HarmonicDrive
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® coupling

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CSF - 20 - 100 - GH - F0 - 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>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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<td>GH: Gearhead</td>
<td>J2: Shaft output without key</td>
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Gearhead Construction

Mounting pilot
Grease filling port (2 locations)
Shielded bearing
Rubber cap
Quick Connect® coupling
Input rotational direction
Output rotational direction

Cross roller bearing
Motor mounting flange
Mounting bolt hole
Oil seal

(The figure indicates output shaft type.)
## Rating Table  CSF-GH

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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. 101.
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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*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 1/2 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.

Note: Never rely on these values as a margin in a system that must hold an external load. A brake must be used where back driving is not permitted.

*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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<td>kgf·m/arc min</td>
<td>kgf·m/arc min</td>
<td>kgf·m/arc min</td>
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<tr>
<td>1.4</td>
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</tr>
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<td>11</td>
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<td>$\theta_3$</td>
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<td>$&lt;10^6$ Nm/rad</td>
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<td>kgf·m/arc min</td>
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<td>1.2</td>
</tr>
<tr>
<td>3.9</td>
<td>1.5</td>
<td>11.3</td>
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<tr>
<td>4.0</td>
<td>1.5</td>
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</tr>
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<td>3.8</td>
<td>1.4</td>
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</tr>
<tr>
<td>3.9</td>
<td>1.5</td>
<td>11.3</td>
</tr>
</tbody>
</table>

* The values in this table are average values. See page 98 for more information about torsional stiffness.

**Hysteresis Loss  CSF-GH**

Reduction ratio 50: Approx. 5.8X10^-4 rad (2arc min)
Reduction ratio 80 or more: Approx. 2.9X10^-5 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.

**Flange Type I**

**Flange Type II**

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 090-1
---|---
**Flange** | Coupling | A (H7) | B | C | F (H7) | G | H | Moment of Inertia | Mass (kg)
---|---|---|---|---|---|---|---|---|---|---
Type I | 1 | 30 | 50 | 6.5 | 35 | 55 | 6.0 | 8 | 20.5 | 32.5 | 76 | 0.07 | 0.88 | 0.76
Type II | 1 | 30 | 55 | 7 | 55 | 75 | 6.0 | 8 | 20.5 | 32.5 | 76 | 0.07 | 0.90 | 0.78

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.

![Diagram of CSF-GH-20 Outline Dimensions](image)

*Output dimensions are the same as 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

<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 (10^-4 kgm²)</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
<tr>
<td>Type I</td>
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<td>35</td>
<td>50</td>
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<td></td>
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<td>2.3</td>
</tr>
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<td></td>
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<td></td>
<td></td>
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<td>22</td>
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<td></td>
<td></td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>Type II</td>
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<td>2</td>
<td>50</td>
<td>79</td>
<td>10</td>
<td>55</td>
<td>84</td>
<td>8.0</td>
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</tr>
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</tr>
<tr>
<td>Type III</td>
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<td>100</td>
<td>10</td>
<td>55</td>
<td>105</td>
<td>8.0</td>
<td>2.8</td>
</tr>
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<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>2.2</td>
<td></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.

### Dimension Table

**Flange**  | **Coupling** | **A (H7)** | **B** | **C** | **F (H7)** | **G** | **H** | **Moment of Inertia** | **Mass (kg)**
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<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>
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<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.

(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.
CSF-GH-45 Outline Dimensions

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

**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 ((10^3)kgf·cm²)</th>
<th>H ((10^{-3})kgf·cm²)</th>
<th>Moment of Inertia</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
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<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>
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<tr>
<td>Type II</td>
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<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.

*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.

(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.
### CSF-GH-65 Outline Dimensions

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

#### 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) *3</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>10^5kgm²</td>
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<tr>
<td>Type I</td>
<td>1</td>
<td>95</td>
<td>110</td>
<td>10</td>
<td>105</td>
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<td>19.0</td>
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<td>32.0</td>
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<td>280</td>
<td>19.0</td>
<td>39.3</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.

*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.
NOTES

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 counterclockwise by two teeth from its original position relative to the Circular Spline. Normally, this motion is taken out as output.

Direction of Rotation

The output rotational direction of CSG/CSF-GH series is reverse of the input rotational direction.

Input: Wave Generator (Motor shaft mounting)

Fixed: Circular Spline (Casing)

Output: Flexspline (Cross roller bearing)

Operating Principles

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.

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
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 096-1)
  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 100)

- **Limit for Momentary Torque**
  (see Graph 096-1)
  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 100.

- **Maximum Average Input Speed**
  **Maximum Input Speed**
  Do not exceed the allowable rating. (calculation formula of the average input speed: Page 100).

- **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>
<tr>
<td>L9</td>
<td>35,000 hours</td>
</tr>
<tr>
<td>L10</td>
<td>50,000 hours</td>
</tr>
</tbody>
</table>

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

Calculation formula for Rated Lifetime

\[ L_h = \ln \left( \frac{N_r}{N_a} \right) \left( \frac{T_r}{T_{av}} \right) \]

Table 096-1

<table>
<thead>
<tr>
<th>Life</th>
<th>7,000 hours</th>
<th>10,000 hours</th>
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</thead>
<tbody>
<tr>
<td>L9</td>
<td>35,000 hours</td>
<td>50,000 hours</td>
</tr>
</tbody>
</table>

**Life of wave generator (L10)**

**Fatigue strength of the flexspline**

**Buckling torque**

**Ratcheting torque**

**Momentary peak torque**

**Repeated peak torque**

**Fatigue strength of the flexspline**

Calculation formula for Rated Lifetime

\[ L_h = \ln \left( \frac{T_r}{T_{av}} \right) \left( \frac{N_r}{N_a} \right) \]

Table 096-2

**Warning**

**Caution**

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

**Strength of flexspline**
The Flexspline 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 Flexspline.
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)

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

\[
N = \frac{1.0 \times 10^4}{2 \times \frac{n}{60} \times t}
\]

Permissible occurrences \(N\) occurrences

Time that impact torque is applied \(t\) sec

Rotational speed of the wave generator \(n\) rpm

The flexspline bends two times per one revolution of the wave generator.

**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.

**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 Flexspline may not engage properly. This phenomenon is called ratcheting and the torque at which this occurs is called ratcheting torque. Ratcheting may cause the Flexspline to become non-concentric with the Circular Spline. Operating in this condition may result in shortened life and a Flexspline fatigue failure.

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

Caution: If the number of occurrences is exceeded, the Flexspline may experience a fatigue failure.

When ratcheting occurs, the teeth may not be correctly engaged and become out of alignment as shown in Figure 097-1. Operating the drive in this condition will cause vibration and damage the flexspline.

Once ratcheting occurs, the teeth wear excessively and the ratcheting torque may be lowered.

Caution

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

**Dedoidal** condition.

\(N\) occurrences

Time that impact torque is applied

Rotational speed of the wave generator

Figure 097-1
## Torsional Stiffness

Stiffness and backlash of the drive system greatly affect 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 098-1 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 098-2, this "Torque – torsion 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 10⁴ Nm/rad
- **K2** = 12 x 10⁴ Nm/rad
- **K3** = 6.7 x 10⁵ Nm/rad

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

\[
θ₁ = \frac{T₁}{K₁} = \frac{6.0}{6.7 \times 10^4} \approx 0.9 \times 10^{-4} \text{ rad} (0.31 \text{ arc min})
\]

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

\[
θ₂ = \frac{T₂ - T₁}{K₂} = \frac{4.4 \times 10^4 - 29}{12 \times 10^4} \approx 1.9 \times 10^{-4} \text{ rad} (1.27 \text{ arc min})
\]

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

\[
θ₃ = \frac{T₃ - T₂}{K₃} = \frac{108 - 108}{6.7 \times 10^5} = 0 \text{ rad}
\]

When a bidirectional load is applied, the total torsion angle will be **2 x θ₃** plus hysteresis loss.

### Hysteresis loss

As shown in Figure 098-1, 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.

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

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

<table>
<thead>
<tr>
<th>Formula variables</th>
<th>Table 099-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>f</td>
<td>Hz</td>
</tr>
<tr>
<td>K</td>
<td>Nm/rad, See pages of each series.</td>
</tr>
<tr>
<td>J</td>
<td>kgm²</td>
</tr>
</tbody>
</table>

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

**Application Motion Profile**

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

![Application Motion Profile Diagram](image)

Obtain the value of each application motion profile.
- **Load torque** $T_n$ (Nm)
- **Time** $t_n$ (sec)
- **Output rotational speed** $n_n$ (rpm)

**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)

![Flowchart for selecting a size](image)

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

1. Make a preliminary model selection with the following conditions. $T_{av}$: Limit for average torque
   (See the ratings for each series).
   1. Calculate the average load torque applied on the output side from the load torque pattern: $T_{av}$ (Nm).
      $$T_{av} = \frac{T_1 \cdot n_1 + T_2 \cdot n_2 + \cdots + T_n \cdot n_n}{n_1 + n_2 + \cdots + n_n}$$

2. Obtain the reduction ratio ($R$). A limit is placed on “$n_{max}$” by motors.
   $$n_{max} = \frac{n_{max}}{n_{av}} \geq R$$

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

4. Calculate the allowable number of rotations during impact torque.
   $$N_s = \frac{10^4}{n_s \cdot R \cdot n_{max} \cdot 1.8 \times 10^4}$$

