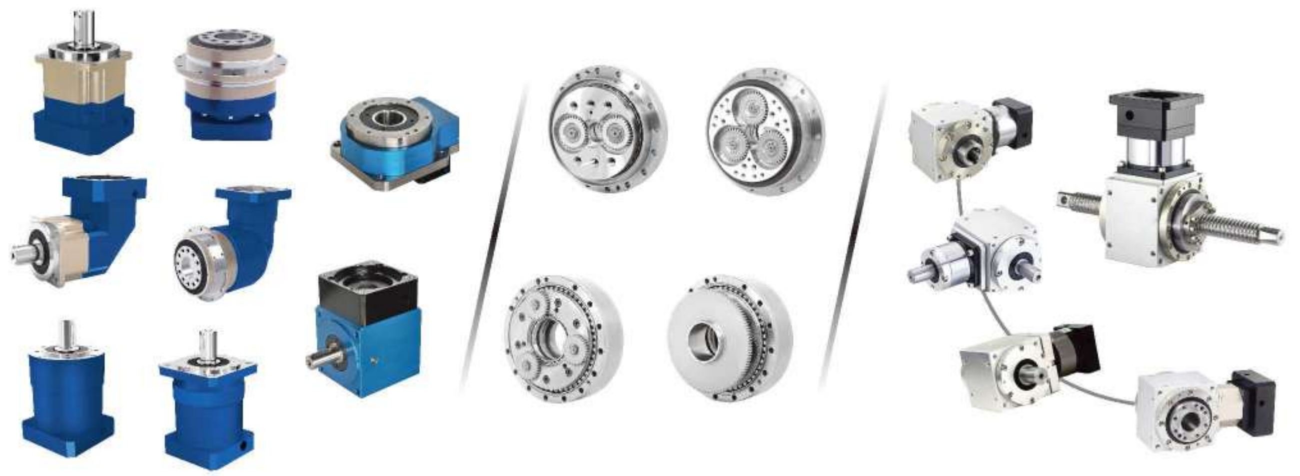
Fenghua Technology Servo Precision Reducer Products



Planetary Gearbox RV Reducer 90 Degree Right Angle Gearbox

Fenghua Transmission is committed to offering you quality products
Specializing in R & D and production of various precision planetary gear transmission products
Free service hotline: 400-8040-668
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3F FAMED®

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3F FAMED

Fenghua Transmission Technology (Shanghai) Co.,Ltd.

Fenghua Transmission Technology (Jiangsu) Co.,Ltd.

Stepper/servo motor driving (for robot industry)

Harmonic Reducer

High cost-effective/perfectly match and replace the sizes of Japanes harmonic reducers

3F FAMED®

Jiangsu Fenghua Transmission Technology Co.,Ltd.

FAMED® Company Introduction

Jiangsu Fenghua Transmission Technology Co., Ltd. is developed from a factory which professionally manufactures the gears. All staffs of factory and R & D team have more than 20 years' gear manufacturing and designing experience. The factory cooperated with Taiwan planetary gearbox technology team in the early period, and then established business department of the planetary gearbox , and developed the design and manufacturing process of product line of planetary gearbox series. Later, we developed and produced multi-joint robot industry reducers (RV high-precision pin-wheel reducers) with the Japanese NDK company, and the wave gear device (harmonic reducers) invented by American genius inventor C. W. Musser.

Harmonic reducer is composed of three components of wave generator, flexspline and circular spline. The product utilizes the transmission mode of metal winding deformation, and through the breakthrough of tooth meshing and material and processing accuracy, the company successfully developed CSG, CSF, SHG, SHF, SHD series harmonic reducer products, which are widely applied in horizontal reciprocating joint motion occasions like SCARA horizontal multi-joint robots.

RV high-precision cycloidal pinwheel reducer is composed of a cycloid pin wheel and a planet carrier. It features of small volume, strong impact resistance, large torque and high positioning accuracy, small vibration, large reduction ratio, etc. RV-E and RV-C series reducers are widely used in six-axis industrial robots, palletizing robots, and other robot fields like welding robots and positioners in the welding fields, and stamping robots in the punching field. Combined with the application of peripheral automation, Fenghua company developed the RV-EM, RV-CM, FHA & FHD series reducers models for direct-connected motor, which is more convenient for customers to choose and implement.

Fenghua high-precision reducers can directly replace the products manufactured by Germany and Japanese company. Fenghua product series range are full, and sizes and precision can be perfectly matched with the gearbox produced by Japanese & German manufacturers. The products are widely used in six-axis industrial robots, SCARA horizontal multi-joint robots, parallel robots, and palletizing robots, as well as welding robots in the welding field, positioners, stamping robots in the punching field, and rotating application of the fourth & fifth axis in the machine tool industry, and rotary positioning control in the fields of 3C, semiconductor and high-end medical devices. And Fenghua harmonic reducers can be found having been long-term applied in the fields of photovoltaic equipment, lithium battery and other new energy equipment.

The factory set up a service department in mainland of China in the early period, mainly promoting domestic market, and later established Fenghua Transmission Equipment (Shanghai) Co., Ltd. The company matches a large stocks of products to coordinate with servo motor manufacturers and system integration traders, rooting in the domestic market, and determined to serve the domestic automatic industry and robotic field by excellent products and serve for the Chinese robot cause and Industrial 4.0 direction.

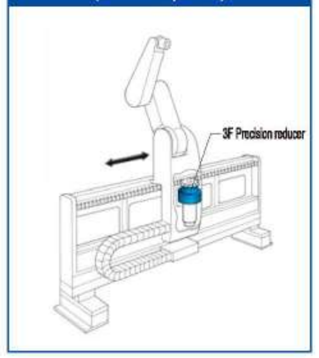
CONTENTS

PAGES

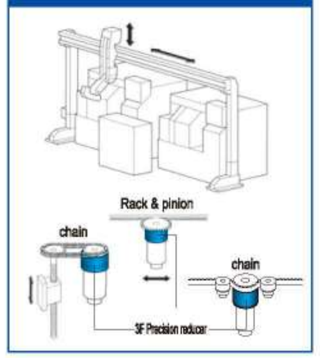
Product Application Industry

Semiconductor liquid crystal manufacturing equipment, robots, machine tools, and other frontier areas requiring precision motion control are widely used.

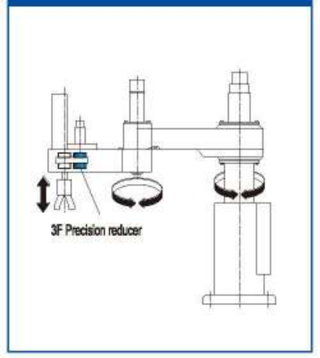
The walking shaft of a robot (rack and pinion)



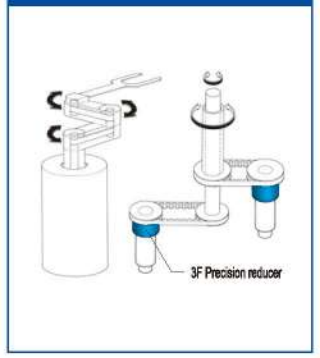
Gantry robot of machine tool



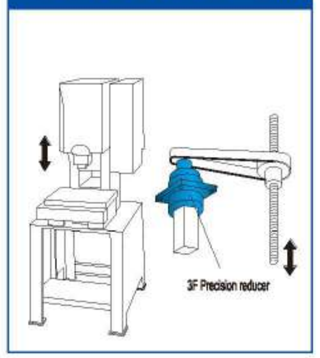
Horizontal multi-joint robot



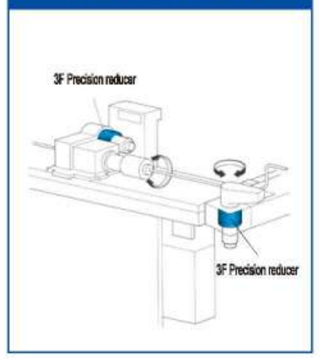
Wafer handling robot



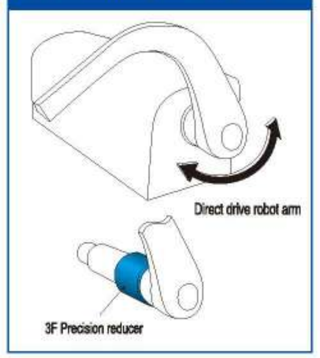
Stamping equipment (riveting)



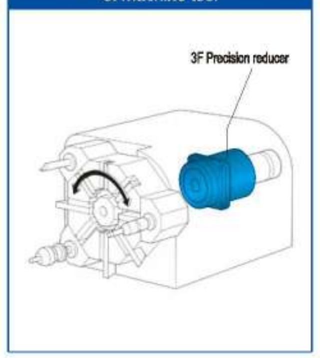
Pipe bending machine



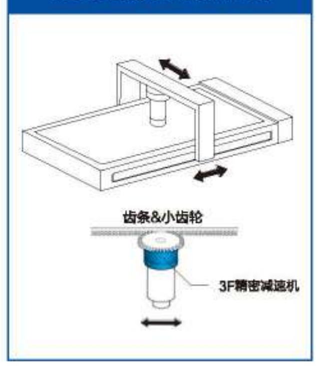
Injection mold taken-out robot



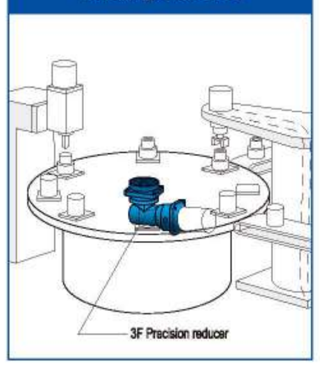
Rotary tower knife frame rotation of machine tool



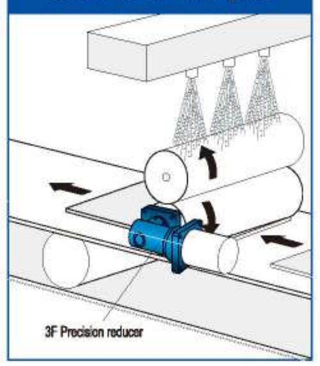
The XY axis of machine tool



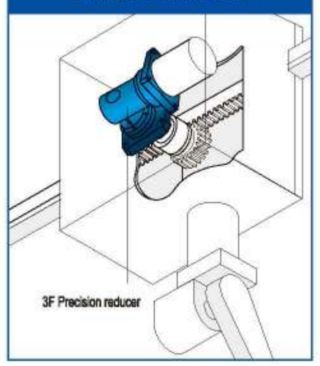
Indexing table drive



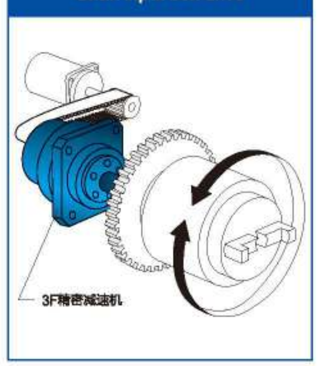
Roller drive for daubing use



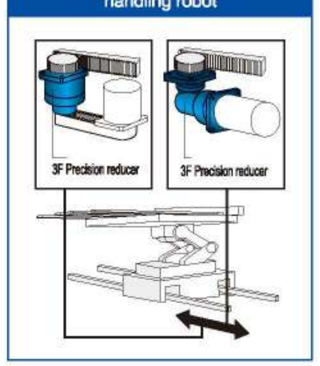
Pulley for loader use



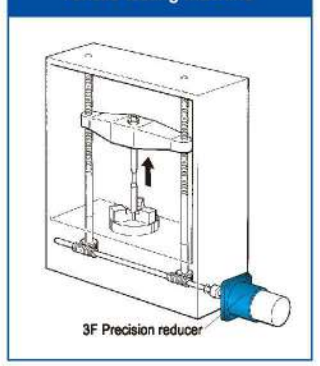
Shaft input belt drive



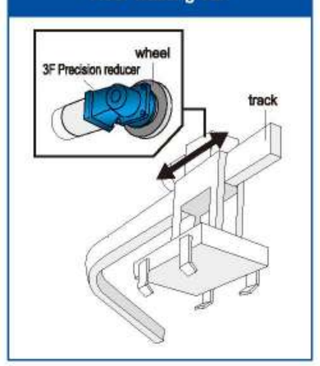
Liquid crystal glass substrate handling robot



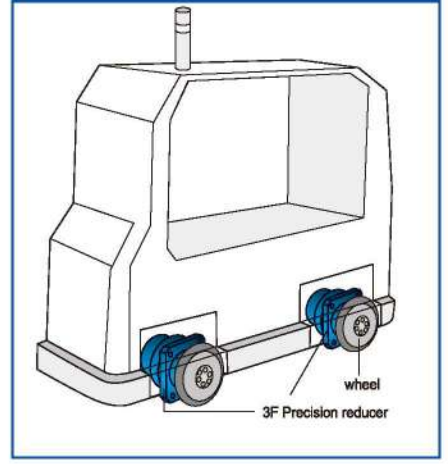
Tensile testing machine



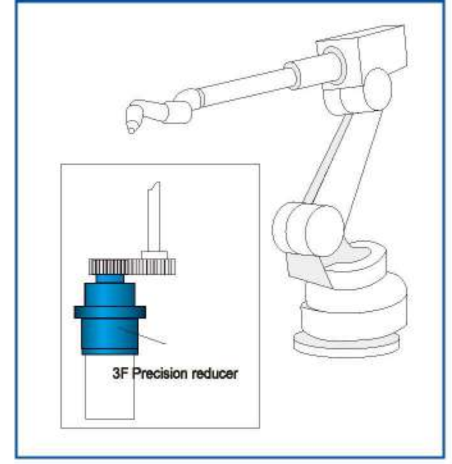
Roof walking van



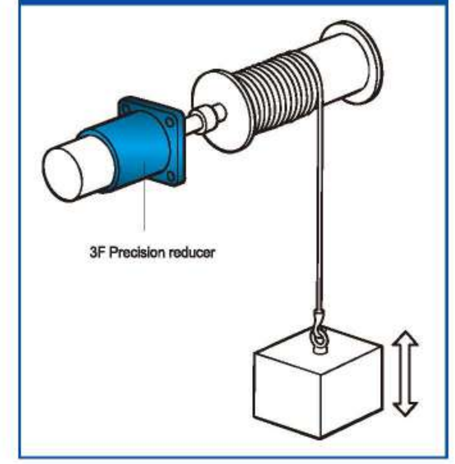
Unmanned vehicle



Robot for working in height

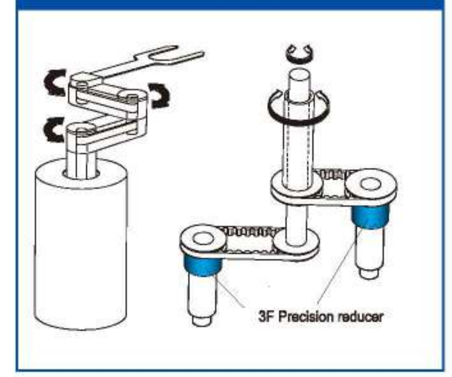


Roll up

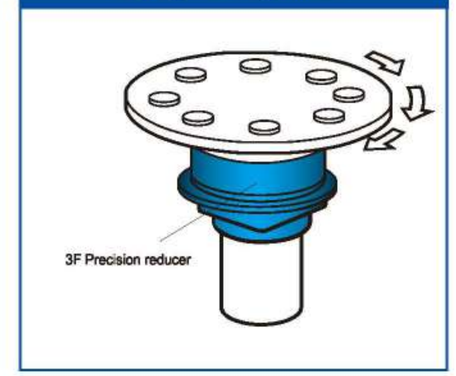


Rotate

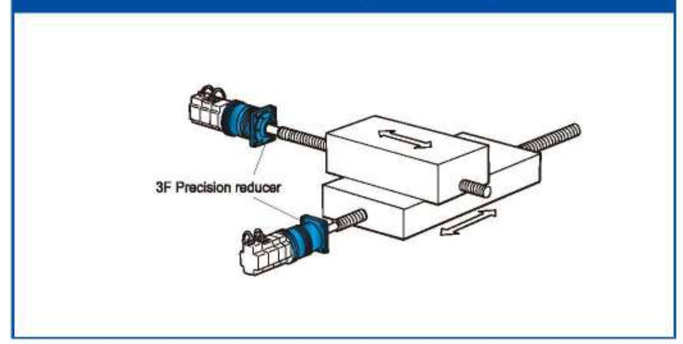
Transport



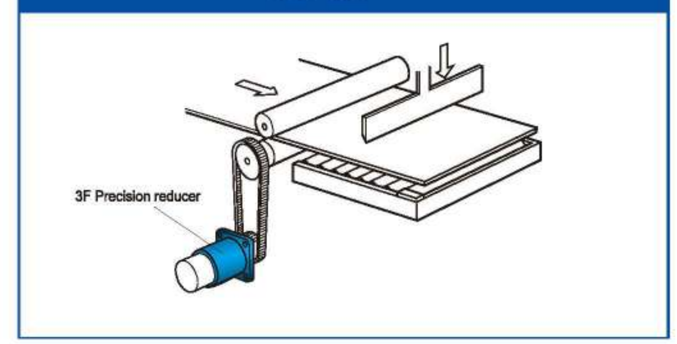
Angle (positioning) control



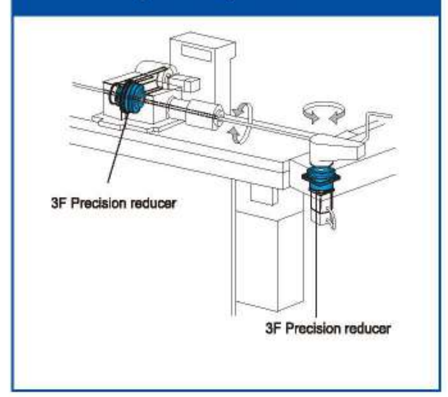
Two axis control (XY workbench)



