0.040

0.060

0.050

20

0.020

0.040

0.060

0.050

32

0.020

0.040

0.060

0.050

50

0.020

0.040

0.060

0.050

65

0.040

0.060

0.090

0.080

45

0.020

0.040

0.060

0.050

65

0.020

0.040

0.060

0.050

25

0.020

0.040

0.060

0.050

32

0.020

0.040

0.060

0.050

Mechanical Tolerances

Superior mechanical precision is achieved by integrating the output flange with a high-precision cross roller bearing as a single component. The mechanical tolerances of the output shaft and mounting flange are specified below.
**Lubrication**

### Prevention of grease and oil leakage

(Common to all models)
- Only use the recommended greases.
- Provisions for proper sealing to prevent grease leakage are incorporated into the gearheads. However, please note that some leakage may occur depending on the application or operating condition. Discuss other sealing options with our applications engineers.
- When mounting the gearhead horizontally, position the gearhead so that the rubber contact seal on both sides

(HPG/HPGP/HPF/HPN Series)
- Using the double sealed bearing (D type) for the HPGP/HPG series gearhead will result in a slightly lower efficiency compared to the standard product.
- An oil seal without a spring is used on the input side of HPG series with an input shaft (HPG-1U) and HPF series hollow shaft reducer. An option for an oil seal with a spring is available for improved seal reliability, however, the efficiency will be slightly lower (available for HPF and HPG series for sizes 14 and larger).
- Do not remove the screw plug and seal cap of the HPG series right angle gearhead. Removing them may cause leakage of grease or affect the precision of the gear.

### Sealing

(Common to all models)
- Provisions for proper sealing to prevent grease leakage from the input shaft are incorporated into the gearhead.
- A double lip Teflon oil seal is used for the output shaft (HPGP/HPG uses a single lip seal), gaskets or o-rings are used on all mating surfaces, and non contact shielded bearings are used for the motor shaft coupling (Double sealed bearings (D type) are available as an option*). On the CSG/CSF-GH series, non contact shielded bearing and a Teflon oil seal with a spring is used.
- Material and surface: Gearbox: Aluminum, corrosion protected roller bearing steel, carbon steel (output shaft).
  Adapter flange: (if provided by Harmonic Drive) high-strength aluminum or carbon steel. Screws: black phosphate. The ambient environment should not subject any corrosive agents to the above mentioned material. The product provides protection class IP 54 under the provision that corrosion from the ambient atmosphere (condensation, liquids or gases) at the running surface of the output shaft seal is prevented. If necessary, the adapter flange can be sealed by means of a surface seal (e.g. Loctite 515).
* D type: Bearing with a rubber contact seal on both sides

### Standard Lubricants

**HPG/HPGP/HPF/HPN Series**

The standard lubrication for the HPG/HPGP/HPF/HPN series gearheads is grease.
All gearheads are lubricated at the factory prior to shipment and additional application of grease during assembly is not required.
The gearheads are lubricated for the life of the gear and do not require re-lubrication.
High efficiency is achieved through the unique planetary gear design and grease selection.