5. Calculate the lifetime.
   $$L_{10} = 7,000 \left( \frac{T_r}{T_{av}} \right)^{1.3} \left( \frac{n_r}{n_{max}} \right)$$ (hours)

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

7. Check whether $T_1$ is equal to or less than the the momentary torque specification.

8. Check whether the preliminary model number satisfies the following condition from the ratings.
   $N_{av} \leq \frac{n_{max}}{n_{av}} \cdot R$
   $N_{max} \leq \frac{n_{max}}{n_{av}} \cdot R$

9. The model number is confirmed.
### Example of model number selection

<table>
<thead>
<tr>
<th>Load torque (Nm)</th>
<th>Time (sec)</th>
<th>Output rotational speed (rpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>t1</td>
<td>n1</td>
</tr>
<tr>
<td>T2</td>
<td>t2</td>
<td>n2</td>
</tr>
<tr>
<td>T3</td>
<td>t3</td>
<td>n3</td>
</tr>
<tr>
<td>T4</td>
<td>t4</td>
<td>n4</td>
</tr>
</tbody>
</table>

**Normal operation pattern**

- Starting (acceleration): $T_1 = 400 \text{ Nm}$, $t_1 = 0.3 \text{ sec}$, $n_1 = 7 \text{ rpm}$
- Steady operation (constant velocity): $T_2 = 320 \text{ Nm}$, $t_2 = 3 \text{ sec}$, $n_2 = 14 \text{ rpm}$
- Stopping (deceleration): $T_3 = 200 \text{ Nm}$, $t_3 = 0.4 \text{ sec}$, $n_3 = 7 \text{ rpm}$
- Dwell Idle: $T_4 = 0 \text{ Nm}$, $t_4 = 0.2 \text{ sec}$, $n_4 = 0 \text{ rpm}$

**Maximum rotational speed**

- Max. output rotational speed: $n_{\text{max}} = 1800 \text{ rpm}$
- Max. input rotational speed: $n_{i \text{ max}} = 14 \text{ rpm}$ (Restricted by motors)

**Emergency stop torque**

- When impact torque is applied: $T_s = 500 \text{ Nm}$, $t_s = 0.15 \text{ sec}$, $n_s = 14 \text{ rpm}$

**Required life**

- $L_{10} = 7000 \text{ (hours)}$

---

Calculate the average load torque applied on the output side of the Harmonic Drive® gear from the load torque pattern: $T_{av} (\text{Nm})$.

$$T_{av} = \frac{7 \text{ rpm} \times 0.3 \text{ sec} \times 400 \text{ Nm}^2 + 14 \text{ rpm} \times 3 \text{ sec} \times 200 \text{ Nm}^2 + 7 \text{ rpm} \times 0.4 \text{ sec} \times 320 \text{ Nm}^2}{7 \text{ rpm} \times 0.3 \text{ sec} + 14 \text{ rpm} \times 3 \text{ sec} + 7 \text{ rpm} \times 0.4 \text{ sec}}$$

Make a preliminary model selection with the following conditions. $T_{av} = 319 \text{ Nm} \leq 620 \text{ Nm}$ (Limit for average torque for model number CSF-45-120-GH; See the ratings on Page 87.)

Thus, CSF-45-120-GH is tentatively selected.

Calculate the average output rotational speed: $n_{av} (\text{rpm})$.

$$n_{av} = \frac{7 \text{ rpm} \times 0.3 \text{ sec} + 14 \text{ rpm} \times 3 \text{ sec} + 7 \text{ rpm} \times 0.4 \text{ sec}}{0.3 \text{ sec} + 3 \text{ sec} + 0.4 \text{ sec} + 0.2 \text{ sec}} = 12 \text{ rpm}$$

Obtain the reduction ratio ($R$).

- $T_1 = 400 \text{ Nm}$, $t_1 = 0.3 \text{ sec}$, $n_1 = 7 \text{ rpm}$
- $T_2 = 320 \text{ Nm}$, $t_2 = 3 \text{ sec}$, $n_2 = 14 \text{ rpm}$
- $T_3 = 200 \text{ Nm}$, $t_3 = 0.4 \text{ sec}$, $n_3 = 7 \text{ rpm}$
- $T_4 = 0 \text{ Nm}$, $t_4 = 0.2 \text{ sec}$, $n_4 = 0 \text{ rpm}$

Calculate the maximum input rotational speed from the average output rotational speed ($n_{av}$) and the reduction ratio ($R$); $n_{i \text{ av}} (\text{rpm})$.

- $n_{i \text{ max}} = 14 \text{ rpm}$
- $n_{i \text{ max}} = 14 \text{ rpm}$

Calculate the maximum input rotational speed from the maximum output rotational speed ($n_{\text{max}}$) and the reduction ratio ($R$).

$$n_{\text{max}} = \frac{1190}{1.0} = 1190 \text{ rpm}$$

Check whether the preliminary selected model number satisfies the following condition from the ratings.

- $n_{\text{max}} = 1440 \text{ rpm} \leq 3000 \text{ rpm}$ (Max average input speed of size 45)
- $n_{i \text{ max}} = 1680 \text{ rpm} \leq 3800 \text{ rpm}$ (Max input speed of size 45)

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

- $T_1 = 400 \text{ Nm} \leq 823 \text{ Nm}$ (Limit of repeated peak torque of size 45)
- $T_3 = 200 \text{ Nm} \leq 823 \text{ Nm}$ (Limit of repeated peak torque of size 45)

Check whether $T_5$ is equal to or less than the momentary torque specification.

- $T_5 = 500 \text{ Nm} \leq 1760 \text{ Nm}$ (Limit for momentary torque of size 45)

Calculate the allowable number ($N_s$) rotation during impact torque and confirm $\leq 1.0 \times 10^4$ rotation.

$$N_s = \frac{10^4}{\frac{14 \text{ rpm} \times 120}{60} \times 0.15 \text{ sec}} = \frac{10^4}{2} = 5000$$

Calculate the lifetime.

$$L_{10} = 7000 \times (\frac{402 \text{ Nm}}{319 \text{ Nm}})^{0.5} \times \left(\frac{1440 \text{ rpm}}{2000 \text{ rpm}}\right) = 19,457 \text{ hours} \geq 7000 \text{ (life of the wave generator: } L_{10})$$

Check whether the calculated life is equal to or more than the life of the wave generator (see Page 96).

$L_{10} = 19,457 \text{ hours} \geq 7000 \text{ (life of the wave generator: } L_{10})$

The selection of model number CSF-45-120-GH is confirmed from the above calculations.
HarmonicDrive® gearing has a unique operating principle which utilizes the elastic mechanics of metals. This precision gear reducer consists of only 3 basic parts and provides high accuracy and repeatability.

The greatest benefit of HarmonicDrive® gearing is the weight and space savings compared to other gearheads because it consists of only three basic parts. Since many teeth are engaged simultaneously, it can transmit higher torque and provides high accuracy. A unique S tooth profile significantly improves torque capacity, life and torsional stiffness of the gear.

- Zero-backlash
- High Reduction ratios, 50:1 to 160:1 in a single stage
- High precision positioning (repeatability ±4 to ±10 arc-sec)
- High capacity cross roller output bearing
- High torque capacity
The greatest benefit of HarmonicDrive® gearing is the weight and space savings compared to other gearheads because it consists of only three basic parts. Since many teeth are engaged simultaneously, it can transmit higher torque and provides high accuracy. A unique S tooth profile significantly improves torque capacity, life and torsional stiffness of the gear.

- Zero-backlash
- High Reduction ratios, 50:1 to 160:1 in a single stage
- High precision positioning (repeatability ±4 to ±10 arc-sec)
- High capacity cross roller output bearing
- High torque capacity

Robust cross roller bearing is integrated with the output flange to provide high moment stiffness, high load capacity and precise positioning accuracy.

Quick Connect® coupling for easy mounting of any servomotor
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>CSF-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 151-152 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.

---

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

---

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

**Size 11**: Gearhead  
**HPGP**

### Reduction Ratio = 5

![Graph 123-1](image1)

- **Efficiency %** vs. **Input torque Nm**
- **Gearhead (standard item)**
- **Gearhead with D bearing (double sealed)**
- **Full load torque**
- **Torque corresponding to output torque**

### Reduction Ratio = 21

![Graph 123-2](image2)

- **Efficiency %** vs. **Input torque Nm**
- **Gearhead (standard item)**
- **Gearhead with D bearing (double sealed)**
- **Full load torque**
- **Torque corresponding to output torque**

### Reduction Ratio = 37, 45

![Graph 123-3](image3)

- **Efficiency %** vs. **Input torque Nm**
- **Gearhead (standard item)**
- **Gearhead with D bearing (double sealed)**
- **Full load torque**
- **Torque corresponding to output torque**

### Size 14**: Gearhead  
**HPGP**

### Reduction Ratio = 5

![Graph 123-4](image4)

- **Efficiency %** vs. **Input torque Nm**
- **Gearhead (standard item)**
- **Gearhead with D bearing (double sealed)**
- **Full load torque**
- **Torque corresponding to output torque**

### Reduction Ratio = 11

![Graph 123-5](image5)

- **Efficiency %** vs. **Input torque Nm**
- **Gearhead (standard item)**
- **Gearhead with D bearing (double sealed)**
- **Full load torque**
- **Torque corresponding to output torque**

### Reduction Ratio = 15, 21

![Graph 123-6](image6)

- **Efficiency %** vs. **Input torque Nm**
- **Gearhead (standard item)**
- **Gearhead with D bearing (double sealed)**
- **Full load torque**
- **Torque corresponding to output torque**