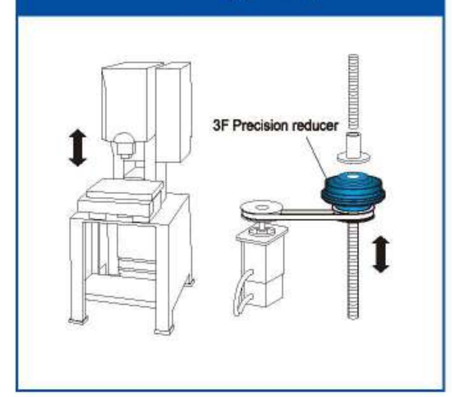
Roller drive



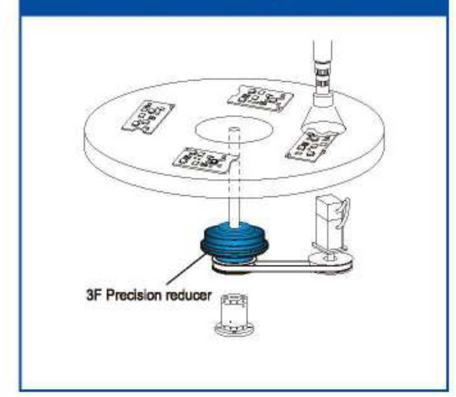
Pipe bending machine



Punching (riveting)



Printed circuit board inspection device



Structure of harmonic reducer

Wave Generator Flex Spline Circular Spline

Wave Generator

A ball bearing with thin-walled construction is fitted onto the outer circumference of an oval cam. The entire structure is oval. The inner ring of the bearing is fixed onto the oval cam and the outer ring elastically deforms through a ball. The wave generator can be mounted on a motor shaft.

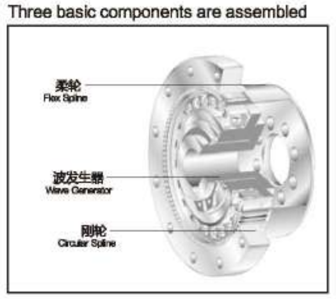
Flex Spline

The inner gear of the rigid body, with teeth of equivalent size to those on the flex spline cut into the inner circumference. The circular spline has two more teeth than the flex spline and is normally fixed onto the gear casing.

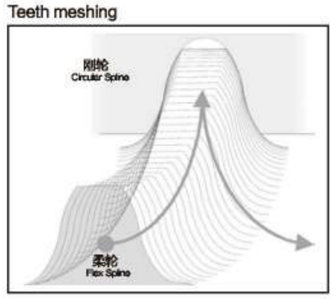
Flex Spline

A cup-like elastic metal part with thin wall thickness. Teeth are cut into the outer circumference of the opening of the cup, from where the output is usually extracted.

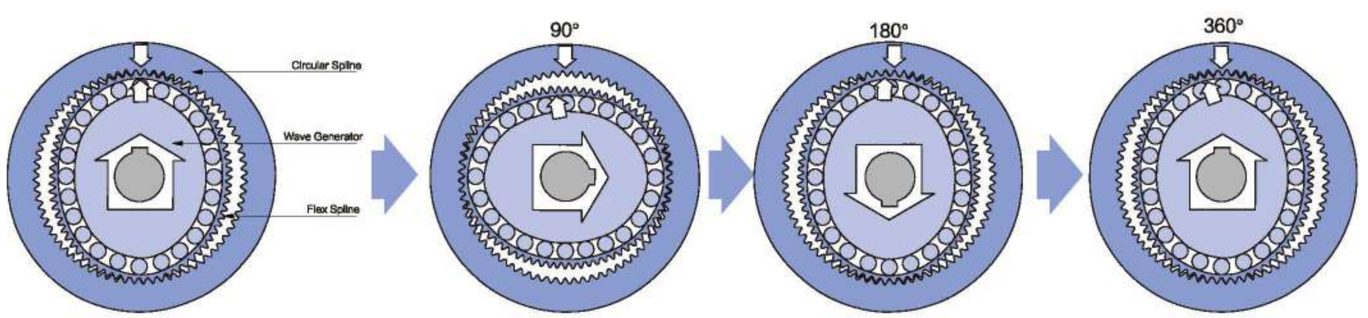
Three basic components are assembled



Teeth meshing



Working principle of harmonic reducer



The flex spline is bent into an oval shape by the wave generator. Teeth on the long axis of the oval therefore mesh with the circular spline, while the teeth on the short axis of the oval perfectly detach from the circular spline.

Fixing the circular spline and rotating the wave generator clockwise will elastically deform the flex spline, sequentially moving the tooth meshing positions with the circular spline.

Rotating the wave generator through 180° in a clockwise direction will move the flex spline counterclockwise by one tooth as a difference in the number of teeth.

When the wave generator rotates through one turn (360°), the flex spline movescounterclockwise by two teeth based on the difference in the number of teeth because the flex spline has two teeth fewer than the

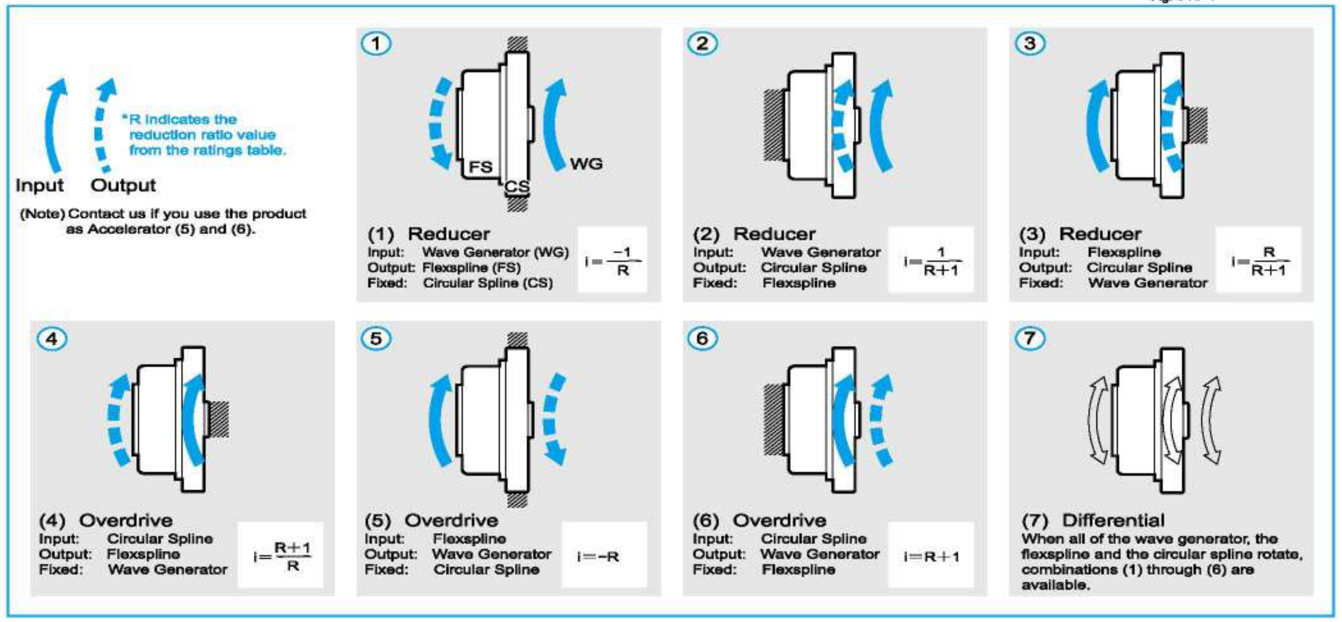
Rotational direction and reduction ratio

Cup Style

Series: CSG, CSF, CSD, CSF-mini

■ Rotational direction

Fig. 010-1

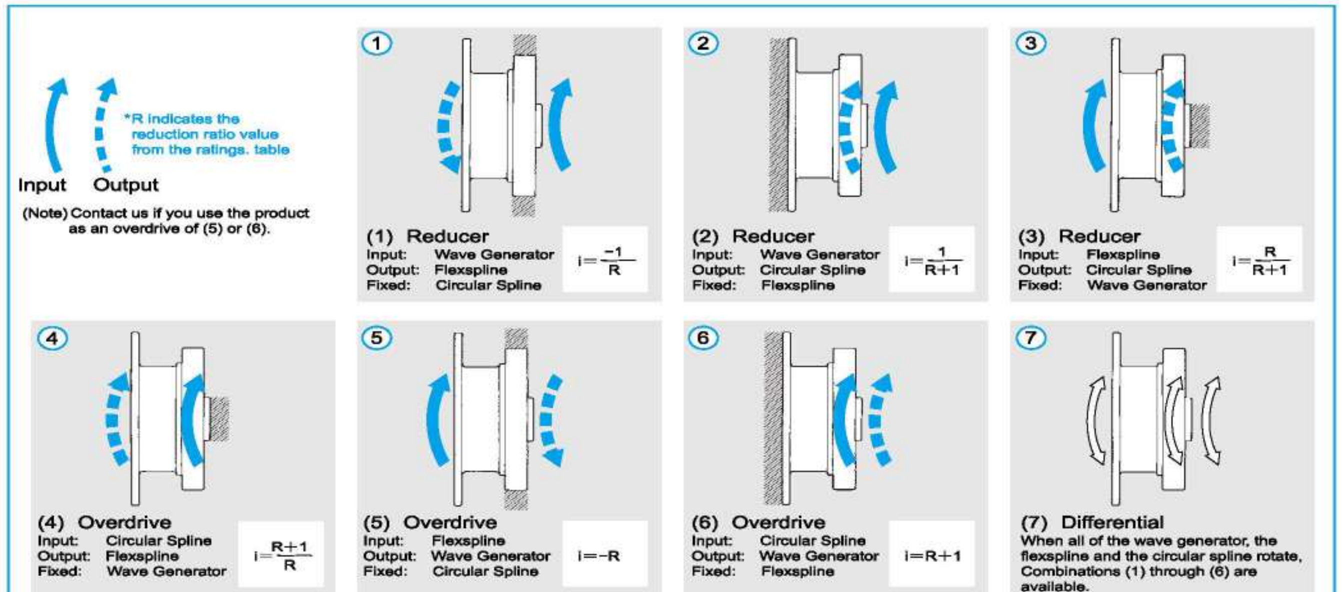


Silk hat

Series: SHG, SHF, SHD

■ Rotational direction

Fig. 010-2



■ Reduction ratio

The reduction ratio is determined by the number of teeth of the Flexspline and the Circular Spline

Number of teeth of the Flexspline: Zf
Number of teeth of the Circular Spline: Zc

▶ Input: Wave Generator
Output: Flexspline
Fixed: Circular Spline
Reduction ratio $i_1 = \frac{1}{R_1} = \frac{Zf-Zc}{Zf}$

▶ Input: Wave Generator
Output: Circular Spline
Fixed: Flexspline
Reduction ratio $i_2 = \frac{1}{R_2} = \frac{Zc-Zf}{Zc}$

Example

Number of teeth of the Flexspline: 200
Number of teeth of the Circular Spline: 202

▶ Input: Wave Generator
Output: Flexspline
Fixed: Circular Spline
Reduction ratio $i_1 = \frac{1}{R_1} = \frac{200-202}{200} = \frac{-1}{100}$

▶ Input: Wave Generator
Output: Circular Spline
Fixed: Flexspline
Reduction ratio $i_2 = \frac{1}{R_2} = \frac{202-200}{202} = \frac{1}{101}$

■ R_1 indicates the reduction ratio value from the ratings table.

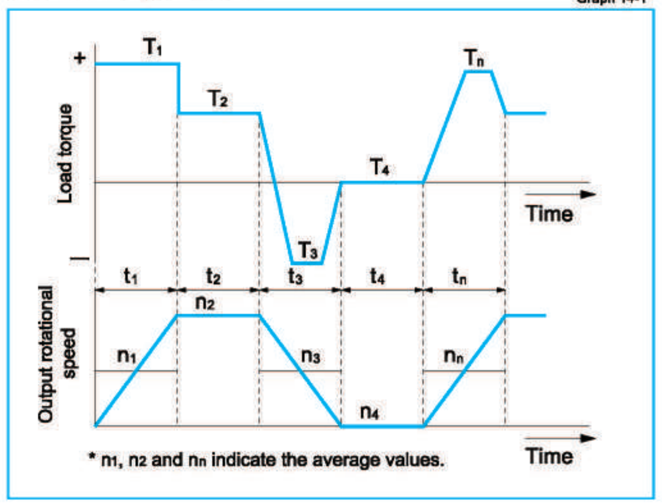
Product Sizing & Selection

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.

■ Checking the application motion profile

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

Graph 14-1



* n_1, n_2 and n_n indicate the average values.

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
Dwell	T_4, t_4, n_4
Maximum rotational speed	
Max. output speed	no max
Max. input rotational speed (Restricted by motors)	ni max
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

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

Calculate the average load torque applied on the output side from the application motion profile: Tav (Nm).

$$Tav = \sqrt[3]{\frac{n_1 \cdot t_1 \cdot |T_1|^3 + n_2 \cdot t_2 \cdot |T_2|^3 + \cdots n_n \cdot t_n \cdot |T_n|^3}{n_1 \cdot t_1 + n_2 \cdot t_2 + \cdots n_n \cdot t_n}}$$

Make a preliminary model selection with the following conditions.
Tav ≦ Limit for average torque torque
(See the rating table of each series).

Calculate the average output speed: no av (rpm)

$$no\ av = \frac{n_1 \cdot t_1 + n_2 \cdot t_2 + \cdots n_n \cdot t_n}{t_1 + t_2 + \cdots t_n}$$

Obtain the reduction ratio (R). A limit is placed on "ni max" by motors.

$$\frac{ni\ max}{no\ max} \geqq R$$

Calculate the average input rotational speed from the average output rotational speed (no av) and the reduction ratio (R): ni av (rpm)

$$ni\ av = no\ av \cdot R$$

Calculate the maximum input rotational speed from the max. output rotational speed (no max) and the reduction ratio (R): ni max (rpm)

$$ni\ max = no\ max \cdot R$$

Check whether the preliminary model number satisfies the following condition from the rating table.
Ni av ≦ Limit for average speed (rpm)
Ni max ≦ Limit for maximum speed (rpm)

NG / OK

Check whether T_1 and T_3 are less than the repeated peak torque specification.

NG / OK

Check whether T_s is less than the the momentary peak torque specification.

NG / OK

Calculate (Ns) the allowable number of rotations during impact torque.

$$N_S = \frac{10^4}{2 \cdot \frac{n_S \cdot R}{60} \cdot t} \qquad N_S \leqq 1.0 \times 10^4$$

NG / OK

Calculate the lifetime.

$$L_{10} = 7000 \cdot \left(\frac{Tr}{Tav}\right)^3 \cdot \left(\frac{nr}{ni\ av}\right) \text{(hours)}$$

Check whether the calculated life is equal to or more than the life of the wave generator (see Page 13).

NG / OK

The model number is confirmed.