#### Lubricants

<table>
<thead>
<tr>
<th>Harmonic Grease SK-2</th>
<th>EPNOC Grease AP (N) 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HPG/HPGP-14, 20, 32</strong></td>
<td><strong>HPG/HPGP-11, 50, 65./HPF-25, 32</strong></td>
</tr>
<tr>
<td>Manufacturer: Harmonic Drive Systems Inc.</td>
<td>Manufacturer: Nippon Oil Co.</td>
</tr>
<tr>
<td>Base oil: Refined mineral oil</td>
<td>Base oil: Refined mineral oil</td>
</tr>
<tr>
<td>Thickening agent: Lithium soap</td>
<td>Thickening agent: Lithium soap</td>
</tr>
<tr>
<td>Additive: Extreme pressure agent</td>
<td>Additive: Extreme pressure agent</td>
</tr>
<tr>
<td>and other</td>
<td>and other</td>
</tr>
<tr>
<td>Standard: NLGI No. 2</td>
<td>Standard: NLGI No. 2</td>
</tr>
<tr>
<td>Consistency: 265 to 295 at 25°C</td>
<td>Consistency: 282 at 25°C</td>
</tr>
<tr>
<td>Color: Green</td>
<td>Color: Light brown</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PYRONOC UNIVERSAL 00</th>
<th>MULTEMP AC-P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HPG right angle gearhead/HPN</strong></td>
<td><strong>HPG-X-R</strong></td>
</tr>
<tr>
<td>Manufacturer: Nippon Oil Co.</td>
<td>Manufacturer: KYODO YUSHI CO., LTD</td>
</tr>
<tr>
<td>Base oil: Refined mineral oil</td>
<td>Base oil: Composite hydrocarbon oil and diester</td>
</tr>
<tr>
<td>Thickening agent: Urea</td>
<td>Thickening agent: Lithium soap</td>
</tr>
<tr>
<td>Standard: NLGI No. 00</td>
<td>Additive: Extreme pressure and others</td>
</tr>
<tr>
<td>Consistency: 420 at 25°C</td>
<td>Standard: NLGI No. 2</td>
</tr>
<tr>
<td>Dropping point: 250°C or higher</td>
<td>Consistency: 280 at 25°C</td>
</tr>
<tr>
<td>Color: Light yellow</td>
<td>Dropping point: 200°C</td>
</tr>
<tr>
<td>Color: Black viscose</td>
<td></td>
</tr>
</tbody>
</table>

**Ambient operating temperature range: -10°C to +40°C**

The lubricant may deteriorate if the ambient operating temperature is outside of recommended operating range. Please contact our sales office or distributor for operation outside of the ambient operating temperature range.
The temperature rise of the gear depends upon the operating cycle, ambient temperature and heat conduction and radiation based on the customers installation of the gear. A housing surface temperature of 70°C is the maximum allowable limit.

---

*Note*:
- The allowable radial load of HPG series is the value of a radial load applied to the point of 20 mm from the shaft edge (input flange edge).
- The allowable axial load is the value of an axial load applied along the axis of rotation.
- The allowable moment load is the value of a moment load applied about the axis of rotation.
CSG-GH/CSF-GH Series

The standard lubrication for the CGS-GH / CSF-GH series gearheads is grease. All gearheads are lubricated at the factory prior to shipment and additional application of grease during assembly is not necessary.

Lubricants

<table>
<thead>
<tr>
<th>Harmonic Grease SK-1A</th>
<th>Harmonic Grease SK-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Size 20, 32, 45, 65)</td>
<td>(Size 14)</td>
</tr>
<tr>
<td>Manufacturer: Harmonic Drive Systems Inc.</td>
<td>Manufacturer: Harmonic Drive Systems Inc.</td>
</tr>
<tr>
<td>This grease has been developed exclusively for HarmonicDrive® gears and is excellent in durability and efficiency compared to commercial general-purpose grease.</td>
<td>This grease has been developed exclusively for smaller sized HarmonicDrive® gears and allows smooth wave generator rotation.</td>
</tr>
</tbody>
</table>

- Base oil: Refined mineral oil
- Thickening Agent: Lithium soap and other
- Additive: Extreme pressure agent
- Consistency: 265 to 295 at 25°C
- Dropping point: 197°C
- Color: Yellow
- Standard: NLGI No. 2

- Base oil: Refined mineral oil
- Thickening Agent: Lithium soap and other
- Additive: Extreme pressure agent
- Consistency: 265 to 295 at 25°C
- Dropping point: 198°C
- Color: Green
- Standard: NLGI No. 2

Ambient operating temperature range: -10°C to +40°C

The lubricant may deteriorate if the ambient operating temperature is outside the recommended temperature range. Please contact our sales office or distributor for operation outside of the ambient operating temperature range. The temperature rise of the gear depends upon the operating cycle, ambient temperature and heat conduction and radiation based on the customers installation of the gear. A housing surface temperature of 70°C is the maximum allowable limit.