### Reduction Ratio = 33, 45

![Graph 123-7](image7)

- **Efficiency %** vs. **Input torque Nm**
- **Gearhead (standard item)**
- **Gearhead with D bearing (double sealed)**
- **Full load torque**
- **Torque corresponding to output torque**

---

**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). 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.

---

**Efficiency %** vs. **Input torque Nm**

- **Gearhead (standard item)**
- **Gearhead with D bearing (double sealed)**
- **Full load torque**
- **Torque corresponding to output torque**
Technical Data

Size 20 : Gearhead  HPGP

**Reduction ratio = 5**

<table>
<thead>
<tr>
<th>Efficiency %</th>
<th>Input torque Nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>100</td>
<td>10</td>
</tr>
</tbody>
</table>

**Reduction ratio = 11**

<table>
<thead>
<tr>
<th>Efficiency %</th>
<th>Input torque Nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>100</td>
<td>5</td>
</tr>
</tbody>
</table>

**Reduction ratio = 15, 21**

<table>
<thead>
<tr>
<th>Efficiency %</th>
<th>Input torque Nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>100</td>
<td>5</td>
</tr>
</tbody>
</table>

**Reduction ratio = 33, 45**

<table>
<thead>
<tr>
<th>Efficiency %</th>
<th>Input torque Nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>100</td>
<td>5</td>
</tr>
</tbody>
</table>

---

Size 32 : Gearhead  HPGP

**Reduction ratio = 5**

<table>
<thead>
<tr>
<th>Efficiency %</th>
<th>Input torque Nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

**Reduction ratio = 11**

<table>
<thead>
<tr>
<th>Efficiency %</th>
<th>Input torque Nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

**Reduction ratio = 15, 21**

<table>
<thead>
<tr>
<th>Efficiency %</th>
<th>Input torque Nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

**Reduction ratio = 33, 45**

<table>
<thead>
<tr>
<th>Efficiency %</th>
<th>Input torque Nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

---

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

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).

Checking maximum load

**Input Bearing Specifications and Checking Procedure**

### Size 50: Gearhead

- **Reduction ratio = 5**
  - See Graph 125-1
  - Efficiency % vs. Input torque Nm
  - Reduction ratio = 5

- **Reduction ratio = 11**
  - See Graph 125-2
  - Efficiency % vs. Input torque Nm
  - Reduction ratio = 11

### Size 65: Gearhead

- **Reduction ratio = 4, 5**
  - See Graph 125-3
  - Efficiency % vs. Input torque Nm
  - Reduction ratio = 4, 5

- **Reduction ratio = 12**
  - See Graph 125-4
  - Efficiency % vs. Input torque Nm
  - Reduction ratio = 12

- **Reduction ratio = 15, 20**
  - See Graph 125-5
  - Efficiency % vs. Input torque Nm
  - Reduction ratio = 15, 20

- **Reduction ratio = 25**
  - See Graph 125-6
  - Efficiency % vs. Input torque Nm
  - Reduction ratio = 25

### Notes

* 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**
  - 5, 11
  - 4, 5, 12
  - 15, 20, 25

- **Efficiency %**
  - Calculation:
    - Reduction ratio = 15, 21
    - Efficiency % = 100

- **Input speed**
  - Moment load
  - Average input speed

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

---

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

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

- 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 shaft unit.

### Specification of input shaft bearing

<table>
<thead>
<tr>
<th>Size</th>
<th>Size</th>
<th>Specification of input bearing</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>25</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>32</td>
</tr>
</tbody>
</table>

#### How to calculate average load

- **Input torque (TRi)**: For each reduction ratio, the input torque corresponding to the output torque can be obtained from the graphs.

#### How to calculate the average axial load (Fai)

- **Average axial load (Fai)**: If moment load and axial load fluctuate, they should be averaged for the life check of the bearing.

#### How to calculate the average moment load (Mi)

- **Average moment load Nm (kgfm)**: See Formula 146-2.

#### Technical Information / Handling Explanation

- **Max. axial load**: See Table 145-1 and -3.
- **Efficiency %**: See Table 145-4.

### Technical Data

- **Efficiency %**:
  - Reduction ratio = 3, 5
  - Reduction ratio = 11
  - Reduction ratio = 15
  - Reduction ratio = 21
  - Reduction ratio = 33
  - Reduction ratio = 45

*Only one line is shown because the difference between the gearhead and a bearing assembled on the input side is small.*
**Reduction ratio** = 40

**230** 231

128

**Technical Data**

**Reduction ratio = 40**

**av**

**40**

**Average input speed (Nia)**

**Average axial load (Fai)**

**Average moment load (Mia)**

Calculate:

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

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

*3 Reduction ratio = 12 Reduction ratio = 15, 20

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

**HPG**

**Reduction ratio = 4, 5**

**Graph 128-5**

**Reduction ratio = 4**

**Reduction ratio = 5**

**Reduction ratio = 12**

**Graph 128-6**

**Reduction ratio = 15, 20**

**Graph 128-7**

**Reduction ratio = 15, 21**

**Graph 128-3**

**Reduction ratio = 15**

**Reduction ratio = 21**

**Reduction ratio = 33**

**Graph 128-4**

**Reduction ratio = 33**

**Reduction ratio = 45**

**Graph 128-2**

**Reduction ratio = 11**

**Graph 128-1**

**Reduction ratio = 3**

**Graph 128**

---

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

**Size 11: Gearhead  HPG-Helical**

Reduction ratio = 4

Graph 129-1

Reduction ratio = 7, 8

Graph 129-3

Reduction ratio = 9, 10

Graph 129-5

---

**Size 14: Gearhead  HPG-Helical**

Reduction ratio = 3, 4

Graph 129-6

Reduction ratio = 7, 8

Graph 129-7

Reduction ratio = 9, 10

Graph 129-8

---

Input Bearing Specifications and Checking Procedure

<table>
<thead>
<tr>
<th>Specification of Input Shaft Bearing</th>
<th>Specification of Input Bearing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>Size</td>
</tr>
<tr>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>20</td>
<td>32</td>
</tr>
</tbody>
</table>

### Checking Maximum Load

- Maximum radial load (Fri)
- Maximum axial load (Fai)
- Maximum moment load (M)
- Average axial load (Fai)
- Average moment load (M)

### Example Calculation

\[ P_{ci} = 96.9 \text{ Nm} \]

\[ F_{ai} = 44.4 \text{ kgf} \]

\[ M_{i} = 13.5 \text{ Nm} \]

\[ F_{ai} = 4.16 \text{ kgf} \]

\[ M_{i} = 2.7 \text{ Nm} \]

### Technical Data

- **Basic dynamic load rating** (Cr) HPG, HPF: 0.016 kgf
- **Basic static load rating** (Cor) HPG, HPF: 9.88 kgf
- **Reduction ratio**
  - 3, 4
  - 5, 6
  - 7, 8
  - 9, 10

### Gearheads

- Gearhead with Z bearing (Double shielded)
- Gearhead with D bearing (Double sealed)

### Graphs

- Graph 129-1
- Graph 129-2
- Graph 129-3
- Graph 129-4
- Graph 129-5
- Graph 129-6
- Graph 129-7
- Graph 129-8
### Technical Data

#### Gearhead with Z bearing (double sealed)

**Reduction ratio = 3, 4**

**Graph 130-1**

- Gearhead with Z bearing (Double shielded)
- Gearhead with D bearing (double sealed)

**Reduction ratio = 5, 6**

**Graph 130-2**

**Reduction ratio = 7, 8**

**Graph 130-3**

**Reduction ratio = 9, 10**

**Graph 130-4**

---

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

**Reduction ratio = 3, 4**

**Graph 130-5**

**Reduction ratio = 5, 6**

**Graph 130-6**

**Reduction ratio = 7, 8**

**Graph 130-7**

**Reduction ratio = 9, 10**

**Graph 130-8**

---

#### Technical Information / Handling Explanation

- 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 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. **Specification of input bearing**
   - 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. **Checking procedure**
   - **Input speed (N1)**
   - **Moment load (Mi)**
   - **Axial load (Fai)**
   - **Radial load (Fric)**

   **Formula 146-4**
   
   \[
   Fric \leq Frc \quad \text{Allowable radial load}
   \]

   \[
   Mi \leq Mc \quad \text{Allowable moment load}
   \]

   \[
   Fai \leq Fac \quad \text{Allowable axial load}
   \]

   Calculate:
   - **Average moment load (M1)**
   - **Average axial load (Faiav)**
   - **Average input speed (Niav)**

   **Formula 146-2**
   \[
   M1 = 0.041 \times Mi + 0.137 \times Fai
   \]

   **Formula 146-3**
   \[
   Faiav = 0.071 \times Mi + 1.232 \times Fai
   \]

   **Formula 146-5**
   \[
   Niav = \frac{1}{10} \times Pci
   \]

   Where:
   - **Pci** = Input power of the input gear unit

---

**Table 145-1 and -3**

**Table 145-2 and 145-4**

---

**Graph 130-1 to 130-8**

---

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

Checking maximum load

Specification of input shaft bearing

<table>
<thead>
<tr>
<th>Size</th>
<th>Size</th>
<th>Size</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>65</td>
<td>50</td>
<td>20</td>
<td>32</td>
</tr>
<tr>
<td>32</td>
<td>65</td>
<td>14</td>
<td></td>
</tr>
</tbody>
</table>

Average input speed ($n_1$)

Average moment load ($M_{i}$)

