HarmonicPlanetary®
HPF Hollow Shaft Gear Unit

Size
25, 32

Peak torque
Size 25: 100Nm, Size 32: 220Nm

Reduction ratio
11:1

Low backlash
Standard: <3 arc-min  Low Backlash for Life
innovative ring gear automatically adjusts for backlash, ensuring consistent, low backlash for the life of the gearhead. The ring gear design automatically provides the optimum backlash in the planetary gear train and maintains the same low backlash for the life of the gearhead.

Inside diameter of the hollow shaft
Size 25: Ø25mm  Size 32: Ø30mm

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.

Based on Harmonic Planetary® gearhead design concept, the hollow shaft planetary features the same superior performance and specifications as the HPG line. The large hollow shaft allows cables, pipes, or shafts to pass directly through the axis of rotation, simplifying the design and improving reliability.

<table>
<thead>
<tr>
<th>Model Name</th>
<th>Size</th>
<th>Design</th>
<th>Reduction Ratio</th>
<th>Output Configuration</th>
<th>Input Configuration</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPF Hollow Shaft</td>
<td>25</td>
<td>A</td>
<td>11</td>
<td>F0: Flange output</td>
<td>U1: Hollow shaft type</td>
<td>None: Standard item SP: Special specification</td>
</tr>
<tr>
<td>HPF Hollow Shaft</td>
<td>32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Gearhead Construction

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Rating Table

The HPF hollow shaft planetary gear features a large hollow shaft that allows cables, shafts, ball screws or lasers to pass directly through the axis of rotation.

<table>
<thead>
<tr>
<th>Size</th>
<th>Ratio</th>
<th>Rated Torque at 2000 rpm</th>
<th>Rated Torque at 3000 rpm</th>
<th>Limit for Repeated Peak Torque</th>
<th>Limit for Momentary Torque</th>
<th>Max. Average Input Speed</th>
<th>Max. Input Speed</th>
<th>Input Moment of Inertia</th>
<th>Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>11</td>
<td>48</td>
<td>21</td>
<td>100</td>
<td>170</td>
<td>3000</td>
<td>3000</td>
<td>1.63</td>
<td>3.8</td>
</tr>
<tr>
<td>32</td>
<td>11</td>
<td>100</td>
<td>44</td>
<td>220</td>
<td>450</td>
<td>3000</td>
<td>4800</td>
<td>3.84</td>
<td>7.2</td>
</tr>
</tbody>
</table>

*1: Rated torque is based on L10 life of 20,000 hours when input speed is 2000 rpm
*2: Rated torque is based on L10 life of 20,000 hours when input speed is 3000 rpm
*3: The limit for torque during start and stop cycles.
*4: The limit for torque during emergency stops or from external shock loads. Always operate below this value. Calculate the number of permissible events to ensure it meets required operating conditions.
*5: Maximum instantaneous input speed.
*6: Maximum instantaneous input speed.

Performance Table

<table>
<thead>
<tr>
<th>Size</th>
<th>Reduction ratio</th>
<th>Accuracy (°)</th>
<th>Repeatability (°)</th>
<th>Starting torque</th>
<th>Backdriving torque</th>
<th>No-load running torque</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>arc min</td>
<td>x10° rad</td>
<td>Ncm kgf cm</td>
<td>Nm kgfm</td>
<td>Ncm kgf cm</td>
</tr>
<tr>
<td>25</td>
<td>11</td>
<td>4</td>
<td>11.6</td>
<td>±15</td>
<td>59</td>
<td>6.0</td>
</tr>
<tr>
<td>32</td>
<td>11</td>
<td>4</td>
<td>11.6</td>
<td>±15</td>
<td>75</td>
<td>7.7</td>
</tr>
</tbody>
</table>

*1: Accuracy values represent the difference between the theoretical angle and the actual angle of output for any given input. The values 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.
*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.
Backlash and Torsional Stiffness