Review the operation conditions and model number

■ Example of model number selection

Value of each application motion profile		Maximum rotational speed	
Load torque	T_n (Nm)	Max. output speed	no max = 14 rpm
Time	t_n (sec)	Max. input speed	ni max = 1800 rpm
Output speed	n_n (rpm)	(Restricted by motors)	
Normal operation pattern		Emergency stop torque	
Starting (acceleration)	T1 = 400 Nm, t1 = 0.3sec, n1 = 7rpm	When impact torque is applied	T_s = 500 Nm, t_s = 0.15 sec, n_s = 14 rpm
Steady operation (constant velocity)	T2 = 320 Nm, t2 = 3sec, n2 = 14rpm	Required life	L_{10} = 7000 (hours)
Stopping (deceleration)	T3 = 200 Nm, t3 = 0.4sec, n3 = 7rpm		
Dwell	T_4 = 0 Nm, t_4 = 0.2 sec, n_4 = 0 rpm		

Calculate the average load torque to the output side based on the application motion profile: T av (Nm).

$$Tav = \sqrt[3]{\frac{7\text{ rpm} \cdot 0.3\text{ sec} \cdot |400\text{Nm}|^3 + 14\text{ rpm} \cdot 3\text{ sec} \cdot |320\text{Nm}|^3 + 7\text{ rpm} \cdot 0.4\text{ sec} \cdot |200\text{Nm}|^3}{7\text{ rpm} \cdot 0.3\text{ sec} + 14\text{ rpm} \cdot 3\text{ sec} + 7\text{ rpm} \cdot 0.4\text{ sec}}}$$

Make a preliminary model selection with the following conditions. T av = 319 Nm ≦ 620 Nm
(Limit for average torque for model number CSF-40-120-2A-GR: See the rating table on Page 39.)
Thus, CSF-40-120-2A-GR is tentatively selected.

Calculate the average output rotational speed: no av (rpm)

$$no\ av = \frac{7\text{ rpm} \cdot 0.3\text{ sec} + 14\text{ rpm} \cdot 3\text{ sec} + 7\text{ rpm} \cdot 0.4\text{ sec}}{0.3\text{ sec} + 3\text{ sec} + 0.4\text{ sec} + 0.2\text{ sec}} = 12\text{ rpm}$$

Obtain the reduction ratio (R).

$$\frac{1800\text{ rpm}}{14\text{ rpm}} = 128.6 \geqq 120$$

Calculate the average input rotational speed from the average output rotational speed (no av) and the reduction ratio (R): ni av (rpm)

ni av = 12 rpm · 120 = 1440 rpm

Calculate the maximum input rotational speed from the maximum output rotational speed (no max) and the reduction ratio (R): ni max (rpm)

ni max = 14 rpm · 120 = 1680 rpm

Check whether the preliminary selected model number satisfies the following condition from the rating table.
Ni av = 1440 rpm ≦ 3600 rpm (Max average input speed of size 40)
Ni max = 1680 rpm ≦ 5600 rpm (Max input speed of size 40)

NG / OK

Check whether T_1 and T_3 are equal to or less than the repeated peak torque specification.
T_1 = 400 Nm ≦ 617 Nm (Limit of repeated peak torque of size 40)
T_3 = 200 Nm ≦ 617 Nm (Limit of repeated peak torque of size 40)

NG / OK

Check whether T_s is equal to or less than the momentary peak torque specification.
T_s = 500 Nm ≦ 1180 Nm (Limit for momentary torque of size 40)

NG / OK

Calculate the allowable number (Ns) rotation during impact torque and confirm ≦ 1.0×10^4

$$N_S = \frac{10^4}{2 \cdot \frac{14\text{ rpm} \cdot 120}{60} \cdot 0.15\text{ sec}} = 1190 \leqq 1.0 \times 10^4$$

NG / OK

Calculate the lifetime.

$$L_{10} = 7000 \cdot \left(\frac{294\text{ Nm}}{319\text{ Nm}}\right)^3 \cdot \left(\frac{2000\text{ rpm}}{1440\text{ rpm}}\right) \text{(hours)}$$

Check whether the calculated life is equal to or more than the life of the wave generator (see Page 12).
L_{10} = 7610 hours ≧ 7000 (life of the wave generator: L_{10})

NG / OK

The selection of model number CSF-40-120-2A-GR is confirmed from the above calculations.

Review the operation conditions, size and reduction ratio

Lubrication

Component Sets: CSD-2A, CSF-2A, CSG-2A, FB-2, FB-0, FR-2, SHF-2A, SHG-2A and SHD and SHG/SHF -2SO and -2SH gear units: Grease lubricant and oil lubricant are available for lubricating the component sets and SHD gear unit. It is extremely important to properly grease your component sets and SHD gear unit. Proper lubrication is essential for high performance and reliability. Harmonic Drive® component sets are shipped with a rust- preventative oil. The characteristics of the lubricating grease and oil types approved by Harmonic Drive are not changed by mixing with the preservation oil. It is therefore not necessary to remove the preservation oil completely from the gear components. However, the mating surfaces must be degreased before the assembly.

Gear Units: CSG/CSF 2UH and 2UH-LW; CSD-2UF and -2UH; SHG/SHF-2UH and 2UH- LW; SHG/SHF-2UJ; CSF Supermini, CSF Mini, and CSF-2UP.
Grease lubricant is standard for lubricating the gear units. You do not need to apply grease during assembly as the product is lubricated and shipped.
See Page 19 for using lubricant beyond the temperature range in table 16-2.

* Contact us if you want consistency zero (NLGI No.0) for maintenance reasons.

Name of lubricant — Table 016-1

Grease	Harmonic Grease® SK-1A
	Harmonic Grease® SK-2
	Harmonic Grease® 4B No.2
Oil	Industrial gear oil class-2 (extreme pressure) ISO VG68

Temperature — Table 016-2

Grease	SK-1A 0°C to + 40°C
	SK-2 0°C to + 40°C
	4B No.2 –10°C to + 70°C
Oil	ISO VG68 0°C to + 40°C

* The hottest section should not be more than 40° above the ambient temperature.

Note: The three basic components of the gear - the Flexspline, Wave Generator and Circular Spline - are matched and serialized in the factory. Depending on the product they are either greased or prepared with preservation oil. Then the individual components are assembled. If you receive several units, please be careful not to mix the matched components. This can be avoided by verifying that the serial numbers of the assembled gear components are identical.

Grease lubricant

■ Types of lubricant

Harmonic Grease® SK-1A

This grease was developed for Harmonic Drive® gears and features good durability and efficiency.

Harmonic Grease® SK-2

This grease was developed for small sized Harmonic Drive® gears and features smooth rotation of the Wave Generator since high pressure additive is liquefied.

Harmonic Grease® 4B No.2

This has been developed exclusively for the CSF and CSG and features long life and can be used over a wide range of temperature.

(Note)
1. Grease lubrication must have proper sealing, this is essential for 4B No.2.
   Rotating part: Oil seal with spring is needed.
   Mating part: O ring or seal adhesive is needed.
2. The grease has the highest deterioration rate in the region where the grease is subjected to the greatest shear (near wave generator).
   Its viscosity is between JIS No.0 and No.00 depending on the operation.

Table 016-3

NLGI consistency No.	Mixing consistency range
0	355 to 385
00	400 to 430

Grease specification — Table 016-4

Grease	SK-1A	SK-2	4B No.2
Base oil	Refined oil	Refined oil	Composite hydrocarbon oil
Base Viscosity cSt (25°C)	265 to 295	265 to 295	290 to 320
Thickening agent	Lithium soap base	Lithium soap base	Urea
NLGI consistency No.	No. 2	No. 2	No. 1.5
Additive	Extreme-pressure additive, others	Extreme-pressure additive, others	Extreme-pressure additive, others
Drop Point	197°C	198°C	247°C
Appearance	Yellow	Green	Light yellow
Storage life	5 years in sealed condition	5 years in sealed condition	5 years in sealed condition

■ Compatible grease by size

Compatible grease varies depending on the size and reduction ratio. See the following compatibility table. We recommend SK-1A and SK-2 for general use.

Ratios 30:1 — Table 016-5

Size	8	11	14	17	20	25	32
SK-1A	—	—	—	—	○	○	○
SK-2	○	○	○	○	—	—	—
4B No.2	△	△	△	△	□	□	□

Ratios 50:1* and above — Table 016-6

Size	8	11	14	17	20	25	32
SK-1A	—	—	—	—	○	○	○
SK-2	○	○	○	○	△	△	△
4B No.2	—	—	□	□	□	□	□

Size	40	45	50	58	65	80	90	100
SK-1A	○	○	○	○	○	○	○	○
SK-2	△	—	—	—	—	—	—	—
4BNo.2	□	□	□	□	□	□	□	□

○ : Standard grease
△: Semi-standard grease
□ : Recommended grease for long life and high load

* Oil lubrication is required for component-sets size 50 or larger with a reduction ratio of 50:1.

Grease characteristics — Table 016-7

Grease	SK-1A	SK-2	4B No.2
Durability	○	○	◎
Fretting resistance	○	○	◎
Low-temperature performance	△	△	◎
Grease leakage	◎	◎	△

Excellent : ◎
Good : ○
Use Caution: △

■ When to replace grease

The wear characteristics of the gear are strongly influenced by the condition of the grease lubrication. The condition of the grease is affected by the ambient temperature. The graph 017-1 shows the maximum number of input rotations for various temperatures. This graph applies to applications where the average load torque does not exceed the rated torque.

Calculation formula when the average load torque exceeds the rated torque — Formula 017-1

$$L_{GT} = L_{GTn} \times \left(\frac{Tr}{Tav}\right)^3$$

Formula Symbols — Table 017-1

L_{GT}	Grease change (If average load torque exceeds rated torque)	input revolutions	————
L_{GTn}	Grease change (if average load torque is equal to or less than rated torque)	Input revolutions (From Graph)	See the Graph 017-1.
Tr	Rated torque	Nm	See the "Ratings Table" of each series.
Tav	Average load torque	Nm	Calculation formula: See Page 014.

■ Other precautions

1. Avoid mixing different kinds of grease. The gear should be in an individual case when installed.
2. Please contact us when you use HarmonicDrive® gears at constant load or in one direction continuously, as it may cause lubrication problems.
3. Grease leakage. A sealed structure is needed to maintain the high durability of the gear and prevent grease leakage.

■ See the corresponding pages of the design guide of each series for "Recommended minimum housing clearance," Application guide" and "Application quantity."

Oil lubricant

■ Types of oil

The specified standard lubricant is "Industrial gear oil class-2 (extreme pressure) ISO VG68." We recommend the following brands as a commercial lubricant.

Table 018-1

Standard	Mobil Oil	Exxon	Shell	COSMO Oil	Japan Energy	NIPPON Oil	Idemitsu Kosan	General Oil	Klüber
Industrial gear oil class-2 (extreme pressure) ISO VG68	Mobilgear 600XP68	Spartan EP68	Omala Oil 68	Cosmo gear SE68	ES gear G68	Bonock M68, Bonock AX68	Daphne super gear LW68	General Oil SP gear roll 68	Syntheso D-68EP

■ When to replace oil

First time .... 100 hours after starting operation
Second time or after .... Every 1000 operation hours or every 6 months
Note that you should replace the oil earlier than specified if the operating condition is demanding.

■ See the corresponding pages of the design guide of each series for specific details.

Lubricant for special environments

When the ambient temperature is special (other than the "temperature range of the operating environment" on Page 016-2), you should select a lubricant appropriate for the operating temperature range.

High temperature lubricant — Table 019-2

Type of lubricant	Lubricant and manufacturer	Available temperature range
Grease	Mobil grease 28: Mobil Oil	–5°C to + 160°C
Oil	Mobil SHC-626: Mobil Oil	–5°C to + 140°C

Low temperature lubricant — Table 019-3

Type of lubricant	Lubricant and manufacturer	Available temperature range
Grease	Multemp SH-KII: Kyodo Oil	–30°C to + 50°C
	Isoflex LDS-18 special A: KLÜBER	–25°C to + 80°C
Oil	SH-200-100CS: Toray Silicon	–40°C to + 140°C
	Syntheso D-32EP: KLÜBER	–25°C to + 90°C

As the available temperature range indicates the temperature of the independent lubricant, restriction is added on operating conditions (such as load torque, rotational speed and operating cycle) of the gear. When the ambient temperature is very high or low, materials of the parts of the gear need to be reviewed for suitability. Contact us if operating in high temperature.

Harmonic Grease 4B No.2 can be used in the available temperature range shown in table 019-1. However, input running torque will increase at low temperatures, and grease life will be decreased at high temperatures due to oxidation and lubricant degradation.

Torsional Stiffness

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

■ Stiffness

Fixing the input side (wave generator) and applying torque to the output side (flexspline) generates torsion almost proportional to the torque on the output side. Figure 018-1 shows the torsional angle at the output side when the torque applied on the output side starts from zero, increases up to $+T_0$ and decreases down to $-T_0$. 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 020-1, this "Torque – torsional angle diagram" is divided into 3 regions, and the spring constants in the area are represented by K_1, K_2 and K_3.

K_1 ···· The spring constant when the torque changes from [zero] to [T_1]
K_2 ···· The spring constant when the torque changes from [T_1] to [T_2]
K_3 ···· The spring constant when the torque changes from [T_2] to [T_3]

■ See the corresponding pages of each series for values of the spring constants (K_1, K_2, K_3) and the torque-torsional angles (T_1, T_2, $-\theta_1$, θ_2).

■ Example for calculating the torsion angle

The torsion angle (θ) is calculated here using CSF-25-100-2A-GR as an example.

When the applied torque is T_1 or less, the torsion angle θ_{L1} is calculated as follows:
When the load torque T_{L1}=2.9 Nm

$\theta_{L1} = T_{L1}/K_1$
$= 2.9/3.1\times10^4$
$= 9.4\times10^{-5}$ rad (0.33 arc min)

When the applied torque is between T_1 and T_2, the torsion angle θ_{L2} is calculated as follows:
When the load torque T_{L2}=39 Nm

$\theta_{L2} = \theta_1 + (T_{L2}-T_1)/K_2$
$= 4.4\times10^{-4} + (39-14)/5.0\times10^4$
$= 9.4\times10^{-4}$ rad (3.2 arc min)

When a bidirectional load is applied, the total torsion angle will be 2 x θ_{LX} plus hysteresis loss.

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

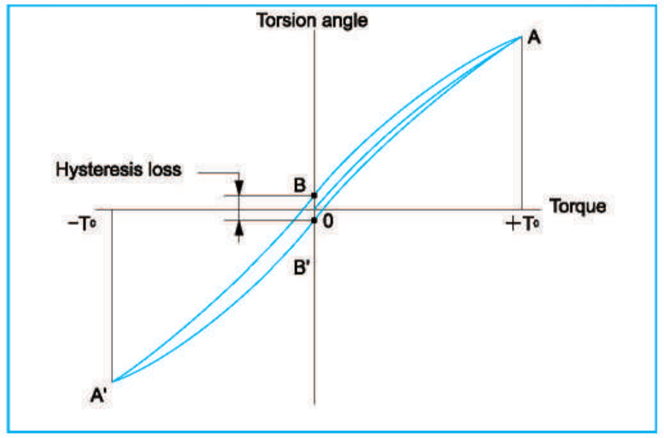
Note: See p.120 for torsional stiffness for pancake gearing .

■ Hysteresis loss (Silk hat and cup style only)

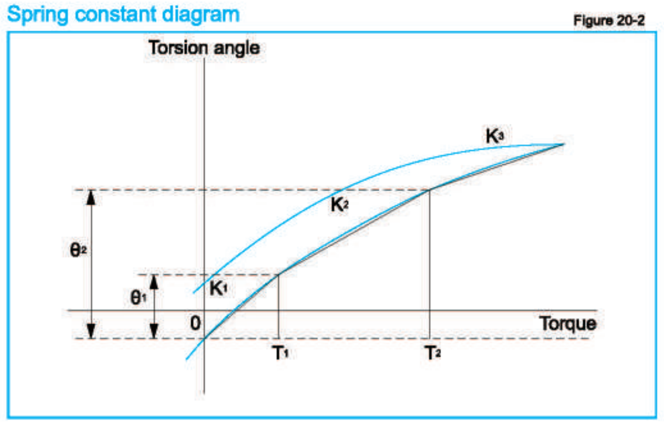
As shown in Figure 020-1, when the applied torque is increased to the rated torque and is brought back to [zero], the torsional angle does not return exactly back to the zero point This small difference (B – B') is called hysteresis loss.

■ See the corresponding page of each series for the hysteresis loss value.

Torque - torsion angle diagram — Figure 20-1



Spring constant diagram — Figure 20-2



■ Backlash (Silk hat and cup style only)

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® gears 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.