Calculate:

Table 145-2 and 145-4

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

*3 Reduction ratio = 4, 5

Reduction ratio = 12

Reduction ratio = 15, 20

Reduction ratio = 15, 21

Efficiency %

Input torque

Reduction ratio = 5

Reduction ratio = 11

Reduction ratio = 15, 21

Reduction ratio = 33, 45

Input torque corresponding to output torque ($T_n$)

Graph 131-1

Graph 131-2

Graph 131-3

Graph 131-4

Graph 131-5

Graph 131-6

Graph 131-7

Graph 131-8

$T_n$: Input torque corresponding to output torque

Technical Data

<table>
<thead>
<tr>
<th>Size 32 RA3</th>
<th>Right Angle Gearhead</th>
<th>HPG</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Reduction ratio = 5</th>
<th>Graph 131-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_n$</td>
<td></td>
</tr>
<tr>
<td>Efficiency %</td>
<td></td>
</tr>
<tr>
<td>Input torque Nm</td>
<td>0 5 10 15 20 25 30 35 40</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reduction ratio = 11</th>
<th>Graph 131-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_n$</td>
<td></td>
</tr>
<tr>
<td>Efficiency %</td>
<td></td>
</tr>
<tr>
<td>Input torque Nm</td>
<td>0 5 10 15 20 25 30 35 40</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reduction ratio = 15, 21</th>
<th>Graph 131-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_n$</td>
<td></td>
</tr>
<tr>
<td>Efficiency %</td>
<td></td>
</tr>
<tr>
<td>Input torque Nm</td>
<td>0 5 10 15 20 25 30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reduction ratio = 33, 45</th>
<th>Graph 131-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_n$</td>
<td></td>
</tr>
<tr>
<td>Efficiency %</td>
<td></td>
</tr>
<tr>
<td>Input torque Nm</td>
<td>0 5 10 15 20 25 30 35</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reduction ratio = 5</th>
<th>Graph 131-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_n$</td>
<td></td>
</tr>
<tr>
<td>Efficiency %</td>
<td></td>
</tr>
<tr>
<td>Input torque Nm</td>
<td>0 5 10 15 20 25 30 35 40</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reduction ratio = 11</th>
<th>Graph 131-6</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_n$</td>
<td></td>
</tr>
<tr>
<td>Efficiency %</td>
<td></td>
</tr>
<tr>
<td>Input torque Nm</td>
<td>0 5 10 15 20 25 30 35 40</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reduction ratio = 15, 21</th>
<th>Graph 131-7</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_n$</td>
<td></td>
</tr>
<tr>
<td>Efficiency %</td>
<td></td>
</tr>
<tr>
<td>Input torque Nm</td>
<td>0 5 10 15 20 25 30 35</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reduction ratio = 33, 45</th>
<th>Graph 131-8</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_n$</td>
<td></td>
</tr>
<tr>
<td>Efficiency %</td>
<td></td>
</tr>
<tr>
<td>Input torque Nm</td>
<td>0 5 10 15 20 25 30 35 40</td>
</tr>
</tbody>
</table>

TRi

TRi

Technical Information / Handling Explanation
Technical Data

Table 145-2 and 145-4

<table>
<thead>
<tr>
<th>Size</th>
<th>Reduction ratio</th>
<th>Input torque (Nm)</th>
<th>Efficiency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>5</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>32</td>
<td>11</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>50</td>
<td>15, 21</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>32</td>
<td>33, 45</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

*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.

Checking maximum load

\[
T_r = \frac{1}{\text{Reduction ratio}} \times \text{Input torque}
\]

Checking the life

- Calculate: Average input speed (N_i) = \( \frac{\text{Input speed}}{\text{Reduction ratio}} \)
- Calculate: Average axial load (F_{ai}) = \( \frac{\text{Axial load}}{\text{Reduction ratio}} \)
- Check that the following formulas are established in all circumstances:
  \[
  \text{Allowable radial load (F_{rc})} \leq \text{Maximum radial load (F_{max})}
  \]
  \[
  \text{Allowable moment load (M_{c})} \leq \text{Maximum moment load (M_{max})}
  \]
  \[
  \text{Allowable axial load (F_{ai})} \leq \text{Allowable axial load (F_{max})}
  \]

Input torque corresponding to output torque

**Technical Information / Handling Explanation**
Technical Data

Size 11A: Gearhead
HPN

Reduction ratio = 4

![Graph 133-1](#)

Reduction ratio = 5

![Graph 133-2](#)

Reduction ratio = 7

![Graph 133-3](#)

Reduction ratio = 10

![Graph 133-4](#)

Reduction ratio = 16

![Graph 133-5](#)

Reduction ratio = 20

![Graph 133-6](#)

Reduction ratio = 30

![Graph 133-7](#)

Reduction ratio = 3

![Graph 133-9](#)

Reduction ratio = 4

![Graph 133-10](#)

Reduction ratio = 5

![Graph 133-11](#)

Reduction ratio = 7

![Graph 133-12](#)

Reduction ratio = 10

![Graph 133-13](#)

Reduction ratio = 13

![Graph 133-14](#)

Reduction ratio = 21

![Graph 133-15](#)

Reduction ratio = 31

![Graph 133-16](#)
### Size 20A: Gearhead

<table>
<thead>
<tr>
<th>Reduction ratio</th>
<th>Graph 134-1</th>
<th>Graph 134-2</th>
<th>Graph 134-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td><img src="image1" alt="Graph 134-1" /></td>
<td><img src="image2" alt="Graph 134-2" /></td>
<td><img src="image3" alt="Graph 134-3" /></td>
</tr>
<tr>
<td>4</td>
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<td><img src="image5" alt="Graph 134-5" /></td>
<td><img src="image6" alt="Graph 134-6" /></td>
</tr>
<tr>
<td>5</td>
<td><img src="image7" alt="Graph 134-7" /></td>
<td><img src="image8" alt="Graph 134-8" /></td>
<td><img src="image9" alt="Graph 134-9" /></td>
</tr>
<tr>
<td>7</td>
<td><img src="image10" alt="Graph 134-10" /></td>
<td><img src="image11" alt="Graph 134-11" /></td>
<td><img src="image12" alt="Graph 134-12" /></td>
</tr>
<tr>
<td>10</td>
<td><img src="image13" alt="Graph 134-13" /></td>
<td><img src="image14" alt="Graph 134-14" /></td>
<td><img src="image15" alt="Graph 134-15" /></td>
</tr>
<tr>
<td>13</td>
<td><img src="image16" alt="Graph 134-16" /></td>
<td><img src="image17" alt="Graph 134-17" /></td>
<td><img src="image18" alt="Graph 134-18" /></td>
</tr>
<tr>
<td>21</td>
<td><img src="image19" alt="Graph 134-19" /></td>
<td><img src="image20" alt="Graph 134-20" /></td>
<td><img src="image21" alt="Graph 134-21" /></td>
</tr>
<tr>
<td>31</td>
<td><img src="image22" alt="Graph 134-22" /></td>
<td><img src="image23" alt="Graph 134-23" /></td>
<td><img src="image24" alt="Graph 134-24" /></td>
</tr>
</tbody>
</table>

### Size 32A: Gearhead

<table>
<thead>
<tr>
<th>Reduction ratio</th>
<th>Graph 134-9</th>
<th>Graph 134-10</th>
<th>Graph 134-11</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td><img src="image25" alt="Graph 134-9" /></td>
<td><img src="image26" alt="Graph 134-10" /></td>
<td><img src="image27" alt="Graph 134-11" /></td>
</tr>
<tr>
<td>4</td>
<td><img src="image28" alt="Graph 134-12" /></td>
<td><img src="image29" alt="Graph 134-13" /></td>
<td><img src="image30" alt="Graph 134-14" /></td>
</tr>
<tr>
<td>5</td>
<td><img src="image31" alt="Graph 134-15" /></td>
<td><img src="image32" alt="Graph 134-16" /></td>
<td><img src="image33" alt="Graph 134-17" /></td>
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<tr>
<td>7</td>
<td><img src="image34" alt="Graph 134-18" /></td>
<td><img src="image35" alt="Graph 134-19" /></td>
<td><img src="image36" alt="Graph 134-20" /></td>
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<tr>
<td>10</td>
<td><img src="image37" alt="Graph 134-21" /></td>
<td><img src="image38" alt="Graph 134-22" /></td>
<td><img src="image39" alt="Graph 134-23" /></td>
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<tr>
<td>13</td>
<td><img src="image40" alt="Graph 134-24" /></td>
<td><img src="image41" alt="Graph 134-25" /></td>
<td><img src="image42" alt="Graph 134-26" /></td>
</tr>
<tr>
<td>21</td>
<td><img src="image43" alt="Graph 134-27" /></td>
<td><img src="image44" alt="Graph 134-28" /></td>
<td><img src="image45" alt="Graph 134-29" /></td>
</tr>
<tr>
<td>31</td>
<td><img src="image46" alt="Graph 134-30" /></td>
<td><img src="image47" alt="Graph 134-31" /></td>
<td><img src="image48" alt="Graph 134-32" /></td>
</tr>
</tbody>
</table>

#### Technical Information / Handling Explanation

- **[Formula 146-4]**
- **Table 145-1 and 145-3**
- **Table 146-1 and 2**
- **Input Bearing Specifications and Checking Procedure**