### HPF Hollow Shaft Unit

<table>
<thead>
<tr>
<th>Size</th>
<th>Reduction Ratio</th>
<th>Backlash arc min</th>
<th>Torsion angle at TR X 0.15 D</th>
<th>Torsional stiffness A/B kgf/arc min</th>
<th>( x_{10} ) rad</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>11</td>
<td>3.0</td>
<td>2.0</td>
<td>1.7</td>
<td>570</td>
</tr>
<tr>
<td>32</td>
<td>11</td>
<td>3.0</td>
<td>1.7</td>
<td>4.9</td>
<td>1173</td>
</tr>
</tbody>
</table>

**Torsional stiffness curve**

With the input of the gear locked in place, a torque applied to the output flange will torsionally deflect in proportion to the applied torque. We generate a torsional stiffness curve by slowly applying torque to the output in the following sequence:

1. Clockwise torque to TR
2. Return to Zero
3. Counter-Clockwise torque to -TR
4. Return to Zero
5. Again Clockwise torque to TR

A loop of (1) > (2) > (3) > (4) > (5) will be drawn as in Fig. 096-1. The torsional stiffness in the region from “zero torque” to “TR” is calculated using the average value of this slope. The torsional stiffness in the region from “TR” to “0.15 x TR” is lower. This is caused by the small amount of backlash plus engagement of the mating parts and loading of the planet gears under the initial torque applied.

**Calculation of total torsion angle**

The method to calculate the total torsion angle (average value) on one side when the speed reducer applies a load in a no-load state.

**Calculation formula**

\[ \theta = D + \frac{T - T_l}{A/B} \]

- \( \theta \): Total torsion angle
- \( D \): Torsion angle on one side \( \theta \) at output torque x 0.15 torque See Fig. 096-1, Table 096-1
- \( T \): Load torque
- \( T_l \): Output torque x 0.15 torque \( (= TR \times 0.15) \) See Fig. 096-1
- \( A/B \): Torsional stiffness See Fig. 096-1, Table 096-1

**Backlash (Hysteresis Loss)**

The vertical distance between points (2) & (4) in Fig. 096-1 is called a hysteresis loss. The hysteresis loss between “Clockwise load torque TR” and “Counter Clockwise load torque -TR” is defined as the backlash of the HPF series. The backlash of the HPF series is less than 3 arc-min (1 arc-min or less is also available.).
Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions. For the specifications of the input side bearing of the hollow shaft gear unit, refer to page 133.

HPF-25 Outline Dimensions

Figure 097-1

(Unit: mm)

12-Ø4.5
12-M4x8
(For mounting output load)

6-M4x5.5
(Use caution regarding bolt length and interference)

12-Ø5.5
12-M5x8
(For mounting output load)

6-M4x6
(Use caution regarding bolt length and interference)

(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. *1: The inside diameter of the hollow shaft rotates with the input shaft (high speed). Use these holes for installing a sleeve which rotates with the output side. (These holes are not for mounting the load).

HPF-32 Outline Dimensions

Figure 097-2

(Unit: mm)

12-Ø4.5
12-M4x8
(For mounting output load)

6-M4x5.5
(Use caution regarding bolt length and interference)

12-Ø5.5
12-M5x8
(For mounting output load)

6-M4x6
(Use caution regarding bolt length and interference)

(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. *1: The inside diameter of the hollow shaft rotates with the input shaft (high speed). Use these holes for installing a sleeve which rotates with the output side. (These holes are not for mounting the load).
### Product Sizing & Selection

To fully utilize the excellent performance of the HPF HarmonicPlanetary® gearheads, check your operating conditions and, using the flowchart, select the appropriate size gear for your application.

In general, a servo system rarely operates at a continuous load and speed. The input speed, load torque change and a comparatively large torque is applied during start and stop. Unexpected impact torques may also be applied.

Check your operating conditions against the following load torque pattern and select a suitable size based on the flowchart shown on the right. Also check the life and static safety coefficient of the cross roller bearing and input side main bearing (input shaft type only).

#### Checking the load torque pattern

Review the load torque pattern. Check the specifications shown in the figure below.