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 peak torque (impact torque). The maximum number of occurrences is given by the equation below.

■ Buckling torque

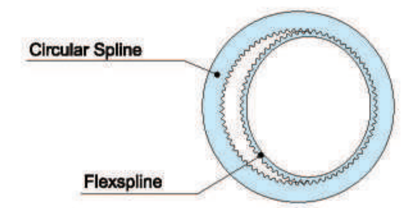
When a highly excessive torque (16 to 17 times rated torque) is applied to the output with the input stationary, the flexspline may experience plastic deformation. This is defined as buckling torque.

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

■ 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.

Figure 013-1



"Dedoidal" condition.

Positional Accuracy

Positional 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.

■ See the corresponding pages of each series for transmission accuracy values.

Example of measurement — Graph 021-1

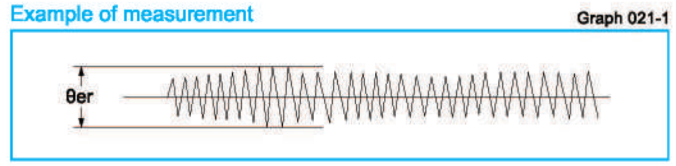


Table 021-1

θ_{er}	Transmission accuracy
θ_1	Input angle
θ_2	Actual output angle
R	Reduction ratio

Formula 021-1

$$\theta_{er} = \theta_2 - \frac{\theta_1}{R}$$

Vibration

The primary frequency of the transmission error of the HarmonicDrive® gear may 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.

Formula 021-2

$$N = \frac{15}{2}\ 60 = 450 \text{ rpm}$$

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

How to the calculate resonant frequency of the system — Formula 021-3

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

Formula variables — Table 021-2

f	The resonant frequency of the system	Hz	
K	Spring constant	Nm/rad	See pages of each series
J	Load inertia	kgm²	

Rating Table Definitions

See the corresponding pages of each series for values.

■ Rated torque

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

■ Limit for Repeated Peak Torque (see Graph 12-1)

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 14)

■ Limit for Momentary Peak Torque (see Graph 12-1)

The gear may be subjected to momentary peak 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 peak torque may be calculated by using formula 13-1.

■ Maximum Average Input Speed Maximum Input Speed

Do not exceed the allowable rating. (calculation formula of the average input speed: Page 14).

■ Moment of Inertia

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

Life of the wave generator

■ 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 012-1

Series name	Life: CSF, CSD, SHF, SHD, CSF-mini	Life: CSG, SHG
L_{10}	7,000 hours	10,000 hours
L_{50} (average life)	35,000 hours	50,000 hours

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

Calculation formula for Rated Lifetime

Formula 012-1

$$L_h = L_n \cdot \left(\frac{T_r}{T_{av}}\right)^3 \cdot \left(\frac{N_r}{N_{av}}\right)$$

Table 012-2

Ln	Life of L_{10} or L_{50}
Tr	Rated torque
Nr	Rated input speed
Tav	Average load torque on the output side (calculation formula: Page 14)
Nav	Average input speed (calculation formula: Page 14)

On starting torque

Starting torque refers to that when FH harmonic reducer is mounted on the shell and applied torque to the input side (high-speed side), "start-up torque" produced by the instantaneous rotation of the output side (low-speed side). The values shown in the series tables are the maximum and the lower limit is about 1/2-1/3 of the maximum.

On increasing starting torque

Increasing starting torque refers to that when FH harmonic reducer is mounted on the shell and applied torque to the input side (high-speed side), "start-up torque" produced by the instantaneous rotation of the output side (low-speed side). The values shown in the series tables are the maximum, and the lower limit is about 1/2 of the maximum.

Load-free operating torque

Load-free operating torque refers to the necessary input side (high-speed axle side) torque for rotating the FH harmonic reducer under no-load conditions. For reduction ratios other than 100, please add the correction amount shown in each series to calculate.

Efficiency characteristics

Efficiency varies according to the following conditions.

- ■ Reduction ratio
- ■ Input speed
- ■ Load torque
- ■ Temperature
- ■ Lubrication conditions (types and its amount of use)
- ■ Efficiency correction oefficient

When the load torque is less than the rated torque, the efficiency decreases.

Please calculate the correction coefficient Ke according to the series of efficiency correction coefficient tables, and calculate the efficiency by referring to the following calculation example.

Design Guidelines

Design guideline

The relative perpendicularity and concentricity of the three basic Harmonic Drive® elements have an important influence on accuracy and service life.

Misalignments will adversely affect performance and reliability. Compliance with recommended assembly tolerances is essential in order for the advantages of Harmonic Drive® gearing to be fully realized. Please consider the following when designing:

(1) Input shaft, Circular Spline and housing must be concentric.

(2) When operating, an axial force is generated on the wave generator. Input bearings must be selected to accommodate this axial load. See page 27.

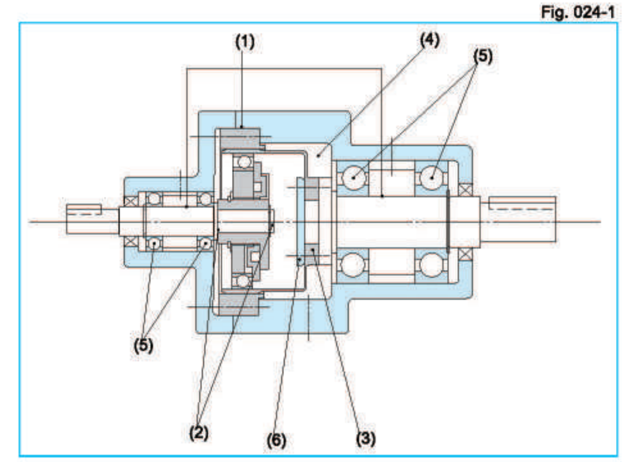
(3) Even though a HarmonicDrive® gear is compact, it transmits large torques. Therefore, assure that all required bolts are used to fastened the circular spline and flexspline and that they are tightened to the recommended torque.

(4) As the flexspline is subject to elastic deformation, the A minimal clearance between the flexspline and housing is required. Refer to "Minimum Housing Clearance" on the drawing dimension tables.

(5) The input shaft and output shaft are supported by anti-friction bearings. As the wave generator and flexspline elements are meant to transmit pure torque only, the bearing arrangement needs to isolate the harmonic gearing from external forces applied to either shaft. A common bearing arrangement is depicted in the diagram.

(6) A clamping plate is recommended (Item 6). Its purpose is to spread fastening forces and to avoid any chance of making physical contact with the thin section of the flexspline diaphragm. The clamping plate shall not exceed the diaphragm's boss diameter and is to be designed in accordance with catalog recommendations.

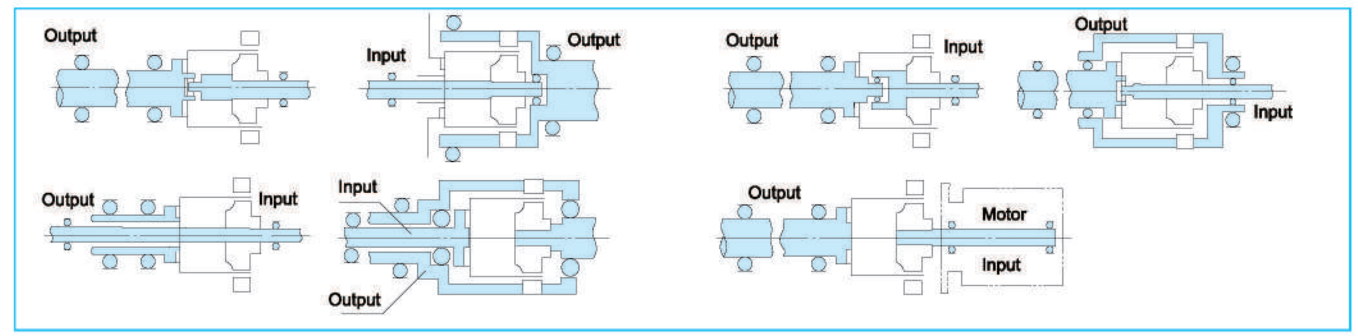
Fig. 024-1



Bearing support for the input and output shafts

For the component sets, both input and output shafts must be supported by two adequately spaced bearings in order to withstand external radial and axial forces without excessive deflection. In order to avoid damage to the component set when limited external loads are anticipated, both input and output shafts must be axially fixed. Bearings must be selected whose radial play does not exceed ISO-standard C 2 class or "normal" class. The bearings should be axially and radially preloaded to eliminate backlash.

Examples of correct bearing arrangements are shown in fig 025-1.



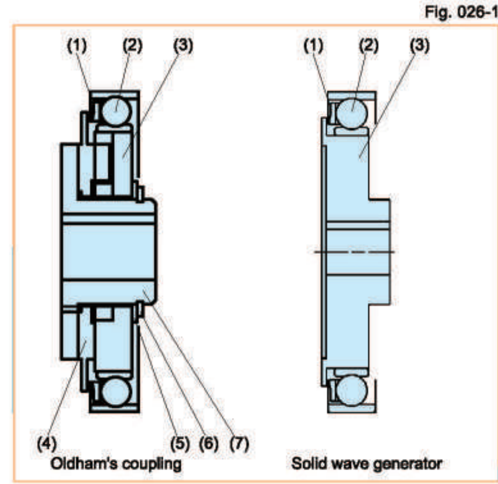
Wave generator

■ Structure of the wave generator

The wave generator includes an Oldham's coupling type with a self-aligning structure and an integrated solid wave generator without a self-aligning structure, and which is used depends on the series.

See the diagram of each series for details. The basic structure of the wave generator and the shape are shown below.

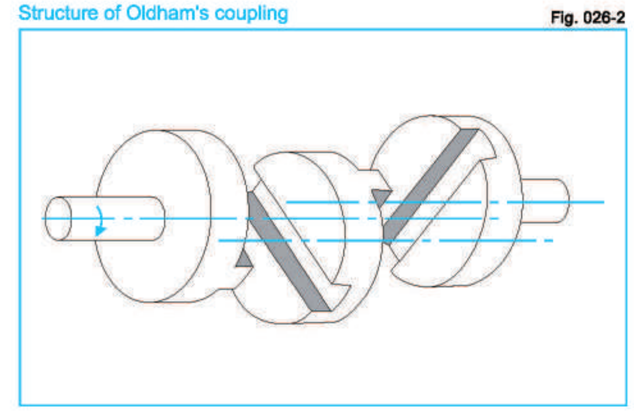
Fig. 026-1



(1) Ball Separator
(2) Wave generator bearing
(3) Wave generator plug
(4) Insert
(5) Rubwasher
(6) Snap ring
(7) Wave generator hub

Structure of Oldham's coupling

Fig. 026-2



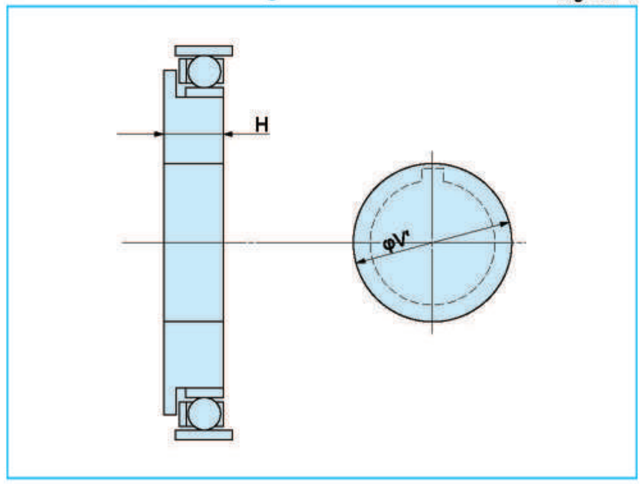
■ Maximum hole diameter of wave generator

The standard hole dimension of the wave generator is shown for each size. The dimension can be changed within a range up to the maximum hole dimension. We recommend the dimension of keyway based on JIS standard. It is necessary that the dimension of keyways should sustain the transmission torque.

* Tapered holes are also available.

In cases where a larger hole is required, use the wave generator without the Oldham coupling. The maximum diameter of the hole should be considered to prevent deformation of the Wave Generator plug by load torque. The dimension is shown in the table below and includes the dimension of depth of keyway.
(This is the value including the dimension of the depth of keyway.)

Hole diameter of the wave generator — Fig. 027-1



Hole diameter of the wave generator hub with Oldham coupling — Table 027-1, Unit: mm

Size	8	11	14	17	20	25	32	40	45	50	58	65	80	90	100
Standard dim. (H7)	3	5	6	8	9	11	14	14	19	19	22	24	28	28	28
Minimum hole dim.	—	—	3	4	5	6	6	10	10	10	13	16	16	19	22
Maximum hole dim.	—	—	8	10	13	15	15	20	20	20	25	30	35	37	40

Maximum hole diameter without Oldham Coupling — Table 027-2, Unit: mm

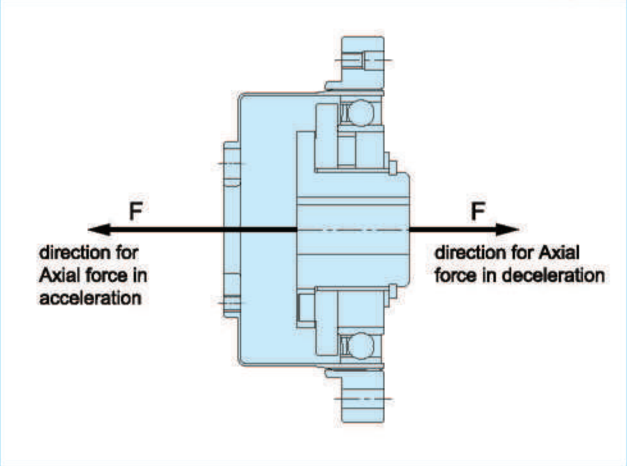
Size	8	11	14	17	20	25	32	40	45	50	58	65	80	90	100
Max. hole dia. φV'	10	14	17	20	23	28	36	42	47	52	60	67	72	84	95
Min. plug thick. $H^{0}_{-0.1}$	5.7	6.7	7.2	7.6	11.3	11.3	13.7	15.9	17.8	19	21.4	23.5	28.5	31.3	34.9

■ Axial Force of Wave Generator

When the gear is used to accelerate a load, the deflection of t he Flexspline leads to an axial force acting on the Wave Generator. This axial force, which acts in the direction of the closed end of the Flexspline, must be supported by the bearings of the input shaft (motor shaft). When the gear is used to decelerate a load, an axial force acts to push the Wave Generator out of the Flexspline cup. Maximum axial force of the Wave Generator can be calculated by the equation shown below. The axial force may vary depending on its operating condition. The value of axial force tends to be a larger number when using high torque, extreme low speed and constant operation. The force is calculated (approximately) by the equation. In all cases, the Wave Generator must be axially (in both directions), as well as torsionally, fixed to the input shaft.

(Note)
Please contact us for further information on attaching the Wave Generator to the input (motor) shaft.

Axial force direction of the wave generator — Fig. 027-2



Formula for Axial Force — Table 027-3

Reduction ratio	Calculation formula
30	$F=2\times\frac{T}{D}\times0.07\times\tan 32°$
50	$F=2\times\frac{T}{D}\times0.07\times\tan 30°$
80 or more	$F=2\times\frac{T}{D}\times0.07\times\tan 20°$

Symbols for Formula — Table 027-4

F	Axial force	N	See Figure 027-2
D	Size	m	
T	Output torque	Nm	

Calculation example — Formula 027-1

Model name: CSF series
Size: 32
Reduction ratio: 50
Output torque: 382 Nm
(maximum allowable momentary torque)

$$F=2\times\frac{382}{(32\times0.00254)}\times0.07\times\tan 30°$$

$$F=380N$$

Assembly Precautions

Sealing

Sealing is needed to maintain the high durability of the gear and prevent grease leakage. Recommended for all mating surfaces, if the o-ring is not used. Flanges provided with o-ring grooves must be sealed when a proper seal cannot be achieved using the o-ring alone.

- Rotating Parts .... Oil seal with spring is needed.
- Mating flange .... O-ring or seal adhesive is needed.
- Screw hole area .... Screws should have a thread lock (LOCTITE® 242 is recommended) or seal adhesive.

(Note) If you use Harmonic Grease 4BNo.2, strict sealing is required.

Sealing recommendations for gear units — Table 028-1

Area requiring sealing		Recommended sealing method
Output side	Holes which penetrate housing	Use O-ring (supplied with the product)
	Installation screw / bolt	Screw lock adhesive which has effective seal (LOCTITE® 242 is recommended)
Input side	Flange surfaces	Use O-ring (supplied with the product)
	Motor output shaft	Please select a motor which has an oil seal on the output shaft.