#### Technical Data

- **Gearhead HPN**

#### Specification of input shaft bearing

- Checking procedure
- Checking the life

#### Allowable radial load (Frc)

<table>
<thead>
<tr>
<th>Load Type</th>
<th>Frc (Allowable Axial Load)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic</td>
<td>Cr</td>
</tr>
<tr>
<td>Static</td>
<td>Ni</td>
</tr>
</tbody>
</table>

#### Dynamic equivalent load

- 

#### Life

- Calculating life of input bearing
- See Formula 146-3

### Gearhead Details

- **Input torque**
- **Efficiency %**
- **Reduction ratio**
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

- 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 shaft bearing**

**Specification of input bearing**

Size | Size
--- | ---
50 25 32 | 20 25 32
14

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

Calculate:

\[
\text{Average input speed (N_{i}}) = \frac{t_1 + t_2 + t_3 + t_4}{4}
\]

\[
\text{Average moment load (M_{i}} = \frac{M_1 + M_2 + M_3 + M_4}{4}
\]

\[
\text{Average axial load (N_{i}} = \frac{N_1 + N_2 + N_3 + N_4}{4}
\]

**Reduction ratio**

- 3
- 4
- 5
- 7
- 10
- 13
- 21
- 31
- 90

**Reduction ratio**

- 3
- 4
- 5
- 7
- 10
- 13
- 21
- 31
- 90

**Technical Data**

- Efficiency %
- Input torque (Nm)
- Input speed
- Life (Hour)
- Load coefficient (fw)
- Output shaft load limits
- Graphs 135-1 to 135-8

**Dynamic equivalent load**

- F_{d_{avg}} = 0.041 \times M_i
- F_{d_{avg}} = 0.053 \times M_i
- F_{d_{avg}} = 0.071 \times M_i

**Graphs**

- Graph 135-1 to 135-8

**Technical Information / Handling Explanation**

- Standard operation without impact: fw=1.2~1.5
- Smooth operation: fw=1~1.2
- Standard operation with impact: fw=1.5~2.0

**Technical Data**

- Input torque (Nm)
- Input speed
- Life (Hour)
- Load coefficient (fw)
- Output shaft load limits

**Graphs**

- Graph 135-1 to 135-8

**Technical Information / Handling Explanation**

- Standard operation without impact: fw=1.2~1.5
- Smooth operation: fw=1~1.2
- Standard operation with impact: fw=1.5~2.0
**Technical Data**

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

**Reduction ratio = 11**

Graph 136-1

---

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

**Reduction ratio = 11**

Graph 136-2

---

**Technical Information / Handling Explanation**

- **Reduction ratio = 15, 21**
  - Reduction ratio = 33, 45

- **Size 50 RA5**

- **Input torque corresponding to output torque**

- **Efficiency %**
  - 100
  - 90
  - 90
  - 90
  - 80
  - 80
  - 80
  - 80
  - 70
  - 70
  - 70
  - 70
  - 60
  - 60
  - 60
  - 60
  - 50
  - 50
  - 50
  - 50
  - 40
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  - 40
  - 30
  - 30
  - 30
  - 30
  - 20
  - 20
  - 20
  - 20
  - 10
  - 10
  - 10
  - 10
  - 0
  - 0
  - 0
  - 0
  - 0

---

**Note**

- **Formula 146-4**

See Table 145-1 and -3

See Table 146-1 and -2

Input Bearing Specifications and Checking Procedure

- **Specification of input shaft bearing**
  - **Size 32**

- **Specification of input bearing**
  - **Size 50 RA5**

---

**Calculating life of input bearing**

- **How to calculate average load**
  - **Average axial load (F_{ai})**
  - **Average moment load (M_{i})**

- **Allowable moment load (M_{c})**
  - **Allowable axial load (F_{a})**
  - **Allowable radial load (F_{r})**

- **Maximum radial load (F_{r_{max}})**
  - **Maximum axial load (F_{a_{max}})**

- **Calculate**:
  - **Dynamic equivalent load**:  
    - **Basic dynamic load rating (C_{r})**
    - **Basic static load rating (C_{r_{max}})**

- **Check the life and calculate**:
  - **Average input speed (N_{i_{av}})**
  - **Input speed (N_{i})**
  - **Moment load (M_{i})**

- **How to calculate average input speed (N_{i_{av}})**
  - **How to calculate average axial load (F_{a_{av}})**
  - **How to calculate average moment load (M_{i_{av}})**

---

**External load influence diagram**

- **Formula 146-1**
  - **Formula 146-2**
  - **Formula 146-3**
  - **Formula 146-4**

---

**Technical Information / Handling Explanation**

- **Note**
  - **Allowable moment load M_{c}**
  - **Allowable axial load F_{a}**
  - **Allowable radial load F_{r}**

- **Maximum radial load F_{r_{max}}**
  - **Maximum axial load F_{a_{max}}**

---

See Fig. 146-1.

See Fig. 146-2.

See Fig. 146-3.

---

**Graphs**

Graph 136-1

Graph 136-2

---

**Technical Data**

**Graphs**

Graph 132-6

Graph 132-8
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.

**Checking maximum load**

1. **Checking the life**
2. **Checking the shaft unit.**

**Specification of input bearing**

<table>
<thead>
<tr>
<th>Size</th>
<th>Gearhead</th>
<th>CSG-GH</th>
<th>CSF-GH</th>
</tr>
</thead>
<tbody>
<tr>
<td>65</td>
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<td></td>
</tr>
<tr>
<td>32</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Checking procedure**

- Maximum axial load ($F_{a_{max}}$)
- Maximum moment load ($M_{max}$)

Calculate:

- Average input speed ($N_{i}$)
- Average axial load ($F_{a_{av}}$)
- Average moment load ($M_{av}$)

**Technical Information / Handling Explanation**

- Reducing ratio = 50
- Reducing ratio = 80
- Reducing ratio = 100

Input rotational speed:

- 500 rpm
- 1000 rpm
- 2000 rpm
- 3500 rpm
**Technical Information / Handling Explanation**

**Size 20**

Reduction ratio = 50

Graph 137-1

Reduction ratio = 80

Graph 138-2

Reduction ratio = 100

Graph 138-3

<table>
<thead>
<tr>
<th>Input Torque (Ncm)</th>
<th>Efficiency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>50</td>
<td>90</td>
</tr>
<tr>
<td>100</td>
<td>80</td>
</tr>
<tr>
<td>150</td>
<td>70</td>
</tr>
<tr>
<td>200</td>
<td>60</td>
</tr>
<tr>
<td>250</td>
<td>50</td>
</tr>
<tr>
<td>300</td>
<td>40</td>
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<td>350</td>
<td>30</td>
</tr>
<tr>
<td>400</td>
<td>20</td>
</tr>
<tr>
<td>450</td>
<td>10</td>
</tr>
<tr>
<td>500</td>
<td>0</td>
</tr>
</tbody>
</table>

Input rotational speed: 500 rpm, 1000 rpm, 2000 rpm, 3500 rpm

**Size 32**

Reduction ratio = 80

Graph 138-4

Reduction ratio = 120

Graph 138-5

<table>
<thead>
<tr>
<th>Input Torque (Ncm)</th>
<th>Efficiency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>50</td>
<td>90</td>
</tr>
<tr>
<td>100</td>
<td>80</td>
</tr>
<tr>
<td>150</td>
<td>70</td>
</tr>
<tr>
<td>200</td>
<td>60</td>
</tr>
<tr>
<td>250</td>
<td>50</td>
</tr>
<tr>
<td>300</td>
<td>40</td>
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<td>350</td>
<td>30</td>
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<tr>
<td>400</td>
<td>20</td>
</tr>
<tr>
<td>450</td>
<td>10</td>
</tr>
<tr>
<td>500</td>
<td>0</td>
</tr>
</tbody>
</table>

Input rotational speed: 500 rpm, 1000 rpm, 2000 rpm, 3500 rpm

**Size 45**

Reduction ratio = 100

Graph 138-6

Reduction ratio = 120

Graph 138-7

Reduction ratio = 160

Graph 138-8

<table>
<thead>
<tr>
<th>Input Torque (Ncm)</th>
<th>Efficiency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>50</td>
<td>90</td>
</tr>
<tr>
<td>100</td>
<td>80</td>
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<td>150</td>
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<td>200</td>
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<tr>
<td>250</td>
<td>50</td>
</tr>
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<td>300</td>
<td>40</td>
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<tr>
<td>400</td>
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</tr>
<tr>
<td>450</td>
<td>10</td>
</tr>
<tr>
<td>500</td>
<td>0</td>
</tr>
</tbody>
</table>

Input rotational speed: 500 rpm, 1000 rpm, 2000 rpm, 3500 rpm

**Graph 138-1**

**Graph 138-2**

**Graph 138-3**

**Graph 138-4**

**Graph 138-5**

**Graph 138-6**

**Graph 138-7**

**Graph 138-8**

**Graph 138-9**

**Graph 138-10**

---

*Technical Data*

- **Input Torque (Ncm)**
- **Efficiency %**

---

*Input Torque (Ncm)*

**Reduction ratio = 50**

Graph 138-1

**Reduction ratio = 80**

Graph 138-2

**Reduction ratio = 100**

Graph 138-3

**Reduction ratio = 120**

Graph 138-4

**Reduction ratio = 160**

Graph 138-5

**Reduction ratio = 50**

Graph 138-6

**Reduction ratio = 80**

Graph 138-7

**Reduction ratio = 100**

Graph 138-8

**Reduction ratio = 120**

Graph 138-9

**Reduction ratio = 160**

Graph 138-10

---

*Graph 138-1*

*Graph 138-2*

*Graph 138-3*

*Graph 138-4*

*Graph 138-5*

*Graph 138-6*

*Graph 138-7*

*Graph 138-8*

*Graph 138-9*

*Graph 138-10*
Calculating life of input bearing

Reduction ratio = 80

\[
\text{Graph 139-1}
\]

Reduction ratio = 100

\[
\text{Graph 139-2}
\]

Reduction ratio = 120

\[
\text{Graph 139-3}
\]

Reduction ratio = 160

\[
\text{Graph 139-4}
\]

Input rotational speed

- 500 rpm
- 1000 rpm
- 2000 rpm
- 3500 rpm
Output Shaft Bearing Load Limits

HPN Series Output Shaft Load Limits are plotted below.