![Graph 098-1](image)

**Obtain the value of each load torque pattern.**

| Load torque | T1 to Tn (Nm) |
| Time | t1 to tn (sec) |
| Output rotational speed | n1 to n0 (rpm) |

**<Normal operation pattern>**

- Starting: T1, t1, n1
- Steady operation: T2, t2, n2
- Stopping (slowing): T3, t3, n3
- Idle: T4, t4, n4

**<Maximum rotational speed>**

- Max. output rotational speed: no max \( \geq \) n1 to n0
- Max. input rotational speed: ni max \( \geq \) ni max + R
  (Restricted by motors)
- R: Reduction ratio

**<Impact torque>**

- When impact torque is applied: T5

**<Required life>**

\[ L_{10} = L \text{ (hours)} \]

If the expected operation will result in conditions where:

- Actual average load torque (Tav) \( > \) Permissible maximum value of average load torque or
- Actual average input rotational speed (ni av) \( > \) Permissible average input rotational speed (ni)

then please check its effect on the speed reducer temperature rise or other factors. Consider selecting the next larger speed reducer, reduce the operating loads or take other means to ensure safe use of the gear. Exercise caution especially when the duty cycle is close to continuous operation.

**Flowchart for selecting a size**

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

1. **Calculate the average load torque applied on the output side from the load torque pattern: Tav (Nm).**

\[ T_{av} = \frac{T_1 t_1 + T_2 t_2 + \ldots + T_n t_n}{(t_1 + t_2 + \ldots + t_n)} \]

2. **Calculate the average output speed based on the load torque pattern:**

\[ n_{av} = \frac{n_1 t_1 + n_2 t_2 + \ldots + n_n t_n}{(t_1 + t_2 + \ldots + t_n)} \]

3. **Make a preliminary model selection with the following conditions.**

- Tav \( \leq \) Max. output rotational speed no max (Restricted by motors).
- Tav \( \leq \) Max. output rotational speed (no max).
- ni av \( \leq \) Max. input rotational speed (ni max + R)

4. **Determine the reduction ratio (R) based on the maximum output rotational speed (no max) and maximum input rotational speed (ni max).**

\[ n_{max} = \frac{n_{max}}{n_{av}} \leq R \]

5. **Calculate the average input speed (ni av) from the average output speed (no av) and the reduction ratio (R):**

\[ n_{av} = \frac{n_{max}}{R} \]

6. **Check whether T1 and T3 are within peak torques (Nm) on start and stop in the rating table.**

- T1 \( \leq \) Tr max
- T3 \( \leq \) Tr max

7. **Review the operation conditions, size and reduction ratio.**

- Channel HPF series (Hollow Shaft Type)
- Channel HPG series (Input Shaft Type)

**Caution**

- If the expected operation will result in conditions where:
  - Actual average load torque (Tav) > Permissible maximum value of average load torque or
  - Actual average input rotational speed (ni av) > Permissible average input rotational speed (ni),

then please check its effect on the speed reducer temperature rise or other factors. Consider selecting the next larger speed reducer, reduce the operating loads or take other means to ensure safe use of the gear. Exercise caution especially when the duty cycle is close to continuous operation.
Review the load torque pattern. Check the specifications shown in the torque pattern and select a suitable size based on the load torque. Unexpected impact torques may also be applied. In general, a servo system rarely operates at a continuous torque. Using the flowchart, select the appropriate size gear for your application.

Output rotational speed

Load torque

Maximum rotational speed

Required life

Impact torque

When impact torque is applied

| Starting | T1 = 70 Nm, t1 = 0.3 sec, n1 = 60 rpm |
| Steady operation | T2 = 18 Nm, t2 = 3 sec, n2 = 120 rpm |
| Stopping (slowing) | T3 = 35 Nm, t3 = 0.4 sec, n3 = 60 rpm |
| Idle | T4 = 0 Nm, t4 = 5 sec, n4 = 0 rpm |

Calculate the average load torque applied to the output side based on the load torque pattern: $T_{av}$ (Nm).

$$T_{av} = \frac{1}{T_{av}} \left[ \frac{60rpm}{0.3sec} \times 70Nm + \frac{120rpm}{3sec} \times 18Nm + \frac{60rpm}{0.4sec} \times 35Nm \right]$$

Calculate the average output speed based on the load torque pattern: $n_{av}$ (rpm)

$$n_{av} = \frac{1}{n_{av}} \left[ \frac{60rpm}{0.3sec} + \frac{120rpm}{3sec} + \frac{60rpm}{0.4sec} + \frac{60rpm}{5sec} \right]$$

Make a preliminary model selection with the following conditions. $T_{av} = 30.2$ Nm $\leq 48$ Nm. (HPF-25A-11 is tentatively selected based on the average load torque (see the rating table on page 95) of size 25 and reduction ratio of 11.)