Assembly precautions

The wave generator is installed after the flexspline and circular spline. If the wave generator is not inserted into the flexspline last, gear teeth scuffing damage or improper eccentric gear mesh may result. Installation resulting in an eccentric tooth mesh (Dedoidal) will cause noise and vibration, and can lead to early failure of the gear. For proper function, the teeth of the flexspline and Circular Spline mesh symmetrically.

■ Precautions on the wave generator

1. Avoid applying undue axial force to the wave generator during installation. Rotating the wave generator bearing while inserting it is recommended and will ease the process.
2. If the wave generator does not have an Oldham coupling, extra care must be given to ensure that concentricity and inclination are within the specified limits

■ Precautions on the circular spline

The circular Spline must not be deformed in any way during the assembly. It is particularly important that the mounting surfaces are prepared correctly

1. Mounting surfaces need to have adequate flatness, smoothness, and no distortion.
2. Especially in the area of the screw holes, burrs or foreign matter should not be present.
3. Adequate relief in the housing corners is needed to prevent interference with the corner of the circular spline.
4. The circular spline should be rotatable within the housing. Be sure there is not interference and that it does not catch on anything.
5. When a bolt is inserted into a bolt hole during installation, make sure that the bolt fits securely and is not in an improper position or inclination.
6. Do not apply torque at recommended torque all at once. First, apply torque at about half of the recommended value to all bolts, then tighten at recommended torque. Order of tightening bolts must be diagonal.
7. Avoid pinning the circular spline if possible as it can reduce the rotational precision and smoothness of operation.

■ Precautions on the flexspline

1. Mounting surfaces need to have adequate flatness, smoothness, and no distortion.
2. Especially in the area of the screw holes, burrs or foreign matter should not be present.
3. Adequate clearance with the housing is needed to ensure no interference especially with the major axis of flexspline
4. Bolts should rotate freely when installing through the mounting holes of the flexspline and should not have any irregularity due to the shaft bolt holes being misaligned or oblique.
5. Do not tighten the bolts with the specified torque all at once. Tighten the bolts temporarily with about half the specified torque, and then tighten them to the specified torque. Tighten them in an even, crisscross pattern.
6. The flexspline and circular spline are concentric after assembly. After installing the wave generator bearing, if it rotates in unbalanced way, check the mounting for dedoidal or non-concentric installation.
7. Care should be taken not to damage the flexspline diaphragm or gear teeth during assembly.
   Avoid hitting the tips of the flexpline teeth and circular spline teeth.
   Avoid installing the CS from the open side of the flexspline after the wave generator has been installed.

■ Rust prevention

Although the Harmonic Drive® gears come with some corrosion protection, the gear can rust if exposed to the environment. The gear external surfaces typically have only a temporary corrosion inhibitor and some oil applied. If an anti-rust product is needed,please contact us to review the options.

"Dedoidal" state

It is normal for the flexspline to engage with the circular spline symmetrically as shown in Figure 029-1. However, if the ratcheting phenomenon, which is described on Page 013, is caused or if the three parts are forcibly inserted and assembled, engagement of the teeth may be out of alignment as shown in Figure 029-2. This is called "dedoidal". Note: Early failure of the gear will occur.

■ How to check "dedoidal"

By performing the following methods, check whether the gear engagement is "dedoidal".

(1) Judging by the irregular torque generated when the wave generator turns

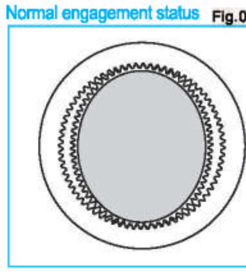
1) Slowly turn the input shaft with your hand in a no-load condition. If you can turn it with average force, it is normal. If it turns irregularly, it may be "dedoidal".

2) Turn the wave generator in a no-load condition if it is attached to a motor. If the average current value of the motor is about 2 to 3 times the normal value, it may be "dedoidal".

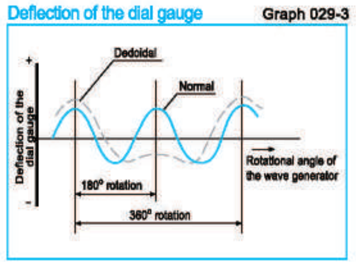
(2) Judging by measuring vibration on the body of the flexspline

The scale deflection of the dial gauge draws a sine wave as shown by the solid line in Graph 029-3 when it is normally assembled. When "dedoidal" occurs, the gauge draws a deflected wave shown by the dotted line as the flexspline is out of alignment.

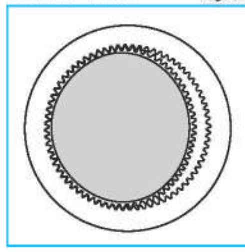
Normal engagement status — Fig.029-1



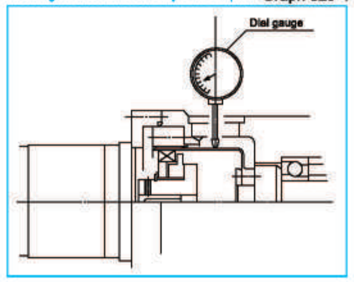
Deflection of the dial gauge — Graph 029-3



"Dedoidal" status — Fig. 029-2



Measuring the deflection on the body of the flexspline — Graph 029-4



Checking Output Bearing

A precision cross roller bearing is built in the unit type and the gear head type to directly support the external load (output flange) (precision 4-point contact ball bearing for the CSF-mini series).
Please calculate maximum moment load, life of cross roller bearing, and static safety factor to fully maximize the performance of a housed unit (gearhead).

■ See the corresponding pages on each series for main bearing specifications.

Checking procedure

(1) Checking the maximum moment load (Mmax)

Calculate maximum moment load (Mmax). → Maximum moment load (M max) ≦ allowable moment (Mc)

(2) Checking the life

Calculate the radial load (Frav) and the average axial load (Faav). → Calculate the radial load coefficient (x) and the axial load coefficient (y). → Calculate lifetime

(3) Checking the static safety coefficient

Calculate the static equivalent radial load coefficient (Po). → Check the static safety coefficient. (fs)

How to calculate the maximum moment load

Maximum moment load (M max) is obtained as follows.
Make sure that Mmax ≦ Mc.

Formula 030-1

$$M\,max = Frmax\,(Lr+R) + Famax \cdot La$$

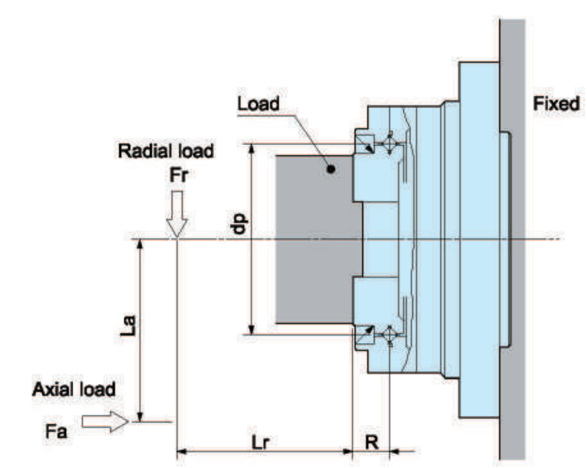
Symbols for Formula 030-1

Table 030-1

Frmax	Max. radial load	N(kgf)	See Fig. 030-1.
Famax	Max. axial load	N(kgf)	See Fig. 030-1.
Lr, La	————	m	See Fig. 030-1.
R	Offset amount	m	See Fig. 030-1 and "Specification of the output bearing" of each series.

External load influence diagram

Fig. 030-1



How to calculate the average load

(Average radial load, average axial load, average output speed)
When the radial load and axial load vary, the life of cross roller bearing can be determined by converting to an average load.

How to calculate the average radial load (Frav)

Formula 031-1

(Cross roller bearing)

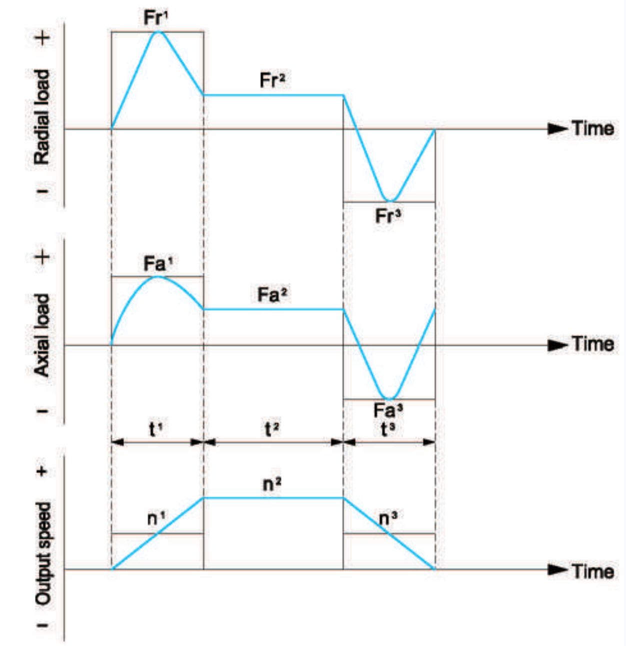
$$Fr\,av = \sqrt[10/3]{\frac{n_1t_1(|Fr_1|)^{10/3} + n_2t_2(|Fr_2|)^{10/3} \cdots + n_nt_n(|Fr_n|)^{10/3}}{n_1t_1 + n_2t_2 \cdots + n_nt_n}}$$

(4-point contact ball bearing)

$$Fr\,av = \sqrt[3]{\frac{n_1t_1(|Fr_1|)^{3} + n_2t_2(|Fr_2|)^{3} \cdots + n_nt_n(|Fr_n|)^{3}}{n_1t_1 + n_2t_2 \cdots + n_nt_n}}$$

Note that the maximum radial load in t_1 is Fr_1 and the maximum radial load in t_3 is Fr_3.

Graph 031-1



How to calculate the average axial load (Faav)

Formula 031-2

(Cross roller bearing)

$$Fa\,av = \sqrt[10/3]{\frac{n_1t_1(|Fa_1|)^{10/3} + n_2t_2(|Fa_2|)^{10/3} \cdots + n_nt_n(|Fa_n|)^{10/3}}{n_1t_1 + n_2t_2 \cdots + n_nt_n}}$$

(4-point contact ball bearing)

$$Fa\,av = \sqrt[3]{\frac{n_1t_1(|Fa_1|)^{3} + n_2t_2(|Fa_2|)^{3} \cdots + n_nt_n(|Fa_n|)^{3}}{n_1t_1 + n_2t_2 \cdots + n_nt_n}}$$

Note that the maximum axial load in t_1 is Fa_1 and the maximum axial load in t_3 is Fa_3.

How to calculate the average output speed (Nav)

Formula 031-3

$$Nav = \frac{n_1t_1 + n_2t_2 \ldots + n_nt_n}{t_1 + t_2 \ldots + t_n}$$

How to calculate the radial load coefficient (X) and axial load coefficient (Y)

Formula 031-4

How to calculate the load coefficient		X	Y
$\frac{Faav}{Frav + 2\,(Frav\,(Lr+R) + Faav \cdot La)\,/dp}$	<=1.5	1	0.45
$\frac{Faav}{Frav + 2\,(Frav\,(Lr+R) + Faav \cdot La)\,/dp}$	>1.5	0.67	0.67

Symbols for Formula 031-4

Table 031-1

Frav	Average radial load	N(kgf)	See "How to calculate the average load." See Formula 031-1.
Faav	Average axial load	N(kgf)	See "How to calculate the average load." See Formula 031-2.
Lr, La	————	m	See fig. 030-1
R	Offset amount	m	See Fig. 030-1 and "Main roller bearing specifications" of each series
dp	Pitch circle diameter of a roller	m	See Fig. 030-1 and "Specification of the output bearing" of each series.

Life of the output bearing

Calculate life of the output bearing by Formula 032-1.
You can calculate the dynamic equivalent radial load (Pc) by Formula 032-2.

Formula 032-1

(Cross roller bearing)

$$L_{10} = \frac{10^6}{60 \times N_{av}} \times \left(\frac{C}{f_w \cdot P_c} \right)^{10/3}$$

(4-point contact ball bearing)

$$L_{10} = \frac{10^6}{60 \times N_{av}} \times \left(\frac{C}{f_w \cdot P_c} \right)^{3}$$

Symbols for Formula 032-1

Table 032-1

L_{10}	Life	hour	——
Nav	Average output rated load speed	rpm	See "How to calculate the average load."
C	Basic dynamic rated load	N(kgf)	See "Specification of the output bearing" of each series.
Pc	Dynamic equivalent	N(kgf)	See Formula 032-2.
fw	Load coefficient	——	See Table 032-3.

Load coefficient

Table 032-3

Load status	fw
Steady operation without impact and vibration	1 to 1.2
Normal operation	1.2 to 1.5
Operation with impact and vibration	1.5 to 3

Formula 032-2

$$P_c = X \cdot \left(F_{rav} + \frac{2(F_{rav}(L_r+R) + F_{av} \cdot L_a)}{d_p} \right) + Y \cdot F_{aav}$$

Symbols for Formula 032-2

Table 032-2

Frav	Average radial load	N(kgf)	See "How to calculate the average load." See Formula 031-1.
Faav	Average axial load	N(kgf)	See "How to calculate the average load." See Formula 031-2.
dp	Pitch circle diameter	m	See Fig. 030-1 and "Specification of the output bearing" of each series.
X	Radial load coefficient	——	See Formula 031-4.
Y	Axial load coefficient	——	See Formula 031-4.
Lr, La	——	m	See Figure 030-1.
R	Offset	m	See Fig. 030-1 and "Specification of the output bearing" of each series.
M ave	Average moment load	Nm	

How to calculate life during oscillating motion

Calculate the life of the cross roller bearing during oscillating motion by Formula 033-1.

Formula 033-1

(Cross roller bearing)

$$L_{oc} = \frac{10^6}{60 \times n_1} \times \frac{90}{\theta} \times \left(\frac{C}{f_w \cdot P_c} \right)^{10/3}$$

(4-point contact ball bearing)

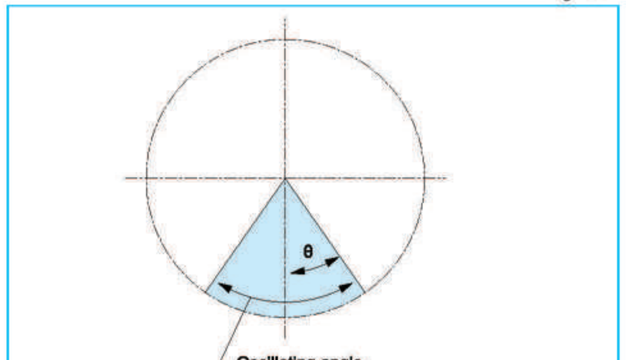
$$L_{oc} = \frac{10^6}{60 \times n_1} \times \frac{90}{\theta} \times \left(\frac{C}{f_w \cdot P_c} \right)^{3}$$

Symbols for Formula 033-1

Table 033-1

Loc	Rated life for oscillating motion	hour	——
n1	Round trip oscillation each minute	cpm	——
C	Basic dynamic rated load	N(kgf)	——
Pc	Dynamic equivalent radial load	N(kgf)	See Formula 032-2.
fw	Load coefficient	——	See Table 032-3.
θ	Oscillating angle /2	Degree	See Fig. 033-1.

Fig. 033-1



(Note) A small angle of oscillation (less than 5 degrees) may cause fretting corrosion to occur since lubrication may not circulate properly. Contact us if this happens.

How to calculate the static safety coefficient

Basic static rated load is an allowable limit for static load, but its limit is determined by usage. In this case, static safety coefficient of the cross roller bearing can be calculated by Formula 034-2.

Formula 034-1

$$f_s = \frac{C_o}{P_o}$$

Formula 034-2

$$P_o = F_{rmax} + \frac{2M_{max}}{d_p} + 0.44F_{a\,max}$$

Symbols for Formula 034-1

Table 034-1

Co	Basic static rated load	N(kgf)	See "Specification of the output bearing" of each series.
Po	Static equivalent radial load	N(kgf)	See Formula 034-2.

Static Safety Coefficient

Table 034-3

Operating condition of the roller bearing	fs
When high rotation precision is required	≧3
When shock and vibration are expected	≧2
Under normal operating condition	≧1.5

Symbols for Formula 034-2

Table 034-2

Frmax	Max. radial load	N(kgf)	See "How to calculate the maximum moment load" on Page 030.
Famax	Max. axial load	N(kgf)	
Mmax	Max. moment load	Nm(kgfm)	
dp	Pitch circle diameter of a roller	m	See Fig. 030-1 and "Specification of the output bearing" of each series.