HPN uses radial 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

HPG, 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 (\( M_{\text{max}} \)) in the table. \( M_{\text{max}} \leq \text{Permissible moment (} M_c \)\)

2. **Checking the life**
   - Calculate the average radial load (\( F_{\text{av}} \)) and the average axial load (\( F_{\text{ax}} \)).
   - 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 static equivalent radial load coefficient (\( P_{\text{ci}} \)).
   - Check the static safety coefficient (\( f_s \)).

### Specification of output bearing

**HPG/HPG Series**

<table>
<thead>
<tr>
<th>Size</th>
<th>Pitch circle m</th>
<th>Offset amount m</th>
<th>Basic dynamic load rating ( C ) N</th>
<th>Basic static load rating ( C_0 ) N</th>
<th>Allowable moment load ( M_c ) ( \times 10^6 )</th>
<th>Moment stiffness ( K_m ) m ( \times ) kgfNm ( \times ) rad/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>0.0275</td>
<td>0.006</td>
<td>3116</td>
<td>318</td>
<td>4087</td>
<td>417</td>
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<tr>
<td>14</td>
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<td>0.011</td>
<td>5110</td>
<td>521</td>
<td>7060</td>
<td>720</td>
</tr>
<tr>
<td>20</td>
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<td>0.0155</td>
<td>10600</td>
<td>1082</td>
<td>17300</td>
<td>1765</td>
</tr>
<tr>
<td>32</td>
<td>0.085</td>
<td>0.014</td>
<td>20500</td>
<td>2092</td>
<td>32800</td>
<td>3347</td>
</tr>
<tr>
<td>50</td>
<td>0.123</td>
<td>0.019</td>
<td>41600</td>
<td>4245</td>
<td>76000</td>
<td>7755</td>
</tr>
<tr>
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<td>9245</td>
<td>148000</td>
<td>15102</td>
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</table>

**HPF Series**

<table>
<thead>
<tr>
<th>Size</th>
<th>Reduction ratio</th>
<th>Allowable radial load ( \times 10^3 ) Kgf</th>
<th>Allowable axial load ( \times 10^3 ) Kgf</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>5</td>
<td>280</td>
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</tr>
<tr>
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<td>440</td>
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</tr>
<tr>
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<td>550</td>
<td>830</td>
</tr>
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<td>600</td>
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</tr>
<tr>
<td>14</td>
<td>5</td>
<td>650</td>
<td>980</td>
</tr>
<tr>
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<td>15</td>
<td>720</td>
<td>1080</td>
</tr>
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</tr>
<tr>
<td>14</td>
<td>45</td>
<td>910</td>
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</tr>
<tr>
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<td>45</td>
<td>1890</td>
<td>2830</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Size</th>
<th>Reduction ratio</th>
<th>Allowable radial load ( \times 10^3 ) Kgf</th>
<th>Allowable axial load ( \times 10^3 ) Kgf</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
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<td>11</td>
<td>2140</td>
<td>3590</td>
</tr>
<tr>
<td>32</td>
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<td>5480</td>
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<td>11</td>
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<td>8220</td>
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<td>15</td>
<td>6050</td>
<td>9030</td>
</tr>
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</tr>
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</tr>
<tr>
<td>65</td>
<td>50</td>
<td>18900</td>
<td>28200</td>
</tr>
</tbody>
</table>

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

**Note:** Table 141-1, -2 and -3  Table 142-1 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.
Table 142-1 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 $\text{Mc}^\text{av}$</th>
<th>Moment stiffness $K_m$</th>
<th>Allowable radial load $L_r$</th>
<th>Allowable axial load $L_a$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dp</td>
<td>m</td>
<td>R</td>
<td>m</td>
<td>N</td>
<td>kgf</td>
<td>N</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>
<td>27</td>
</tr>
<tr>
<td>20</td>
<td>0.064</td>
<td>0.0115</td>
<td>10600</td>
<td>1082</td>
<td>17300</td>
<td>1765</td>
<td>145</td>
</tr>
<tr>
<td>32</td>
<td>0.085</td>
<td>0.014</td>
<td>20500</td>
<td>2092</td>
<td>32800</td>
<td>3347</td>
<td>258</td>
</tr>
<tr>
<td>45</td>
<td>0.123</td>
<td>0.019</td>
<td>41600</td>
<td>4245</td>
<td>76000</td>
<td>7755</td>
<td>797</td>
</tr>
<tr>
<td>65</td>
<td>0.170</td>
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<td>81600</td>
<td>8327</td>
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<td>15204</td>
<td>2156</td>
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</table>

HPF Series Table 142-2 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 $\text{Mc}^\text{av}$</th>
<th>Moment stiffness $K_m$</th>
<th>Allowable radial load $L_r$</th>
<th>Allowable axial load $L_a$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dp</td>
<td>m</td>
<td>R</td>
<td>m</td>
<td>N</td>
<td>kgf</td>
<td>N</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 141-1, -2 and -3 Table 142-1 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.
Maximum moment load \((M_{\text{max}})\) is obtained as follows. Make sure that \(M_{\text{max}} \leq M_c\).

\[
M_{\text{max}} = F_r \cdot \max (L_r + R) + F_a \cdot \max L_a
\]

| \(F_{r_{\text{max}}}\) | Max. radial load (N) | See Fig. 143-1. |
| \(F_{a_{\text{max}}}\) | Max. axial load (N) | See Fig. 143-1. |
| \(L_r, L_a\) | m | See Fig. 143-1. |
| \(R\) | Offset amount m | See Fig. 143-1. |
| \(d_p\) | Circular pitch of roller m | See Fig. 143-1. |

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

\[
X = \frac{F_{a_{\text{av}}} \cdot (L_r + R) + F_{r_{\text{av}}} \cdot L_a}{d_p}
\]

\[
Y = \frac{F_{a_{\text{av}}} \cdot (L_r + R) + F_{r_{\text{av}}} \cdot L_a}{d_p}
\]

| \(F_{a_{\text{av}}}\) | Average axial load (N) | See "How to calculate the average load below." |
| \(F_{r_{\text{av}}}\) | Average radial load (N) | See "How to calculate the average load below." |
| \(L_r, L_a\) | m | See Fig. 143-1. |
| \(R\) | Offset amount m | See Fig. 143-1. |
| \(d_p\) | Circular pitch of roller m | See Fig. 143-1. |

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

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.

\[
F_{r_{\text{av}}} = \frac{n \cdot t \cdot (F_{r1} \cdot 10^5) + n_{t1} \cdot t \cdot (F_{r2} \cdot 10^5) + \cdots + n_{t_n} \cdot t \cdot (F_{r_n} \cdot 10^5)}{n \cdot t + n_{t1} + \cdots + n_{t_n}}
\]

Note that the maximum radial load within the \(t_i\) section is \(F_{r_i}\) and the maximum radial load within the \(t_i\) section is \(F_{r_i}\).

\[
F_{a_{\text{av}}} = \frac{n \cdot t \cdot (F_{a1} \cdot 10^5) + n_{t1} \cdot t \cdot (F_{a2} \cdot 10^5) + \cdots + n_{t_n} \cdot t \cdot (F_{a_n} \cdot 10^5)}{n \cdot t + n_{t1} + \cdots + n_{t_n}}
\]

Note that the maximum axial load within the \(t_i\) section is \(F_{a_i}\) and the maximum axial load within the \(t_i\) section is \(F_{a_i}\).

\[
N_{\text{av}} = \frac{n \cdot t \cdot (n_{t1} + \cdots + n_{t_n})}{t_i \cdot t + \cdots + t_i}
\]
How to calculate the life

Calculate the life of the cross roller bearing using Formula 144-1. You can obtain the dynamic equivalent load \( (P_c) \) using Formula 144-2.

\[
L_o = \frac{10^6 \times 60 \times N_{av} \times C}{f_w \times P_c} \]

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 144-3.

\[
L_{oc} = \frac{10^6 \times \theta \times C}{f_w \times P_c} \]

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 \( (C_0) \) 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 \( (f_s) \) of the cross roller bearing using Formula 144-4.

\[
f_s = \frac{C_0}{P_0} \]

Static safety coefficient

<table>
<thead>
<tr>
<th>Load status</th>
<th>( f_s )</th>
</tr>
</thead>
<tbody>
<tr>
<td>When high precision is required</td>
<td>( \geq 3 )</td>
</tr>
<tr>
<td>When impact or vibration is expected</td>
<td>( \geq 2 )</td>
</tr>
<tr>
<td>Under normal operating condition</td>
<td>( \geq 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**
  - **HPG**
  - **HPF**

(1) Checking maximum load

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

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

(2) Checking the life

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

- Calculate the life and check it.