Determine a reduction ratio (R) from the maximum output speed (no max) and maximum input speed (ni max).

$$\frac{5,000 \text{ rpm}}{120 \text{ rpm}} = 41.7 \geq 11$$

Calculate the maximum input speed (ni max) from the maximum output speed (no max) and reduction ratio (R): $n_{i\text{ max}} = 120 \text{ rpm} \times 11 = 1,320$ rpm

Calculate the average input speed (ni av) from the average output speed (no av) and reduction ratio (R): $n_{i\text{ av}} = 46.2 \text{ rpm} \times 11 = 508$ rpm $\geq$ Max average input speed of size 25 3,000 rpm

Check whether the maximum input speed is equal to or less than the values specified in the rating table. $n_{i\text{ max}} = 1,320$ rpm $\leq 5,600$ rpm (maximum input speed of size 25)

Check whether $T_1$ and $T_3$ are within peak torques (Nm) on start and stop in the rating table. $T_1 = 70$ Nm $\leq 100$ Nm (Limit for repeated peak torque, size 25) $T_3 = 35$ Nm $\leq 100$ Nm (Limit for repeated peak torque, size 25)

Check whether $T_s$ is equal to or less than limit for momentary torque (Nm) in the rating table. $T_s = 120$ Nm $\leq 170$ Nm (momentary max. torque of size 25)

Calculate life and check whether the calculated life meets the requirement.

$$L_{10} = 20,000 \times \left( \frac{21 \text{ Nm}}{30.2 \text{ Nm}} \right) \times \left( \frac{3,000 \text{ rpm}}{508 \text{ rpm}} \right) = 35,182 \text{ hours} \geq 30,000 \text{ hours}$$

The selection of model number HPF-25A-11 is confirmed from the above calculations.
Planetary Gear Units

HPF Series - Hollow Shaft

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.

Based on Harmonic Planetary® gearhead design concept, the hollow shaft planetary features the same superior performance and specifications as the HPG line. The large hollow shaft allows cables, pipes, or shafts to pass directly through the axis of rotation, simplifying the design and improving reliability.

HPF Series - Hollow Shaft

<table>
<thead>
<tr>
<th>Model Name</th>
<th>Size</th>
<th>Design</th>
<th>Revision</th>
<th>Reduction Ratio</th>
<th>Output Configuration</th>
<th>Input Configuration</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPF 25 A 11 F0</td>
<td>25</td>
<td>SP1</td>
<td>U1</td>
<td>11:1</td>
<td>SP</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>HPF 32 A 11 F0</td>
<td>32</td>
<td>SP1</td>
<td>U1</td>
<td>11:1</td>
<td>SP</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

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### Output Bearing Specifications and Checking Procedure

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 load moment load (M_{max})**
   
   Obtain the maximum load moment load (M_{max}).
   
   $\text{Maximum load moment load (M}_{\text{max}}) \leq \text{Permissible moment (M)}$

2. **Checking the life**
   
   Obtain the average radial load (F_{av}) and the average axial load (F_{aav}).
   
   $\text{Check the maximum load and life of the bearing on the input side if the reducer is an HPG input shaft unit or an HPF hollow shaft unit.}$

3. **Checking the static safety coefficient**
   
   Obtain the static equivalent radial load coefficient (Po).
   