Features

CSG/CSF Gear Unit

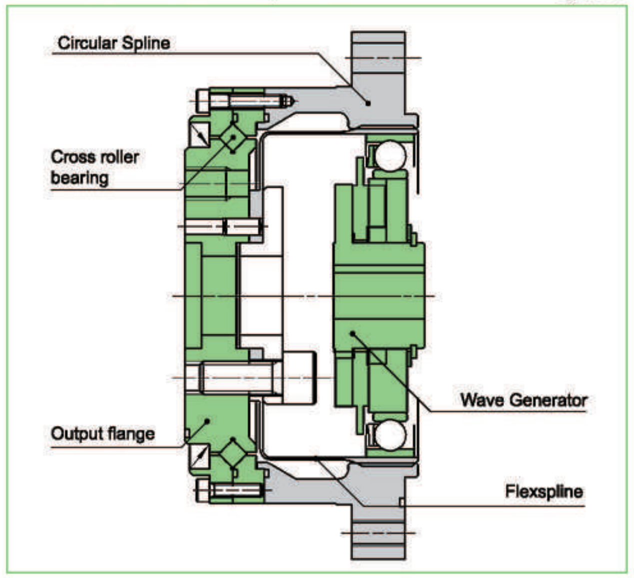
CSF/CSG are housed component gear sets combined with a precision cross roller output bearing & flange. A highly rigid cross roller bearing is built in to directly support (output bearing) the external load. They are a very compact, robust and easy to use gearhead solution. CSF and CSG are also available in lightweight versions.

Features

- Zero backlash
- Compact design
- High-torque capacity
- High stiffness
- High-positional and rotational accuracies

Structure of CSG/CSF series gear unit

Fig. 124-1



CSF v. CSG

CSG high torque
- 30% Higher torque than CSF series.
- The life has been improved by 43% (10,000 hours) compared to CSF.

CSF: standard torque
- Reduction ratio of 30:1 included for high-speed

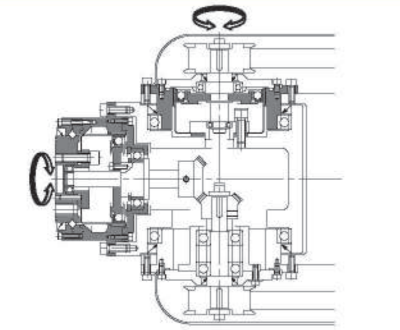
CSF/CSG-LW series: Lightweight (sizes 14 to 45)
- 30% average lower weight than Standard Series.
- Same performance as CSF/CSG series.

Main markets

Industrial robot

Various mechanical equipment

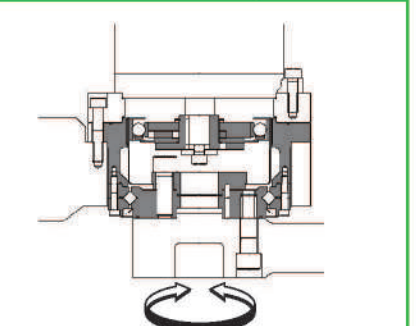
Vertical multi-joint robot



Bending and twisting drive of the wrist of vertical multi joint robot

* In accordance with this assembly example, a seal structure is needed to prevent grease leakage

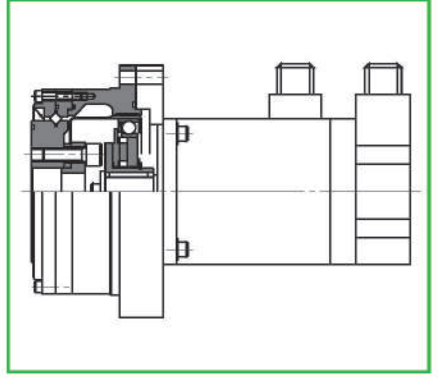
Horizontal multi-joint robot



Robotic arm drive of horizontal multi joint robot

* In accordance with this assembly example, a seal structure is needed to prevent grease leakage

Example of direct-connected servo motor



Ordering Code

CSG - 25 - 100 - 2UH - SP

Table 125-1

Series	Size	Ratio *1					Model	Special specification
CSG	14	50	80	100	—	—	2A= Component type 2UH= Unit type 2UJ = Unit type with input shaft *2	LW= Lightweight SP= Special specification code Blank= Standard product
	17	50	80	100	120	—		
	20	50	80	100	120	160		
	25	50	80	100	120	160		
	32	50	80	100	120	160		
	40	50	80	100	120	160		
	45	50	80	100	120	160		
	50	—	80	100	120	160		
	58	—	80	100	120	160		
	65	—	80	100	120	160		

*1 The reduction ratio value is based on the following configuration: Input: wave generator, fixed: circular spline, output: flexspline
*2 Contact us for details.

Rating table

■ CSG Series

Table 126-1

Size	Ratio	Rated Torque at 2000rpm		Limit for Repeated Peak Torque		Limit for Average Torque		Limit for Momentary Peak Torque		Maximum Input Speed (rpm)		Limit for Average Input Speed (rpm)		Moment of Inertia	
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Oil lubricant	Grease lubricant	Oil lubricant	Grease lubricant	I $\times10^{-4}$ kgm^2	J $\times10^{-5}$ kgfms^2
14	50	7.0	0.7	23	2.3	9	0.9	46	4.7	14000	8500	6500	3500	0.033	0.034
	80	10	1.0	30	3.1	14	1.4	58 *3	5.9 *3						
	100	10	1.0	36	3.7	14	1.4	58 *3	5.9 *3						
17	50	21	2.1	44	4.5	34	3.4	91	9	10000	7300	6500	3500	0.079	0.081
	80	29	2.9	56	5.7	35	3.6	109 *3	11 *3						
	100	31	3.2	70	7.2	51	5.2	109 *3	11 *3						
	120	31	3.2	70	7.2	51	5.2	109 *3	11 *3						
20	50	33	3.3	73	7.4	44	4.5	127	13	10000	6500	6500	3500	0.193	0.197
	80	44	4.5	96	9.8	61	6.2	165	17						
	100	52	5.3	107	10.9	64	6.5	191	20						
	120	52	5.3	113	11.5	64	6.5	191	20						
	160	52	5.3	120	12.2	64	6.5	191	20						
25	50	51	5.2	127	13	72	7.3	242	25	7500	5600	5600	3500	0.413	0.421
	80	82	8.4	178	18	113	12	332	34						
	100	87	8.9	204	21	140	14	369	38						
	120	87	8.9	217	22	140	14	*4	*4						
	160	87	8.9	229	23	140	14	*4	*4						
32	50	99	10	281	29	140	14	497	51	7000	4800	4600	3500	1.69	1.72
	80	153	16	395	40	217	22	738	75						
	100	178	18	433	44	281	29	841	86						
	120	178	18	459	47	281	29	892	91						
	160	178	18	484	49	281	29	892	91						
40	50	178	18	523	53	255	26	892	91	5600	4000	3600	3000	4.50	4.59
	80	268	27	675	69	369	38	1270	130						
	100	345	35	738	75	484	49	1400	143						
	120	382	39	802	82	586	60	1510 *4	154 *4						
	160	382	39	841	86	586	60	1510 *4	154 *4						
45	50	229	23	650	66	345	35	1235	126	5000	3800	3300	3000	8.68	8.86
	80	407	41	918	94	507	52	1651	168						
	100	459	47	982	100	650	66	2041	208						
	120	523	53	1070	109	806	82	2288	233						
	160	523	53	1147	117	819	84	2483	253						
50	80	484	49	1223	125	675	69	2418	247	4500	3500	3000	2500	12.5	12.8
	100	611	62	1274	130	866	88	2678	273						
	120	688	70	1404	143	1057	108	2678	273						
	160	688	70	1534	156	1096	112	3185	325						
58	80	714	73	1924	196	1001	102	3185	325	4000	3000	2700	2200	27.3	27.9
	100	905	92	2067	211	1378	141	4134	422						
	120	969	99	2236	228	1547	158	4329	441						
	160	969	99	2392	244	1573	160	4459	455						
65	80	969	99	2743	280	1352	138	4836	493	3500	2800	2400	1900	46.8	47.8
	100	1236	126	2990	305	1976	202	6175	630						
	120	1236	126	3263	333	2041	208	6175	630						
	160	1236	126	3419	349	2041	208	6175	630						

(Note) 1. Moment of inertia: $I=\frac{1}{4}GD^2$
2. See "Engineering data" on Page 12 for details of the terms.
3. The value of allowable max momentary torque is limited by the transmission torque of the unit. (See table 138-1, 2 on p.138.)
4. When using LW series, see the transmission torque of the unit (Table 138-3, 4 on p.138) for the allowable maximum momentary torque.

Ordering Code

CSF - 25 - 100 - 2UH - SP

Table 125-2

Series	Size	Ratio *1						Model	Special specification
CSF	14	30	50	80	100	—	—	2A= Component type 2UH= Unit type 2UJ = Unit type with input shaft *2	LW= Lightweight (sizes 14 to 45) SP= Special specification code Blank=Standard product
	17	30	50	80	100	120	—		
	20	30	50	80	100	120	160		
	25	30	50	80	100	120	160		
	32	30	50	80	100	120	160		
	40	—	50	80	100	120	160		
	45	—	50	80	100	120	160		
	50	—	50	80	100	120	160		
	58	—	50	80	100	120	160		
	65	—	50	80	100	120	160		

*1 The reduction ratio value is based on the following configuration: Input: wave generator, fixed: circular spline, output: flexspline
*2 Contact us for details.

Rating table

■ CSF Series

Table 127-1

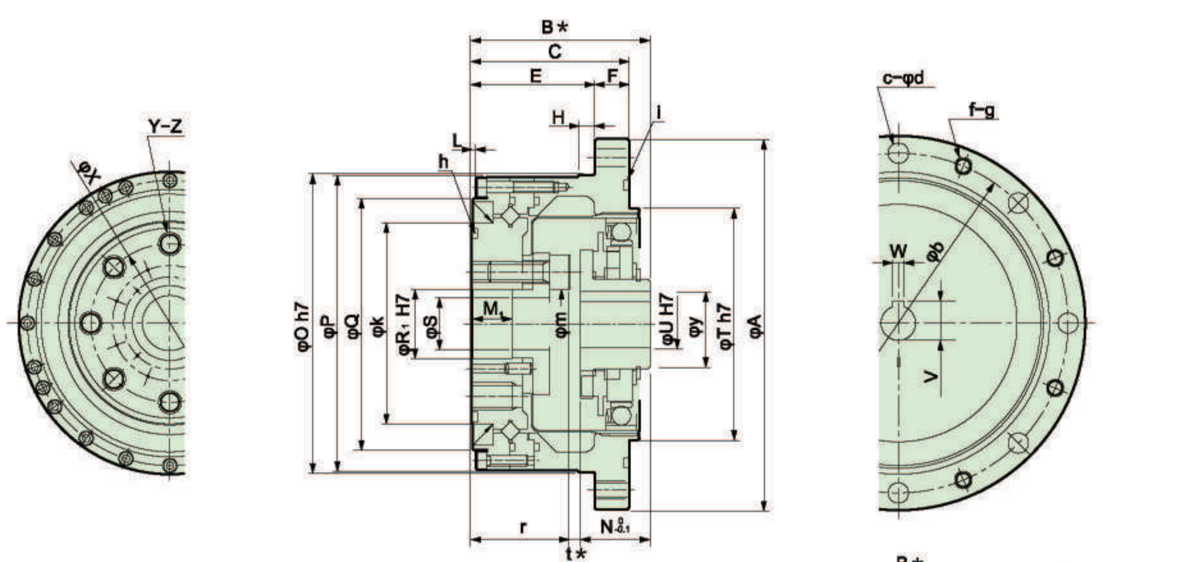
Size	Ratio	Rated Torque at 2000rpm		Limit for Repeated Peak Torque		Limit for Average Torque		Limit for Momentary Peak Torque		Maximum Input Speed (rpm)		Limit for Average Input Speed (rpm)		Moment of Inertia	
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Oil lubricant	Grease lubricant	Oil lubricant	Grease lubricant	I $\times10^{-4}$ kgm^2	J $\times10^{-5}$ kgfms^2
14	30	4.0	0.41	9.0	0.92	6.8	0.69	17	1.7	14000	8500	6500	3500	0.033	0.034
	50	5.4	0.55	18	1.8	6.9	0.70	35	3.6						
	80	7.8	0.80	23	2.4	11	1.1	47	4.8						
	100	7.8	0.80	28	2.9	11	1.1	54	5.5						
17	30	8.8	0.90	16	1.6	12	1.2	30	3.1	10000	7300	6500	3500	0.079	0.081
	50	16	1.6	34	3.5	26	2.6	70	7.1						
	80	22	2.2	43	4.4	27	2.7	87	8.9						
	100	24	2.4	54	5.5	39	4.0	108	11						
	120	24	2.4	54	5.5	39	4.0	86	8.8						
20	30	15	1.5	27	2.8	20	2.0	50	5.1	10000	6500	6500	3500	0.193	0.197
	50	25	2.5	56	5.7	34	3.5	98	10						
	80	34	3.5	74	7.5	47	4.8	127	13						
	100	40	4.1	82	8.4	49	5.0	147	15						
	120	40	4.1	87	8.9	49	5.0	147	15						
	160	40	4.1	92	9.4	49	5.0	147	15						
25	30	27	2.8	50	5.1	38	3.9	95	9.7	7500	5600	5600	3500	0.413	0.421
	50	39	4.0	98	10	55	5.6	186	19						
	80	63	6.4	137	14	87	8.9	255	26						
	100	67	6.8	157	16	108	11	284	29						
	120	67	6.8	167	17	108	11	304	31						
	160	67	6.8	176	18	108	11	314	32						
32	30	54	5.5	100	10	75	7.7	200	20	7000	4800	4600	3500	1.69	1.72
	50	76	7.8	216	22	108	11	382	39						
	80	118	12	304	31	167	17	568	58						
	100	137	14	333	34	216	22	647	66						
	120	137	14	353	36	216	22	686	70						
	160	137	14	372	38	216	22	686	70						
40	50	137	14	402	41	196	20	686	70	5600	4000	3600	3000	4.50	4.59
	80	206	21	519	53	284	29	980	100						
	100	265	27	568	58	372	38	1080	110						
	120	294	30	617	63	451	46	1180	120						
	160	294	30	647	66	451	46	1180	120						
45	50	176	18	500	51	265	27	950	97	5000	3800	3300	3000	8.68	8.86
	80	313	32	706	72	390	40	1270	130						
	100	353	36	755	77	500	51	1570	160						
	120	402	41	823	84	620	63	1760	180						
	160	402	41	882	90	630	64	1910	195						
50	50	245	25	715	73	350	36	1430	146	4500	3500	3000	2500	12.5	12.8
	80	372	38	941	96	519	53	1860	190						
	100	470	48	980	100	666	68	2060	210						
	120	529	54	1080	110	813	83	2060	210						
	160	529	54	1180	120	843	86	2450	250						
58	50	176	18	1020	104	18	27	1960	200	4000	3000	2700	2200	27.3	27.9
	80	549	56	1480	151	770	79	2450	250						
	100	696	71	1590	162	1060	108	3180	325						
	120	745	76	1720	176	1190	121	3330	340						
	160	745	76	1840	188	1210	123	3430	350						
65	50	245	25	1420	145	360	27	2830	289	3500	2800	2400	1900	46.8	47.8
	80	745	76	2110	215	1040	106	3720	380						
	100	951	97	2300	235	1520	155	4750	485						
	120	951	97	2510	256	1570	160	4750	485						
	160	951	97	2630	268	1570	160	4750	485						

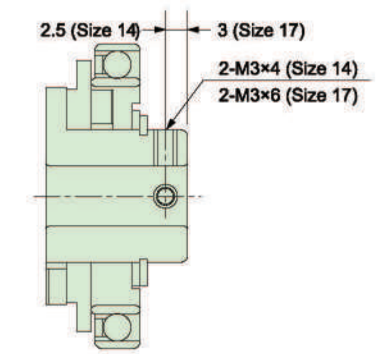
(Note) 1. Moment of inertia: $I=\frac{1}{4}GD^2$
2. See "Engineering data" on Page 12 for details of the terms.