### Specification of input bearing

**HPG**

<table>
<thead>
<tr>
<th>Size</th>
<th>Basic load rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Basic dynamic load rating Cr</td>
</tr>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>11</td>
<td>2700</td>
</tr>
<tr>
<td>14</td>
<td>5800</td>
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<tr>
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<tr>
<td>50</td>
<td>35500</td>
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<tr>
<td>65</td>
<td>51000</td>
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</tbody>
</table>

**HPF**

<table>
<thead>
<tr>
<th>Size</th>
<th>Allowable moment load Mc</th>
<th>Allowable axial load Fac <strong>1</strong></th>
<th>Allowable radial load Frc <strong>2</strong></th>
</tr>
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<tbody>
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<td>kgf/m</td>
<td>N</td>
</tr>
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### Specification of input shaft bearing

**HPF**

<table>
<thead>
<tr>
<th>Size</th>
<th>Basic load rating</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Basic dynamic load rating Cr</td>
</tr>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>25</td>
<td>14500</td>
</tr>
<tr>
<td>32</td>
<td>29700</td>
</tr>
</tbody>
</table>

### Technical Data

- See Table 145-1 and -3.
- See Table 145-2.
- See Fig. 146-1.

(Note: Table 145-2 and 145-4)

**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).
Calculating maximum moment load ON input shaft

The maximum moment load (Mimax) is calculated as follows. Check that the following formulas are established in all circumstances:

\[ \text{Mimax} = \text{Fri max} \cdot \text{Lri} + \text{Fai max} \cdot \text{Lai} \]

\[ \text{Fri max} \quad \text{Max. radial load} \quad \text{N (kgf)} \quad \text{See Fig. 146-1.} \]
\[ \text{Fai max} \quad \text{Max. axial load} \quad \text{N (kgf)} \quad \text{See Fig. 146-1.} \]
\[ \text{Lri, Lai} \quad \text{---} \quad \text{---} \quad \text{m} \quad \text{See Fig. 146-1.} \]

Mimax \( \leq \) Mc (Allowable moment load)
Fai max \( \leq \) Fac (Allowable axial load)

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.

Calculating maximum moment load

\[ \text{Mai} = \text{Fri} \cdot \text{Lri} + \text{Fai} \cdot \text{Lai} \]

\[ \text{Mai} \quad \text{Average moment load} \quad \text{Nm} \quad \text{See Formula 146-2} \]

\[ \text{Fai} \quad \text{Average axial load} \quad \text{N (kgf)} \quad \text{See Formula 146-3} \]

How to calculate average load

Average moment load Nm (kgfNm) and see Table 146-2
Average axial load N (kgf) and see Formula 146-3

Calculating life of input bearing

Calculate the bearing life according to Calculation Formula 132-5 and check the life.

\[ \text{Lli} = \frac{10^6}{60 \times \text{Ni} \text{av}} \times \left( \frac{\text{Cr}}{\text{Pci}} \right)^3 \]

Lli Life Hour —
Ni av Average input speed rpm See Formula 146-4
Cr Basic dynamic load rating N (kgf) See Table 145-1 and -3
Pci Dynamic equivalent load N See Table 146-1 and -2

Dynamic equivalent load

<table>
<thead>
<tr>
<th>Size</th>
<th>Pci</th>
<th>HPG</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>0.444 x Mli av + 1.426 x Fai av</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>0.137 x Mli av + 1.232 x Fai av</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>0.109 x Mli av + 1.232 x Fai av</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>0.071 x Mli av + 1.232 x Fai av</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>0.053 x Mli av + 1.232 x Fai av</td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>0.041 x Mli av + 1.232 x Fai av</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Size</th>
<th>Pci</th>
<th>HPF</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>121 x Mli av + 2.7 x Fai av</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>106 x Mli av + 2.7 x Fai av</td>
<td></td>
</tr>
</tbody>
</table>

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.
- *3 Allowable radial load (Frc) Allowable moment load (Mc) Allowable axial load (Fac)
**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 147-1

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.

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

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

---

**Bolt tightening torque**

<table>
<thead>
<tr>
<th>Bolt size</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M8</th>
<th>M10</th>
<th>M12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tightening torque</td>
<td>Nm</td>
<td>2.0</td>
<td>4.5</td>
<td>9.0</td>
<td>15.3</td>
<td>37.2</td>
<td>73.5</td>
</tr>
<tr>
<td></td>
<td>kgfm</td>
<td>0.20</td>
<td>0.46</td>
<td>0.92</td>
<td>1.56</td>
<td>3.8</td>
<td>7.5</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 (HPG helical). Tighten the screws to the tightening torque specified below.

<table>
<thead>
<tr>
<th>Bolt size</th>
<th>M3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tightening torque</td>
<td>Nm</td>
</tr>
<tr>
<td></td>
<td>kgfm</td>
</tr>
</tbody>
</table>

---

**Bolt tightening torque**

<table>
<thead>
<tr>
<th>Bolt size</th>
<th>M2.5</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M8</th>
<th>M10</th>
<th>M12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tightening torque</td>
<td>Nm</td>
<td>0.59</td>
<td>1.4</td>
<td>3.2</td>
<td>6.3</td>
<td>10.7</td>
<td>26.1</td>
<td>51.5</td>
</tr>
<tr>
<td></td>
<td>kgfm</td>
<td>0.06</td>
<td>0.14</td>
<td>0.32</td>
<td>0.64</td>
<td>1.09</td>
<td>2.66</td>
<td>5.25</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.

---

**Figure 147-1**
### 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 148-1**

<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 (Nm)</td>
<td>1.4</td>
<td>6.3</td>
<td>10.7</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.

**Table 148-2**

<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>Number of bolts</td>
<td>4</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Bolt size</td>
<td>M4</td>
<td>M4</td>
<td>M6</td>
<td>M6</td>
<td>M8</td>
<td>M12</td>
</tr>
<tr>
<td>Mounting PCD (mm)</td>
<td>18</td>
<td>30</td>
<td>45</td>
<td>60</td>
<td>90</td>
<td>120</td>
</tr>
<tr>
<td>Tightening torque (Nm)</td>
<td>4.5</td>
<td>4.5</td>
<td>15.3</td>
<td>37.2</td>
<td>128.4</td>
<td>319</td>
</tr>
<tr>
<td>Transmission torque (kgf·m)</td>
<td>0.46</td>
<td>0.46</td>
<td>1.56</td>
<td>3.8</td>
<td>13.1</td>
<td>32.5</td>
</tr>
</tbody>
</table>

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

**Table 148-3**

<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>Number of bolts</td>
<td>3</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>14</td>
<td>6</td>
</tr>
<tr>
<td>Bolt size</td>
<td>M4</td>
<td>M4</td>
<td>M6</td>
<td>M6</td>
<td>M8</td>
<td>M8</td>
</tr>
<tr>
<td>Mounting PCD (mm)</td>
<td>18</td>
<td>30</td>
<td>45</td>
<td>60</td>
<td>100</td>
<td>120</td>
</tr>
<tr>
<td>Tightening torque (Nm)</td>
<td>4.5</td>
<td>4.5</td>
<td>15.3</td>
<td>37.2</td>
<td>37.2</td>
<td>319</td>
</tr>
<tr>
<td>Transmission torque (kgf·m)</td>
<td>0.46</td>
<td>0.46</td>
<td>1.56</td>
<td>3.8</td>
<td>3.8</td>
<td>32.5</td>
</tr>
</tbody>
</table>

* Recommended bolts: JIS B 1176 “Hexagon socket head bolts.” Strength classification 12.9 or higher in JIS B 1051.
The allowable radial load of HPG series is the value of a radial load applied at the mid-point of the input shaft.

### Specification of input bearing

<table>
<thead>
<tr>
<th>Size</th>
<th>Size</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>20</td>
<td>32</td>
</tr>
<tr>
<td>32</td>
<td>32</td>
<td></td>
</tr>
</tbody>
</table>

### Checking procedure

- Maximum radial load \( F_{ri} \)
- Maximum axial load \( F_{ai} \)
- Maximum moment load \( M_{i} \)
- Average axial load \( F_{ai} \)

#### Calculate:

\[
F_{ri} = 44.4 \text{ Nm}
\]

\[
F_{ai} = 210 \text{ kgf}
\]

\[
M_{i} = 51000 \text{ Nm}
\]

### Basic load rating

<table>
<thead>
<tr>
<th>Basic dynamic load rating ( C_{r} )</th>
<th>Basic static load rating ( C_{r} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.016 kgfm</td>
<td>9.88 kgfm</td>
</tr>
</tbody>
</table>

### Table 145-3

<table>
<thead>
<tr>
<th>Maximum radial load ( F_{ri} )</th>
<th>Maximum axial load ( F_{ai} )</th>
<th>Maximum moment load ( M_{i} )</th>
<th>Average axial load ( F_{ai} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>8600 N</td>
<td>5540 N</td>
<td>25100 N</td>
<td>1970 N</td>
</tr>
<tr>
<td>3263 N</td>
<td>123 N</td>
<td>320 N</td>
<td></td>
</tr>
<tr>
<td>333 N</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 145-2

<table>
<thead>
<tr>
<th>Maximum radial load ( F_{ri} )</th>
<th>Maximum axial load ( F_{ai} )</th>
<th>Maximum moment load ( M_{i} )</th>
<th>Average axial load ( F_{ai} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>84 N</td>
<td>287 N</td>
<td>867 N</td>
<td>3067 N</td>
</tr>
<tr>
<td>29.3 N</td>
<td>88.5 N</td>
<td>313 N</td>
<td>763 N</td>
</tr>
<tr>
<td>5267 N</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>53.2 N</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 149-3