   $\text{Check the static safety coefficient (fs)}$

#### Specification of output bearing

**HPF Series**  
Table 130-2 indicates the specifications for cross roller bearing.

<table>
<thead>
<tr>
<th>Size</th>
<th>Pitch circle dp</th>
<th>Offset amount R</th>
<th>Basic load rating</th>
<th>Allowable moment load M_{c} \times 10^3</th>
<th>Moment stiffness K_{m}</th>
<th>Allowable axial load L_{ri}</th>
<th>Allowable radial load L_{ri}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>m</td>
<td>m</td>
<td>N</td>
<td>N</td>
<td>kgf</td>
<td>kgf</td>
<td>kgf</td>
</tr>
<tr>
<td>25</td>
<td>0.085</td>
<td>0.0153</td>
<td>11400</td>
<td>2071</td>
<td>410</td>
<td>41.8</td>
<td>37.9</td>
</tr>
<tr>
<td>32</td>
<td>0.1115</td>
<td>0.015</td>
<td>22500</td>
<td>4071</td>
<td>932</td>
<td>95</td>
<td>86.1</td>
</tr>
</tbody>
</table>

*1 The basic dynamic load rating means a certain static radial load so that the basic dynamic rated life of the roller bearing is a million rotations.

*2 The basic static load rating means a static load that gives a certain level of contact stress (4kN/mm²) in the center of the contact area between rolling element receiving the maximum load and orbit.

*3 The allowable moment load is a maximum moment load applied to the bearing. Within the allowable range, basic performance is maintained and the bearing is operable. Check the bearing life based on the calculations shown on the next page.

*4 The value of the moment stiffness is the average value.

*5 The allowable radial load and allowable axial load are the values that satisfy the life of a speed reducer when a pure radial load or an axial load applies to the main bearing. (Lr + R = 0 mm for radial load and L = 0 mm for axial load) If a compound load applies, refer to the calculations shown on the next page.
How to calculate the maximum load moment load

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

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

Where:
- \( F_r \) is the max. radial load (N (kgf))
- \( F_a \) is the max. axial load (N (kgf))
- \( L_r \) is the max. load radial load (N (kgf))
- \( L_a \) is the max. load axial load (N (kgf))

\[ F_r = F_{r1} + F_{r2} + \cdots + F_{r4} \]
\[ F_a = F_{a1} + F_{a2} + \cdots + F_{a4} \]

How to calculate the radial load coefficient and the axial load coefficient

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

<table>
<thead>
<tr>
<th>Formula</th>
<th>X</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>( F_{a\text{av}} = \frac{F_{r \text{av}} + 2(F_{r \text{av}}(L_r + R) + F_{a \text{av}} - L_a)}{dp} )</td>
<td>1</td>
<td>0.45</td>
</tr>
<tr>
<td>( F_{a\text{av}} = \frac{F_{r \text{av}} + 2(F_{r \text{av}}(L_r + R) + F_{a \text{av}} - L_a)}{dp} )</td>
<td>&gt;1.5</td>
<td>0.67</td>
</tr>
</tbody>
</table>

Where:
- \( F_{r \text{av}} \) is the average radial load (N (kgf))
- \( F_{a \text{av}} \) is the average axial load (N (kgf))
- \( L_r \) is the max. load radial load (N (kgf))
- \( L_a \) is the max. load axial load (N (kgf))
- \( R \) is the offset amount (m)
- \( dp \) is the circular pitch of roller (m)

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

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

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

\[
F_{r \text{av}} = \sqrt{\frac{n_1 F_{r1}^{10/3} + n_2 F_{r2}^{10/3} + n_3 F_{r3}^{10/3} + n_4 F_{r4}^{10/3}}{n_1 + n_2 + n_3 + n_4}}
\]

Note that the maximum axial load within the \( t_1 \) section is \( F_{r1} \) and the maximum axial load within the \( t_2 \) section is \( F_{r2} \).

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

\[
F_{a \text{av}} = \sqrt{\frac{n_1 F_{a1}^{10/3} + n_2 F_{a2}^{10/3} + n_3 F_{a3}^{10/3} + n_4 F_{a4}^{10/3}}{n_1 + n_2 + n_3 + n_4}}
\]

Note that the maximum axial load within the \( t_1 \) section is \( F_{a1} \) and the maximum axial load within the \( t_2 \) section is \( F_{a2} \).

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

\[
N_{\text{av}} = \frac{n_1 + n_2 + n_3 + n_4}{t_1 + t_2 + t_3}
\]
How to calculate the life

Calculate the life of the cross roller bearing using Formula 132-1. You can obtain the dynamic equivalent radial load (Pc) using Formula 132-2.