Outline Dimensions

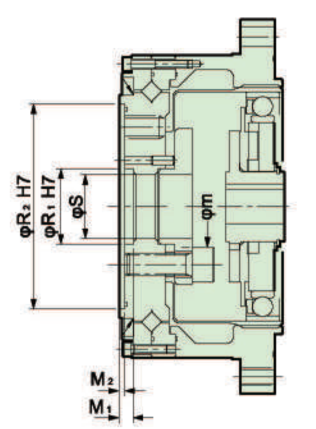
You can download the CAD files from our website: www.3fgearbox.com

Fig. 128-1

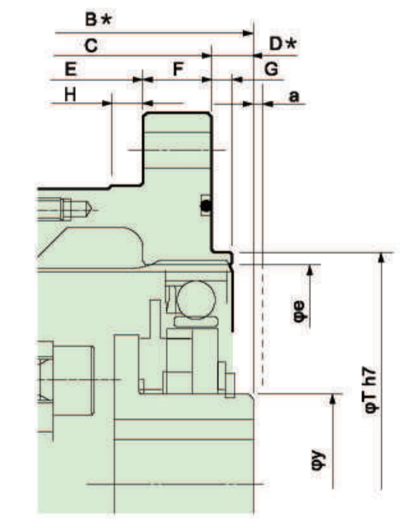




Shape of the wave generator hub for size 14 and 17 (no keyhole)



The shape on the output side of size 65



Enlarged view of the input side

(Note) Note that the length of the path of contact of the bolt will be within the depth of the female screw. If the length exceeds the size indicated by the symbol, Z, it will damage the flexspline.

* The shape of the output flange may vary depending on the size. Contact us for details. * Check the confirmation drawing for de tails of the sizes.
* See Fig. 040-3 on Page 40 for the shapes of the wave generator. The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dime nsion tolerances not shown on the drawing.

Dimensions

Table 129-1
Unit: mm

Symbol	Size	14	17	20	25	32	40	45	50	58	65
φA		73	79	93	107	138	160	180	190	226	260
B*		$41^{0}_{-0.9}$	$45^{0}_{-0.9}$	$45.5^{0}_{-1.0}$	$52^{0}_{-1.0}$	$62^{0}_{-1.1}$	$72.5^{0}_{-1.1}$	$79.5^{0}_{-1.2}$	$90^{0}_{-1.3}$	$104.5^{0}_{-1.3}$	$115^{0}_{-1.3}$
C		34	37	38	46	57	66.5	74	85	97	108.5
D*	CSG Series / CSG-LW Series	$7^{0}_{-0.4}$	$8^{0}_{-0.4}$	$7.5^{0}_{-0.4}$	$6^{0}_{-0.5}$	$5^{0}_{-0.6}$	$6^{0}_{-0.6}$	$5.5^{0}_{-0.6}$	$5^{0}_{-0.6}$	$7.5^{0}_{-0.6}$	$6.5^{0}_{-0.6}$
	CSF Series / CSF-LW Series	$7^{0}_{-0.8}$	$8^{0}_{-0.9}$	$7.5^{0}_{-1.0}$	$6^{0}_{-1.0}$	$5^{0}_{-1.1}$	$6^{0}_{-1.1}$	$5.5^{0}_{-1.2}$	$5^{0}_{-1.3}$	$7.5^{0}_{-1.3}$	$6.5^{0}_{-1.3}$
E		27	29	28	36	45	50.5	58	69	77	84.5
F		7	8	10	10	12	16	16	16	20	24
G		2	2	3	3	3	4	4	4	5	5
H	CSG Series	3.5	4	5	5	5	5	6	6	6	6
	CSG-LW Series	4	4	5	5	4.5	4.5	6	6	6	6
	CSF Series	3.5	4	5	5	5	5	6	6	6	6
	CSF-LW Series	4	4	5	5	4.5	4.5	6	6	6	6
L	CSG Series	0.5	0.5	0.5	0.5	1	1.5	1	1	1.5	1.5
	CSG-LW Series	1.1	1.1	1.1	1.1	1.2	1.6	1.6	1	1.5	1.5
	CSF Series	0.5	1.1	1.1	1.1	1.2	1.6	1.6	1	1.5	1.5
	CSF-LW Series	1.1	1.1	1.1	1.1	1.2	1.6	1.6	1	1.5	1.5
M1		9.4	9.5	9	2	15	5	6	8	10	10
M2		-	-	-	-	-	-	-	-	-	4
$N^{0}_{-0.1}$	CSG Series / CSG-LW Series	18.5	20.7	21.5	21.6	23.6	29.7	30.5	34.8	38.3	44.6
	CSF Series / CSF-LW Series	17.6	19.5	20.1	20.2	22	27.5	27.9	32	34.9	40.9
φO h7		56	63	72	86	113	127	148	158	186	212
φP	CSG Series	56	62	70	85	112	123	147	157	185	210
	CSG-LW Series	54.6	61.6	69.6	85	110	124.5	143	155	183.4	208.4
	CSF Series	55	62	70	85	112	123	147	157	185	210
	CSF-LW Series	54.6	61.6	69.6	85	110	124.5	143	155	183.4	208.4
φQ	CSG Series	42.5	49.5	58	73	96	109	127	137	161	186
	CSG-LW Series	40.5	47.5	55.5	71	91.1	103	123	130	155	180
	CSF Series	42.5	49.5	58	73	96	109	127	137	161	186
	CSF-LW Series	40.5	47.5	55.5	71	91.1	103	123	130	155	180
φR1 H7		11	10	14	20	26	32	32	40	46	52
φR2 H7		-	-	-	-	-	-	-	-	-	142
φS		8	7	10	15	20	24	25	32	38	44
φT h7		38	48	56	67(68)	90	110	124	135	156	177
φU H7		6	8	12	14	14	14	19	19	22	24
V		-	-	$13.8^{+0.1}_{0}$	$16.3^{+0.1}_{0}$	$16.3^{+0.1}_{0}$	$16.3^{+0.1}_{0}$	$21.8^{+0.1}_{0}$	$21.8^{+0.1}_{0}$	$24.8^{+0.1}_{0}$	$27.3^{+0.2}_{0}$
W Js9		-	-	4	5	5	5	6	6	6	8
φX		23	27	32	42	55	68	82	84	100	110
Y		6	6	8	8	8	8	8	8	8	8
Z		M4×8	M5×10	M6×9	M8×12	M10×15	M10×15	M12×18	M14×21	M16×24	M16×24
a		1	1	1.5	1.5	1.5	2	2	2	2.5	2.5
φb		65	71	82	96	125	144	164	174	206	236
c	CSG Series	8	8	8	10	12	10	12	14	12	8
	CSG-LW Series	6	8	8	10	12	10	16	18	16	12
	CSF Series	6	6	6	8	12	8	12	12	12	8
	CSF-LW Series	6	8	8	10	12	10	16	18	16	12
φd		4.5	4.5	5.5	5.5	6.6	9	9	9	11	14
φe		38	45	53	66	86	106	119	133	154	172
f	CSG Series	8	8	8	10	12	10	12	14	12	8
	CSG-LW Series	6	8	8	10	12	10	16	18	16	12
	CSF Series	6	6	6	8	12	8	12	12	12	8
	CSF-LW Series	6	8	8	10	12	10	16	18	16	12
g		M4	M4	M5	M5	M6	M8	M8	M8	M10	M12
h		29.0×0.50	34.5×0.80	40.64×1.14	53.28×0.99	S71	AS568-042	S100	S105	S125	S135
i		S50	S56	S67	S80	S105	S125	S145	S155	S180	S205
φk		31	38	45	58	78	90	107	112	135	155
φm		10	10.5	15.5	20	27	34	36	39	46	56
r		21.4	23.5	23	29	37	39.5	45.5	53	62.8	66.5
t*	CSG Series / CSG-LW Series	1.1	0.8	1	1.4	1.4	3.3	3.5	2.2	3.4	3.9
	CSF Series / CSF-LW Series	2	2	2.4	2.8	3	5.5	6.1	5	6.8	7.6
φy		14	18	21	26	26	32	32	32	40	48
Mass (kg)	CSG Series	0.52	0.68	0.98	1.5	3.2	5.0	7.0	8.9	14.6	20.9
	CSG-LW Series	0.32	0.46	0.64	1.1	2.2	3.5	5.1	7	11.3	16.2
	CSF Series	0.52	0.68	0.98	1.5	3.2	5.0	7.0	8.9	14.6	20.9
	CSF-LW Series	0.32	0.46	0.64	1.1	2.2	3.5	5.1	7	11.3	16.2

(note1) the dimension in parenthesis is for reduction ratio 30.

- *The B, D, and t values indicate relative position of individual gearing components (wave generator, flexspline, circular spline). Please strictly adhere to these values when designing your housing and mating parts.
- Wave generator is removed when the product is delivered.
- CSF & CSG-LW available in sizes 14 to 45.

Positioning accuracy

See "Engineering data" for a description of terms.

Table 150-1
Unt: X10^{-4}rad (arc·min)

Ratio	Size / Specification	14	17	20	25	32	40 to 65
30	Standard product	5.8	4.4	4.4	4.4	4.4	—
		(2)	(1.5)	(1.5)	(1.5)	(1.5)	—
	Special product	—	—	2.9	2.9	2.9	—
		—	—	(1)	(1)	(1)	—
50 or more	Standard product	4.4	4.4	2.9	2.9	2.9	2.9
		(1.5)	(1.5)	(1)	(1)	(1)	(1)
	Special product	2.9	2.9	1.5	1.5	1.5	1.5
		(1)	(1)	(0.5)	(0.5)	(0.5)	(0.5)

Hysteresis loss

See "Engineering data" for a description of terms.

Table 150-2

Ratio	Size	14	17	20	25	32	40 or more
30	$\times10^{-4}$rad	8.7	8.7	8.7	8.7	8.7	—
	arc min	3.0	3.0	3.0	3.0	3.0	—
50	$\times10^{-4}$rad	5.8	5.8	5.8	5.8	5.8	5.8
	arc min	2.0	2.0	2.0	2.0	2.0	2.0
80 or more	$\times10^{-4}$rad	2.9	2.9	2.9	2.9	2.9	2.9
	arc min	1.0	1.0	1.0	1.0	1.0	1.0

Max. backlash quantity

See "Engineering data" for a description of terms.

Table 150-3

Ratio	Size	14	17	20	25	32	40	45	50	58	65
30	$\times10^{-5}$rad	29.1	16.0	13.6	13.6	11.2	—	—	—	—	—
	arc sec	60	33	28	28	23	—	—	—	—	—
50	$\times10^{-5}$rad	17.5	9.7	8.2	8.2	6.8	6.8	5.8	5.8	4.8	4.8
	arc sec	36	20	17	17	14	14	12	12	10	10
80	$\times10^{-5}$rad	11.2	6.3	5.3	5.3	4.4	4.4	3.9	3.9	2.9	2.9
	arc sec	23	13	11	11	9	9	8	8	6	6
100	$\times10^{-5}$rad	8.7	4.8	4.4	4.4	3.4	3.4	2.9	2.9	2.4	2.4
	arc sec	18	10	9	9	7	7	6	6	5	5
120	$\times10^{-5}$rad	—	3.9	3.9	3.9	2.9	2.9	2.4	2.4	1.9	1.9
	arc sec	—	8	8	8	6	6	5	5	4	4
160	$\times10^{-5}$rad	—	—	2.9	2.9	2.4	2.4	1.9	1.9	1.5	1.5
	arc sec	—	—	6	6	5	5	4	4	3	3

Torsional Stiffness

See "Engineering data" for a description of terms.

Table 150-4

Symbol		Size	14	17	20	25	32	40	45	50	58	65
	T_1	Nm	2.0	3.9	7.0	14	29	54	76	108	168	235
		kgfm	0.20	0.40	0.70	1.4	3.0	5.5	7.8	11	17	24
	T_2	Nm	6.9	12	25	48	108	196	275	382	598	843
		kgfm	0.7	1.2	2.5	4.9	11	20	28	39	61	86
Reduction ratio 30	K_1	$\times10^{4}$Nm/rad	0.19	0.34	0.57	1.0	2.4	—	—	—	—	—
		kgfm/arc min	0.056	0.10	0.17	0.30	0.70	—	—	—	—	—
	K_2	$\times10^{4}$Nm/rad	0.24	0.44	0.71	1.3	3.0	—	—	—	—	—
		kgfm/arc min	0.07	0.13	0.21	0.40	0.89	—	—	—	—	—
	K_3	$\times10^{4}$Nm/rad	0.34	0.67	1.1	2.1	4.9	—	—	—	—	—
		kgfm/arc min	0.10	0.20	0.32	0.62	1.5	—	—	—	—	—
	θ	$\times10^{-4}$rad	10.5	11.5	12.3	14	12.1	—	—	—	—	—
		arc min	3.6	4.0	4.1	4.7	4.3	—	—	—	—	—
	θ	$\times10^{-4}$rad	31	30	38	40	38	—	—	—	—	—
		arc min	10.7	10.2	12.7	13.4	13.3	—	—	—	—	—
Reduction ratio 50	K_1	$\times10^{4}$Nm/rad	0.34	0.81	1.3	2.5	5.4	10	15	20	31	44
		kgfm/arc min	0.1	0.24	0.38	0.74	1.6	3.0	4.3	5.9	9.3	13
	K_2	$\times10^{4}$Nm/rad	0.47	1.1	1.8	3.4	7.8	14	20	28	44	61
		kgfm/arc min	0.14	0.32	0.52	1.0	2.3	4.2	6.0	8.2	13	18
	K_3	$\times10^{4}$Nm/rad	0.57	1.3	2.3	4.4	9.8	18	26	34	54	78
		kgfm/arc min	0.17	0.4	0.67	1.3	2.9	5.3	7.6	10	16	23
	θ	$\times10^{-4}$rad	5.8	4.9	5.2	5.5	5.5	5.2	5.2	5.5	5.2	5.2
		arc min	2.0	1.7	1.8	1.9	1.9	1.8	1.8	1.9	1.8	1.8
	θ	$\times10^{-4}$rad	16	12	15.4	15.7	15.7	15.4	15.1	15.4	15.1	15.1
		arc min	5.6	4.2	5.3	5.4	5.4	5.3	5.2	5.3	5.2	5.2

* The values in this table are reference values. The minimum value is approximately 80% of the displayed value.

Table 151-1

Symbol		Size	14	17	20	25	32	40	45	50	58	65
	T_1	Nm	2.0	3.9	7.0	14	29	54	76	108	168	235
		kgfm	0.20	0.40	0.70	1.4	3.0	5.5	7.8	11	17	24
	T_2	Nm	6.9	12	25	48	108	196	275	382	598	843
		kgfm	0.7	1.2	2.5	4.9	11	20	28	39	61	86
Reduction ratio 80 or more	K_1	$\times10^{4}$Nm/rad	0.47	1	1.6	3.1	6.7	13	18	25	40	54
		kgfm/arc min	0.14	0.3	0.47	0.92	2.0	3.8	5.4	7.4	12	16
	K_2	$\times10^{4}$Nm/rad	0.61	1.4	2.5	5.0	11	20	29	40	61	88
		kgfm/arc min	0.18	0.4	0.75	1.5	3.2	6.0	8.5	12	18	26
	K_3	$\times10^{4}$Nm/rad	0.71	1.6	2.9	5.7	12	23	33	44	71	98
		kgfm/arc min	0.21	0.46	0.85	1.7	3.7	6.8	9.7	13	21	29
	θ	$\times10^{-4}$rad	4.1	3.9	4.4	4.4	4.4	4.1	4.1	4.4	4.1	4.4
		arc min	1.4	1.3	1.5	1.5	1.5	1.4	1.4	1.5	1.4	1.5
	θ	$\times10^{-4}$rad	12	9.7	11.3	11.1	11.6	11.1	11.1	11.1	11.1	11.3
		arc min	4.2	3.3	3.9	3.8	4.0	3.8	3.8	3.8	3.8	3.9

* The values in this table are reference values. The minimum value is approximately 80% of the displayed value.

Starting torque

See "Engineering data" for a description of terms. As the values in the table below vary depending on the use conditions, use them as reference values.