When to change the grease

The life of the Harmonic Drive® gear is affected by the grease performance. The grease performance varies with temperature and deteriorates at elevated temperatures. Therefore, the grease will need to be changed sooner than usual when operating at higher temperatures. The graph on the right indicates when to change the grease based upon the temperature (when the average load torque is less than or equal to the rated output torque at 2000 rpm). Also, using the formula below, you can calculate when to change the grease when the average load torque exceeds the rated output torque (at 2000 rpm).

Formula to calculate the grease change interval when the average load torque exceeds the rated torque

\[ L_{gt} = L_{gtm} \times \left( \frac{T_{av}}{T_{av}^*} \right)^{3} \]

Formula symbols

- \( L_{gt} \): Grease change interval when \( T_{av} > T_{av}^* \)
- \( L_{gtm} \): Grease change interval when \( T_{av} = T_{av}^* \)
- \( T_{av} \): Output torque at 2000 rpm
- \( T_{av}^* \): Rated output torque at 2000 rpm
- \( T_{av} \): Average load torque

Reference values for grease refill amount

<table>
<thead>
<tr>
<th>Size</th>
<th>Amount (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>0.8</td>
</tr>
<tr>
<td>20</td>
<td>3.2</td>
</tr>
<tr>
<td>32</td>
<td>6.6</td>
</tr>
<tr>
<td>45</td>
<td>11.6</td>
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<tr>
<td>65</td>
<td>78.6</td>
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Warranty

Please contact us or visit our website at www.harmonicdrive.net for warranty details for your specific product.

All efforts have been made to ensure that the information in this catalog is complete and accurate. However, Harmonic Drive LLC is not liable for any errors, omissions or inaccuracies in the reported data. Harmonic Drive LLC reserves the right to change the product specifications, for any reason, without prior notice. For complete details please refer to our current Terms and Conditions posted on our website.

Disposal

When disposing of the product, disassemble it and sort the component parts by material type and dispose of the parts as industrial waste in accordance with the applicable laws and regulations. The component part materials can be classified into three categories.

- Rubber parts: Oil seals, seal packings, rubber caps, seals of shielded bearings on input side (D type only)
- Aluminum parts: Housings, motor flanges
- Steel parts: Other parts

Trademark

HarmonicDrive® is a registered trademark of Harmonic Drive LLC.
HarmonicPlanetary® is a registered trademark of Harmonic Drive LLC.
### Safety

**Warning**: Means that improper use or handling could result in a risk of death or serious injury.

**Caution**: Means that improper use or handling could result in personal injury or damage to property.

### Application Restrictions

This product cannot be used for the following applications:

- Space flight hardware
- Aircraft equipment
- Nuclear power equipment
- Equipment and apparatus used in residential dwellings
- Vacuum environments
- Automotive equipment
- Personal recreation equipment
- Equipment that directly works on human bodies
- Equipment for transport of humans
- Equipment for use in a special environment
- Medical equipment

Please consult Harmonic Drive LLC beforehand if intending to use our product for the aforementioned applications.

Fail-safe devices that prevent an accident must be designed into the equipment when the products are used in any equipment that could result in personal injury or damage to property in the event of product failure.

### Design Precaution

**Caution**

- Use only in the proper environment.
  - Please ensure to comply with the following environmental conditions:
    - Ambient temperature 0 to 40˚C
    - Do not splash water or oil
    - Do not expose to corrosive or explosive gas
    - No dust such as metal powder

- Install the equipment properly.
  - Carry out the assembly and installation precisely as specified in the catalog.
  - Observe our recommended fastening methods (including bolts used and tightening torques).
  - Operating the equipment without precise assembly can cause problems such as vibration, reduction in life, deterioration of precision and product failure.

- Install the equipment with the required precision.
  - Design and assemble parts to keep all catalog recommended tolerances for installation.
  - Failure to hold the recommended tolerances can cause problems such as vibration, reduction in life, deterioration of precision and product failure.

- Use the specified lubricant.
  - Using other than our recommended lubricant can reduce the life of the product. Replace the lubricant as recommended.
  - Gearheads are factory lubricated. Do not mix installed lubricant with other kinds of grease.

### Operational Precaution

**Caution**

- Use caution when handling the product and parts.
  - Do not hit the gear or any part with a hammer.
  - If you use the equipment in a damaged condition, the gearhead may not perform to catalog specifications. It can also cause problems including product failure.