Formula 132-1
\[ L_0 = \frac{10^6}{60 \times N_{av}} \times \left( \frac{C}{f_w \times P_c} \right)^{1/3} \]

- \( L_0 \): Life, hour
- \( N_{av} \): Average output speed, rpm
- \( C \): Basic dynamic rated load, N (kgf)
- \( P_c \): Dynamic equivalent radial load, N (kgf)
- \( f_w \): 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>

Formula 132-2
\[ P_c = X \left( \frac{F_{av}}{2} \left( F_{av} (L_r + R) + F_{av} \cdot L_a \right) \right) \times \frac{Y}{f_w \times P_c} + \frac{Y}{f_w \times P_c} \]

- \( P_c \): Circular pitch of roller, m
- \( X \): Radial load coefficient
- \( Y \): Axial load coefficient

How to calculate the average moment load (\( \frac{M_{max}}{2} \))

Calculate the life of the cross roller bearing during oscillating movement by Formula 132-3.

Formula 132-3
\[ \frac{L_{oc}}{N_{t1}} \times \frac{90}{\theta} \times \left( \frac{C}{f_w \times P_c} \right)^{1/3} \]

- \( L_{oc} \): Rated life under oscillating movement, hour
- \( N_{t1} \): No. of reciprocating oscillation per min, rpm
- \( C \): Basic dynamic rated load, N (kgf)
- \( P_c \): Dynamic equivalent radial load, N (kgf)
- \( f_w \): Load coefficient
- \( \theta \): Oscillating angle (°), Deg.

<table>
<thead>
<tr>
<th>Load status</th>
<th>( f_s )</th>
</tr>
</thead>
<tbody>
<tr>
<td>When high rotation 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>

Note: When used for a long time while the rotation speed of the output shaft is in the ultra-low operation range (0.02 rpm or less), the lubrication of the bearing becomes insufficient, resulting in deterioration of the bearing or increased load in the driving side. When using it in the ultra-low operation range, contact us.

How to calculate the static safety coefficient

In general, the basic static rated load (Co) is considered to be the permissible limit of the static equivalent load. However, obtain the limit based on the operating and required conditions. Calculate the static safety coefficient \( (f_s) \) of the cross roller bearing using Formula 132-4.

Formula 132-4
\[ f_s = \frac{C_o}{P_o} \]

- \( C_o \): Basic static rated load, N (kgf)
- \( P_o \): Static equivalent radial load, N (kgf)

<table>
<thead>
<tr>
<th>Load status</th>
<th>( f_s )</th>
</tr>
</thead>
<tbody>
<tr>
<td>When high rotation 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**

1. **Checking maximum load**
   - Calculate:
     - Maximum load moment load \((M_{i\text{ max}})\)
     - Maximum load axial load \((F_{i\text{ max}})\)
     - Maximum load radial load \((F_{i\text{ max}})\)
   - \(M_{i\text{ max}} \leq \text{Permissible moment load (Mc)}\)
   - \(F_{i\text{ max}} \leq \text{Permissible axial load (Fac)}\)
   - \(F_{i\text{ max}} \leq \text{Permissible radial load (Frc)}\)

2. **Checking the life**
   - Calculate:
     - Average moment load \((M_{i\text{ av}})\)
     - Average axial load \((F_{i\text{ av}})\)
     - Average input speed \((N_{i\text{ av}})\)
   - Calculate the life and check it.

### Specification of input shaft bearing

The specification of the input side main bearing of the input shaft unit is shown below.