<table>
<thead>
<tr>
<th>Bolt* tightening torque for output flange (Part B in Figure 148-1) CSG-GH</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
</tr>
<tr>
<td>Number of bolts</td>
</tr>
<tr>
<td>Bolt size</td>
</tr>
<tr>
<td>Mounting PCD mm</td>
</tr>
<tr>
<td>Tightening torque Nm</td>
</tr>
<tr>
<td>kgf</td>
</tr>
<tr>
<td>Transmission torque Nm</td>
</tr>
<tr>
<td>kgf</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bolt* tightening torque for output flange (Part B in Figure 148-1) CSF-GH</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
</tr>
<tr>
<td>Number of bolts</td>
</tr>
<tr>
<td>Bolt size</td>
</tr>
<tr>
<td>Mounting PCD mm</td>
</tr>
<tr>
<td>Tightening torque Nm</td>
</tr>
<tr>
<td>kgf</td>
</tr>
<tr>
<td>Transmission torque Nm</td>
</tr>
<tr>
<td>kgf</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bolt* tightening torque for output flange (Part B in Figure 148-1) HPF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
</tr>
<tr>
<td>Number of bolts</td>
</tr>
<tr>
<td>Bolt size</td>
</tr>
<tr>
<td>Mounting PCD mm</td>
</tr>
<tr>
<td>Tightening torque Nm</td>
</tr>
<tr>
<td>kgf</td>
</tr>
<tr>
<td>Transmission torque Nm</td>
</tr>
<tr>
<td>kgf</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.
**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.

---

**Output Flange: F0 (flange)**

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

---

### Table 145-1

<table>
<thead>
<tr>
<th>Size</th>
<th>Axial runout of output flange a</th>
<th>Radial runout of output flange pilot or output shaft b</th>
<th>Perpendicularity of mounting flange c</th>
<th>Concentricity of mounting flange d</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>0.020</td>
<td>0.030</td>
<td>0.050</td>
<td>0.040</td>
</tr>
<tr>
<td>14</td>
<td>0.020</td>
<td>0.040</td>
<td>0.060</td>
<td>0.050</td>
</tr>
<tr>
<td>20</td>
<td>0.020</td>
<td>0.040</td>
<td>0.060</td>
<td>0.050</td>
</tr>
<tr>
<td>32</td>
<td></td>
<td>0.060</td>
<td></td>
<td>0.050</td>
</tr>
</tbody>
</table>

### Table 150-2

<table>
<thead>
<tr>
<th>Size</th>
<th>Axial runout of output flange a</th>
<th>Radial runout of output flange pilot or output shaft b</th>
<th>Perpendicularity of mounting flange c</th>
<th>Concentricity of mounting flange d</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>0.020</td>
<td>0.040</td>
<td>0.060</td>
<td>0.050</td>
</tr>
<tr>
<td>65</td>
<td></td>
<td>0.080</td>
<td></td>
<td>0.080</td>
</tr>
</tbody>
</table>

### Table 150-3

<table>
<thead>
<tr>
<th>Size</th>
<th>Axial runout of output flange a</th>
<th>Radial runout of output flange pilot or output shaft b</th>
<th>Perpendicularity of mounting flange c</th>
<th>Concentricity of mounting flange d</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>0.020</td>
<td>0.040</td>
<td>0.060</td>
<td>0.050</td>
</tr>
<tr>
<td>65</td>
<td></td>
<td>0.060</td>
<td></td>
<td>0.050</td>
</tr>
</tbody>
</table>

### Table 150-4

<table>
<thead>
<tr>
<th>Size</th>
<th>Axial runout of output flange a</th>
<th>Radial runout of output flange pilot or output shaft b</th>
<th>Perpendicularity of mounting flange c</th>
<th>Concentricity of mounting flange d</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>0.020</td>
<td>0.040</td>
<td>0.060</td>
<td>0.050</td>
</tr>
<tr>
<td>32</td>
<td></td>
<td>0.060</td>
<td></td>
<td>0.050</td>
</tr>
</tbody>
</table>

* T.I.R.: Total indicator reading (T.I.R.* Unit: mm)
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 plug in the adapter flange is facing upwards.

(CSG/CSF-GH Series)
- Contact us when using HarmonicDrive® CSG/CSF-GH series with the output shaft facing downward (motor on top) at a constant load or rotating continuously in one direction.

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 65 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

(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.

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

**Harmonic Grease SK-2** (HPG/HPG-14, 20, 32)
Manufacturer: Harmonic Drive Systems Inc.

| Base oil: | Refined mineral oil |
| Thickening agent: | Lithium soap |
| Additive: | Extreme pressure agent |

Other Standard: NLGI No. 2

Consistency: 265 to 295 at 25°C
Color: Green

**EPNOC Grease AP (N) 2** (HPG/HPG-11, 50, 65, /HPF-25, 32)
Manufacturer: Nippon Oil Co.

| Base oil: | Refined mineral oil |
| Thickening agent: | Lithium soap |
| Additive: | Extreme pressure agent |

Other Standard: NLGI No. 2

Consistency: 282 at 25°C
Color: Light brown

**PYRONOC UNIVERSAL 00** (HPG right angle gearhead/HPN)
Manufacturer: Nippon Oil Co.

| Base oil: | Refined mineral oil |
| Thickening agent: | Urea |

Other Standard: NLGI No. 00

Consistency: 420 at 25°C
Color: Light yellow

**MULTEMP AC-P** (HPG-X-R)
Manufacturer: KYODO YUSHI CO., LTD

| Base oil: | Composite hydrocarbon oil and diester |
| Thickening agent: | Lithium soap |
| Additive: | Extreme pressure |

Other Standard: NLGI No. 2

Consistency: 280 at 25°C
Color: Black viscose

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.
CSG-GH/CSF-GH Series

The standard lubrication for the CSG-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**

**Harmonic Grease SK-1A** (Size 20, 32, 45, 65)  
Manufacturer: Harmonic Drive Systems Inc.  
This grease has been developed exclusively for HarmonicDrive® gears and is excellent in durability and efficiency compared to commercial general-purpose grease.

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

**Harmonic Grease SK-2** (Size 14)  
Manufacturer: Harmonic Drive Systems Inc.  
This grease has been developed exclusively for smaller sized HarmonicDrive® gears and allows smooth wave generator rotation.

- **Base oil:** Refined mineral oil  
- **Thickening Agent:** Lithium soap  
- **Additive:** Extreme pressure agent and other  
- **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**

\[
L_{10} = L_{10n} \times \left( \frac{T_{av}}{T_{av}} \right)^3
\]

**Formula symbols**

- \(L_{10}\): Grease change interval when \(T_{av} > T\)  
- \(L_{10n}\): Grease change interval when \(T_{av} = Tr\)  
- \(Tr\): Output torque at 2000 rpm (Nm, kgf-m)  
- \(T_{av}\): Average load torque (Nm, kgf-m)

**Precautions when changing the grease**

Strictly observe the following instructions when changing the grease to avoid problems such as grease leakage or increase in running torque.

- **Note that the amount of grease listed in Table 152-2 is the amount used to lubricate the gear at assembly. This should be used as a reference. Do not exceed this amount when re-greasing the gearhead.**

- **Remove grease from the gearhead and refill it with the same quantity. The adverse effects listed above normally do not occur until the gear has been re-greased 2 times. When re-greasing 3 times or more, it is essential to remove grease (using air pressure or other means) before re-lubricating with the same amount of grease that was removed.**

---

**Product Handling**

**LGT**

See the "Rating table" on pages 77 & 87.

**Reference values for grease refill amount**

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

---

**Technical Data**

**Input Bearing Specifications and Checking Procedure**

**Table 145-1** and **Table 145-3**

**Table 146-1** and **Table 146-2**

**Table 146-3**

**Formula 146-1**

**Formula 146-2**

**Formula 146-3**

**Formula 146-4**

**Formula 146-5**

**Table 152-1**

**Table 152-2**

**Figure 146-1**
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.

(1) Rubber parts: Oil seals, seal packings, rubber caps, seals of shielded bearings on input side (D type only)
(2) Aluminum parts: Housings, motor flanges
(3) 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
- Equipment and apparatus that directly works on human bodies
- Medical equipment

Please consult Harmonic Drive LLC beforehand if intending to use one of 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: Be certain to read the catalog when designing the equipment.

Operational Precaution: Be certain to read the catalog before operating the equipment.

Handling Lubricant

Precautions on handling lubricants

- Lubricant in the eye can cause inflammation. Wear protective glasses to prevent it from getting into your eyes.
- 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.

First-aid

- Inhalation: Remove exposed person to fresh air if adverse effects are observed.
- 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

- 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

- Please dispose of as industrial waste.
- Please dispose of the products as industrial waste when their useful life is over.
Technical Data

Size 65:

- Gearhead: CSG-GH
- CSF-GH

Input rotational speed:

- 500 rpm
- 1000 rpm
- 2000 rpm
- 3500 rpm

Graphs:

Graph 139-1

Graph 139-2

Graph 139-3

Graph 139-4

Efficiency %

Input torque (Ncm)

Reduction ratio:

- 100
- 160
- 120
- 80
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
- Robotics
- Humanoid 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: Courtesy of Haliburton/Sperry Drilling Services
- Source: Honda Motor Co., Ltd.
Experts in Precision Motion Control

Other Products

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

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

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

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