- Do not alter or disassemble the product or parts.
  -Harmonic Planetary® and Harmonic Drive® products are manufactured as matched sets. Catalog ratings may not be achieved if the component parts are interchanged.

- Do not use your finger to turn the gear.
  - The finger may get caught in the gear causing an injury.

- Large sizes (45, 50 and 65) are heavy. Use caution when handling.
  - They are heavy and may cause a lower-back injury or an injury if dropped on a hand or foot. Wear protective shoes and back support when handling the product.

- Stop operating the system if any abnormality occurs.
  - Shut down the system promptly if any abnormal sound or vibration is detected, the rotation has stopped, an abnormally high temperature is generated, or an abnormal motor current value is observed.
  - Continuing to operate the system may adversely affect the product or equipment.
  - Contact the manufacturer or distributor if you are unsure of how to properly dispose of the material.

- Do not disassemble the products.
  - Do not disassemble and reassemble the products. Original performance may not be achieved.

- Rust-proofing was applied before shipping. However, please note that rusting may occur depending on the customers' storage environment.
  - Although black oxide finish is applied to some of our products, it does not guarantee that rust will not form.

### Handling Lubricant

**Warning**

- Lubricant in the eye can cause inflammation. Wear protective glasses to prevent it from getting into your eye.
- Lubricant coming in contact with the skin can cause inflammation. Wear protective gloves when handling the lubricant to prevent it from contacting your skin.

- Do not ingest (to avoid diarrhea and vomiting).
- Use caution when opening the container. There may be sharp edges that can cut your hand. Wear protective gloves.
- Keep lubricant out of reach of children.

- Ingestion: Seek immediate medical attention and do not induce vomiting unless directed by medical personnel.
- Eyes: Flush immediately with water for at least 15 minutes. Get immediate medical attention.
- Skin: Wash with soap and water. Get medical attention if irritation develops.

### Disposal of waste oil and containers

- Do not apply pressure to an empty container. The container may explode.
- Do not weld, heat, drill or cut the container. This may cause residual oil to ignite or cause an explosion.

- Rust-proofing was applied before shipping. However, please note that rusting may occur depending on the customers' storage environment.
  - Although black oxide finish is applied to some of our products, it does not guarantee that rust will not form.

- Disposal of waste oil and containers:
  - Follow all applicable laws regarding waste disposal. Contact your distributor if you are unsure how to properly dispose of the material.
  - Do not apply pressure to an empty container. The container may explode.
  - Do not weld, heat, drill or cut the container. This may cause residual oil to ignite or cause an explosion.

- Storage:
  - Tightly seal the container after use. Store in a cool, dry, dark place.
  - Keep away from open flames and high temperatures.

- Disposal of as industrial waste:
  - Please dispose of as industrial waste when their useful life is over.
Major Applications of Our Products

- Metal Working Machines
- Processing Machine Tools
- Measurement, Analytical and Test Systems
- Medical Equipment
- Telescopes
- Energy
- Crating and Packaging Machines
- Communication Equipment
- Glass and Ceramic Manufacturing Systems
- Robots
- Printing, Bookbinding and Paper Machines
- Semiconductor Manufacturing Equip.
- Optical Equipment
- Machine Tools
- Paper-making Machines
- Flat Panel Display Manufacturing Equip.
- Printed Circuit Board Manufacturing Machines
- Aerospace

Source: National observatory of Inter-University Research Institute Corporation

Source: Honda Motor Co., Ltd.

Source: NASA/JPL-Caltech
Experts in Precision Motion Control

HarmonicDrive® Gearing
HarmonicDrive® speed reducer delivers precise motion control by utilizing the strain wave gearing principle.

Linear Actuators
Compact linear actuators combine a precision lead screw and HarmonicDrive® gear. Our versatile actuators deliver both ultra precise positioning and high torque.

Rotary Actuators
High-torque actuators combine performance matched servomotors with HarmonicDrive® gears to deliver excellent dynamic control characteristics.

CSF Mini Gearheads
CSF mini gearheads provide high positioning accuracy in a super-compact package.

Other Products