#### HPG

<table>
<thead>
<tr>
<th>Size</th>
<th>Basic dynamic rated load Cr</th>
<th>Basic static rated load Cor</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>kgf</td>
<td>N</td>
</tr>
<tr>
<td>11</td>
<td>2700</td>
<td>275</td>
</tr>
<tr>
<td>14</td>
<td>5800</td>
<td>590</td>
</tr>
<tr>
<td>20</td>
<td>9700</td>
<td>990</td>
</tr>
<tr>
<td>32</td>
<td>22500</td>
<td>2300</td>
</tr>
<tr>
<td>50</td>
<td>35500</td>
<td>3600</td>
</tr>
<tr>
<td>65</td>
<td>51000</td>
<td>5200</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Size</th>
<th>Allowable moment load Mc</th>
<th>Allowable axial load Fac</th>
<th>Allowable radial load Frc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nm</td>
<td>kgfm</td>
<td>N</td>
<td>kgf</td>
</tr>
<tr>
<td>11</td>
<td>0.16</td>
<td>0.016</td>
<td>245</td>
</tr>
<tr>
<td>14</td>
<td>6.3</td>
<td>0.64</td>
<td>657</td>
</tr>
<tr>
<td>20</td>
<td>13.5</td>
<td>1.38</td>
<td>1206</td>
</tr>
<tr>
<td>32</td>
<td>44.4</td>
<td>4.53</td>
<td>3285</td>
</tr>
<tr>
<td>50</td>
<td>96.5</td>
<td>9.88</td>
<td>5540</td>
</tr>
<tr>
<td>65</td>
<td>210</td>
<td>21.4</td>
<td>8600</td>
</tr>
</tbody>
</table>

#### HPF

<table>
<thead>
<tr>
<th>Size</th>
<th>Basic dynamic rated load Cr</th>
<th>Basic static rated load Cor</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>kgf</td>
<td>N</td>
</tr>
<tr>
<td>25</td>
<td>14500</td>
<td>1480</td>
</tr>
<tr>
<td>32</td>
<td>29700</td>
<td>3030</td>
</tr>
</tbody>
</table>

### Table 133-2

<table>
<thead>
<tr>
<th>Size</th>
<th>Allowable moment load Mc</th>
<th>Allowable axial load Fac</th>
<th>Allowable radial load Frc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nm</td>
<td>kgfm</td>
<td>N</td>
<td>kgf</td>
</tr>
<tr>
<td>25</td>
<td>10</td>
<td>1.02</td>
<td>1538</td>
</tr>
<tr>
<td>32</td>
<td>19</td>
<td>1.83</td>
<td>3260</td>
</tr>
</tbody>
</table>

(Note: Table 133-2 and 133-4)

1. The allowable axial load is the tolerance of an axial load applied to the shaft center.
2. The allowable radial load of HPG series is the tolerance of a radial load applied to the shaft length center.
3. The allowable radial load of HPG series is the tolerance of a radial load applied to the point of 20 mm from the shaft edge (input flange edge).
Calculating maximum load moment load to input shaft

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

\[ Mi_{\text{max}} = Fri_{\text{max}} \cdot Lri + Fai_{\text{max}} \cdot Lai \]

- \( Fri_{\text{max}} \) Max. radial load N (kgf) See Fig. 134-1.
- \( Fai_{\text{max}} \) Max. axial load N (kgf) See Fig. 134-1.
- \( Lri, Lai \) — — m See Fig. 134-1.

\( Mi_{\text{max}} \leq Mc \) (Permissible moment load)
\( Fai_{\text{max}} \leq Fac \) (Permissible axial load)

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

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

Formula 134-2

\[ Mi_{\text{av}} = 
\frac{n t_{1} (|M_{1}|)^{3} + n t_{2} (|M_{2}|)^{3} + \cdots + n t_{n} (|M_{n}|)^{3}}{n t_{1} + n t_{2} + \cdots + n t_{n}} \]

How to calculate the average axial load (Fai av)

\[ Fai_{\text{av}} = 
\frac{n t_{1} (|Fai|)^{3} + n t_{2} (|Fai|)^{3} + \cdots + n t_{n} (|Fai|)^{3}}{n t_{1} + n t_{2} + \cdots + n t_{n}} \]

How to calculate the average output rotational frequency (Ni av)

\[ Ni_{\text{av}} = \frac{n t_{1} + n t_{2} + \cdots + n t_{n}}{t_{1} + t_{2} + \cdots + t_{n}} \]

Calculating life of input side bearing

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

Formula 134-5

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

- \( Ni_{\text{av}} \) Average input rotational speed rpm See Formula 134-4
- \( Cr \) Basic dynamic rated load N (kgf) See Table 133-1 and -3
- \( Pci \) Dynamic equivalent radial load N See Table 134-1 and -2

Dynamic equivalent radial load

**HPG**

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

**HPF**

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