■ CSG Series

Table 151-2
Unit: Ncm

Ratio \ Size	14	17	20	25	32	40	45	50	58	65
50	4.5	6.7	8.6	17	34	61	85	—	—	—
80	3.1	4.4	5.4	10	21	39	54	73	108	154
100	2.8	3.7	4.7	8.8	20	34	47	64	97	132
120	—	3.4	4.2	8.0	17	31	43	57	88	121
160	—	—	3.6	6.9	15	26	36	50	75	102

■ CSF Series

Table 151-3
Unit: Ncm

Ratio \ Size	14	17	20	25	32	40	45	50	58	65
30	6.4	9.3	15	25	54	—	—	—	—	—
50	4.1	6.1	7.8	15	31	55	77	110	160	220
80	2.8	4	4.9	9.2	19	35	49	66	98	140
100	2.5	3.4	4.3	8	18	31	43	58	88	120
120	—	3.1	3.8	7.3	15	28	39	52	80	110
160	—	—	3.3	6.3	14	24	33	45	68	93

Backdriving torque

See "Engineering data" for a description of terms. As the values in the table below vary depending on the use conditions, use them as reference values.

■ CSG Series

Table 151-4
Unit: Nm

Ratio \ Size	14	17	20	25	32	40	45	50	58	65
50	1.8	3.3	5.2	9.9	20	36	52	—	—	—
80	1.8	3.3	5.3	10	21	36	53	69	106	154
100	2	3.6	5.6	11	22	40	56	75	121	165
120	—	3.9	6.1	12	24	43	61	80	121	176
160	—	—	7	14	29	51	70	94	143	198

■ CSF Series

Table 151-5
Unit: Nm

Ratio \ Size	14	17	20	25	32	40	45	50	58	65
30	2.4	3.8	6.2	11	23	—	—	—	—	—
50	1.6	3	4.7	9	18	33	47	62	95	130
80	1.6	3	4.8	9.1	19	33	48	63	96	140
100	1.8	3.3	5.1	9.8	20	36	51	68	110	150
120	—	3.5	5.5	11	22	39	55	73	110	160
160	—	—	6.4	13	26	46	64	85	130	180

Ratcheting torque

See "Engineering data" for a description of terms.

■ CSG Series

Table 132-1
Unit: Nm

Ratio \ Size	14	17	20	25	32	40	45	50	58	65
50	110	190	280	580	1200	2300	3500	—	—	—
80	140	260	450	880	1800	3600	5000	7000	10000	14000
100	100	200	330	650	1300	2700	4000	5300	8300	12000
120	—	150	310	610	1200	2400	3600	4900	7500	10000
160	—	—	280	580	1200	2300	3300	4600	7200	10000

■ CSF Series

Table 132-2
Unit: Nm

Ratio \ Size	14	17	20	25	32	40	45	50	58	65
30	59	100	170	340	720	—	—	—	—	—
50	88	150	220	450	980	1800	2700	3700	5800	7800
80	110	200	350	680	1400	2800	3900	5400	8200	11000
100	84	160	260	500	1000	2100	3100	4100	6400	9400
120	—	120	240	470	980	1900	2800	3800	5800	8300
160	—	—	220	450	980	1800	2600	3600	5600	8000

Buckling torque

See "Engineering data" for a description of terms.

■ CSG Series

Table 132-3
Unit: Nm

Size	14	17	20	25	32	40	45	50	58	65
Total reduction ratio	260	500	800	1700	3500	6700	8900	12200	19000	26600

■ CSF Series

Table 132-4
Unit: Nm

Size	14	17	20	25	32	40	45	50	58	65
Total reduction ratio	190	330	560	1000	2200	4300	5800	8000	12000	17000

No-load running torque

No load running torque indicates the torque which is needed to rotate input of the gear, "Wave Generator", with no load on the output side (low speed side).

Measurement condition

Table 132-5

Ratio			
Lubricant	Grease lubrication	Name	Harmonic Grease SK-1A
			Harmonic Grease SK-2
		Quantity	Recommended quantity
Torque value is measured after 2 hours at 2000rpm input.			

* Contact us for oil lubrication.

■ Compensation Value in Each Ratio

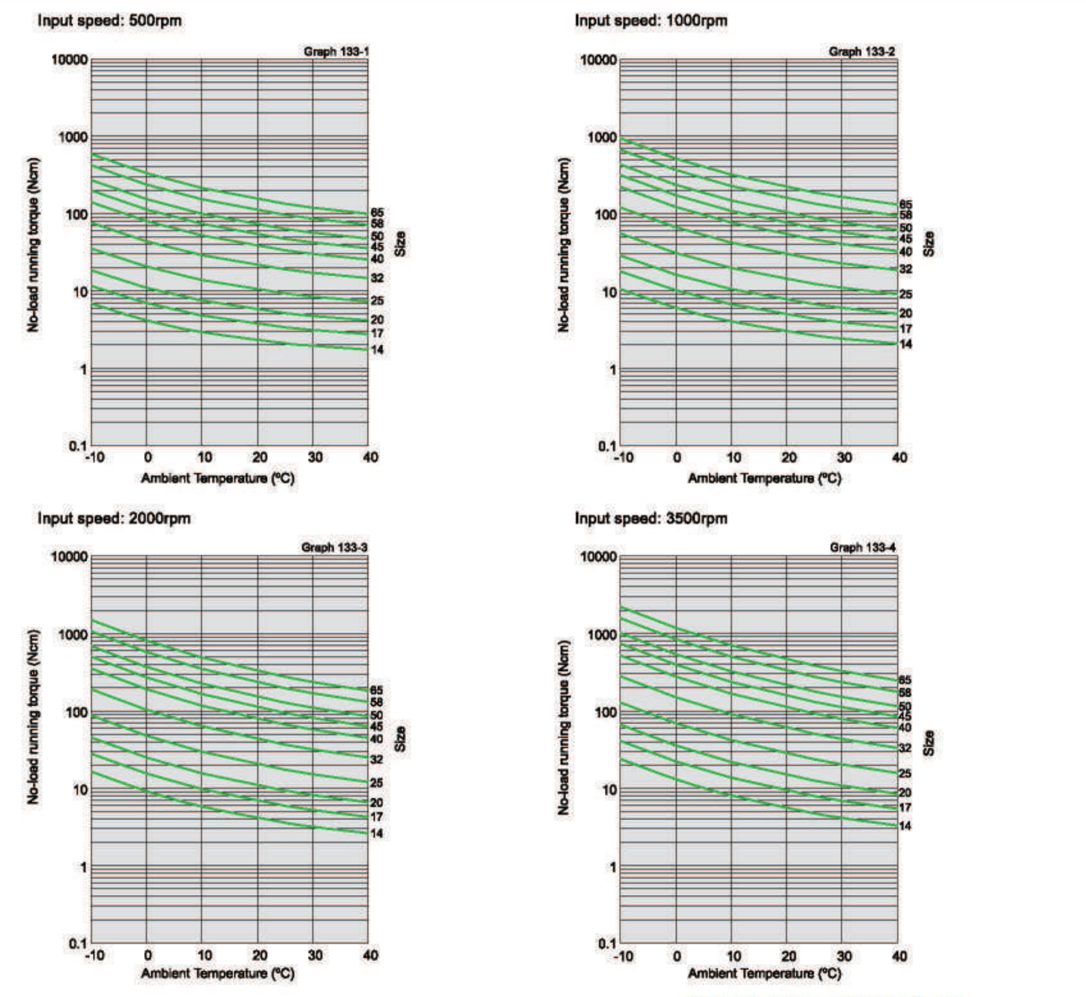
No-load running torque of the gear varies with ratio.
The graphs indicate a value for ratio 100.
For other gear ratios, add the compensation values from table on the right.

Compensation value for no-load running torque

Table 132-6
Unit: Ncm

Size \ Ratio	30	50	80	120	160
14	2.5	1.1	0.2	—	—
17	3.8	1.6	0.3	-0.2	—
20	5.4	2.3	0.5	-0.3	-0.8
25	8.8	3.8	0.7	-0.5	-1.2
32	16	7.1	1.3	-0.9	-2.2
40	—	12	2.1	-1.5	-3.5
45	—	16	2.9	-2.1	-4.9
50	—	21	3.7	-2.6	-6.2
58	—	30	5.3	-3.8	-8.9
65	—	41	7.2	-5.1	-12

■ No-load running torque for a reduction ratio of 100:1



*The values in this graph are average values($\bar{X}$). σ=20%

Efficiency

The efficiency varies depending on the following conditions.

- ■ Reduction ratio
- ■ Input rotational speed
- ■ Load torque
- ■ Temperature
- ■ Lubrication (Type and quantity)

Measurement condition

Table 134-1

Installation	Based on recommended tolerance.		
Load torque	The rated torque shown in the rating table (see page 126 and 127)		
Lubricant	Grease lubrication	Name	Harmonic Grease SK-1A
			Harmonic Grease SK-2
		Quantity	Recommended quantity

■ Efficiency compensation coefficient

If the load torque is lower than the rated torque, the efficiency will be lower. Calculate the compensation coefficient Ke from Graph 134-1 to calculate the efficiency using the following example.

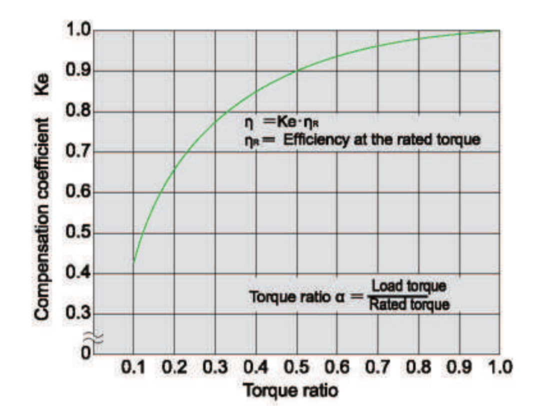
Calculation Example

Efficiency η (%) under the following condition is calculateed from the example of CSF-20-80-2A-GR.
Input rotational speed: 1000 rpm
Load torque: 19.6 Nm
Lubrication: Grease lubrication (Harmonic Grease SK-1A)
Lubricant temperature: 20°C
Since the rated torque of size 20 with a reduction ratio of 80 is 34 Nm (Ratings: Page 127), the torque ratio α is 0.58.
(α =19.6/34=0.58)

- ■ The efficiency compensation coefficient is Ke=0.93 from Graph 134-1.
- ■ Efficiency η at load torque 19.6 Nm: $\eta = Ke \cdot \eta_R = 0.93 \times 78 = 73\%$

Efficiency compensation coefficient

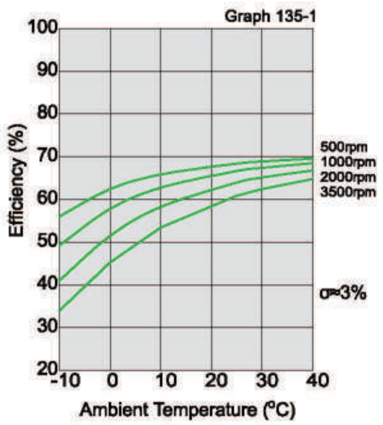
Graph 134-1



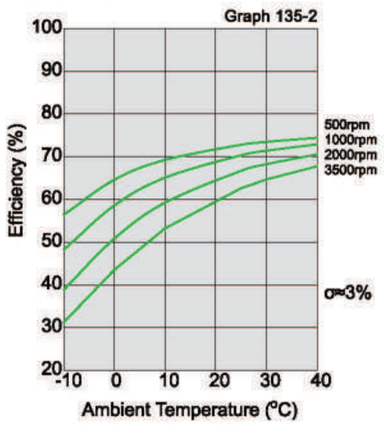
* Efficiency compensation coefficient Ke=1 holds when the load torque is greater than the rated torque.

■ Efficiency at rated torque (Size 14)

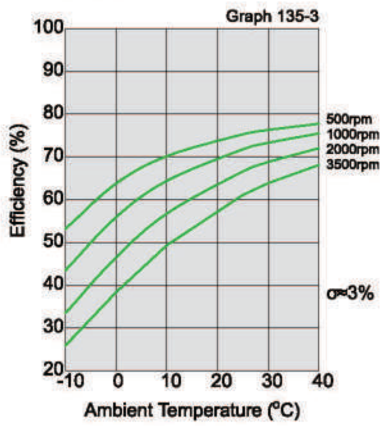
Ratio 30



Ratio 50, 80

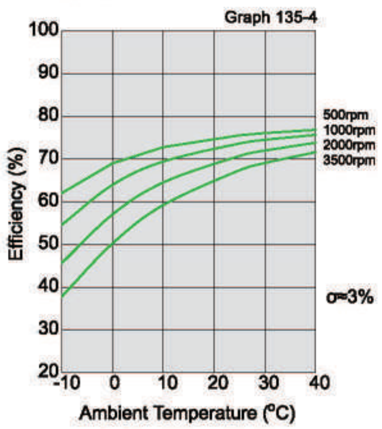


Ratio 100

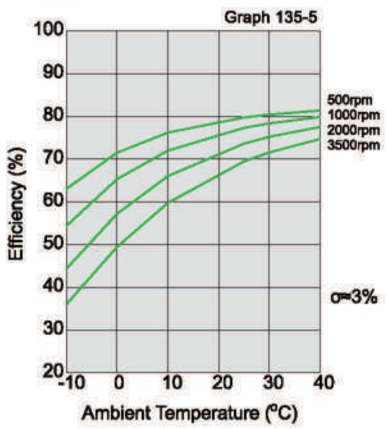


■ Efficiency at rated torque (Sizes 17 to 65)

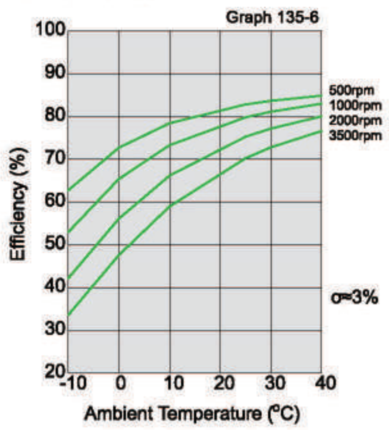
Ratio 30



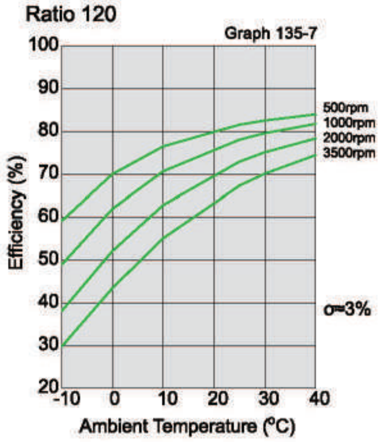
Ratio 50



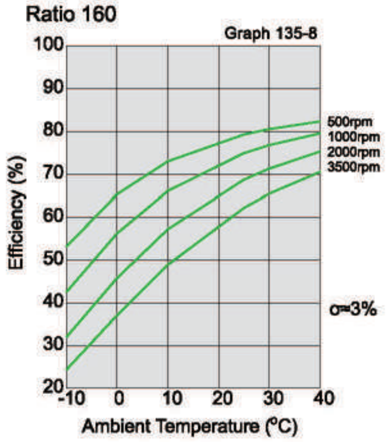
Ratio 80, 100



Ratio 120



Ratio 160



Checking output bearing

A precision cross roller bearing is built in the unit type to directly support the external load (output flange).
Check the maximum moment load, life of the bearing and static safety coefficient to fully bring out the performance of the uni t type.
See Pages 30 to 34 of "Engineering data" for each calculation formula.

■ Checking procedure

(1) Checking the maximum moment load (Mmax)

Calculate maximum moment load (Mmax). → Maximum moment load (Mmax) ≦ allowable moment (Mc)

(2) Checking the life

Calculate the radial load (Frav) and the average axial load (Faav). → Calculate the radial load coefficient (x) and the axial load coefficient (y). → Calculate the lifetime

(3) Checking the static safety coefficient

Calculate the static equivalent radial load coefficient (Po). → Check the static safety coefficient. (fs)

■ Output bearing specifications

The specifications of the cross roller are shown in Table 136-1.

Specifications CSG Series/CSF Series

Table 136-1

Size	Pitch circle dia. of a roller dp	Offset R	Basic rated load				Allowable moment load Mc		Moment stiffness	
			Basic dynamic rated load C		Basic static rated load Co					
	m	m	×10 ³N	kgf	×10 ³N	kgf	Nm	kgfm	×10 ⁴ Nm/rad	kgfm/ arc min
14	0.035	0.0095	47	480	60.7	620	41	4.2	4.38	1.3
17	0.0425	0.0095	52.9	540	75.5	770	64	6.5	7.75	2.3
20	0.050	0.0095	57.8	590	90.0	920	91	9.3	12.8	3.8
25	0.062	0.0115	96.0	980	151	1540	156	16	24.2	7.2
32	0.080	0.013	150	1530	250	2550	313	32	53.9	16
40	0.096	0.0145	213	2170	365	3720	450	46	91.0	27
45	0.111	0.0155	230	2350	426	4340	686	70	141	42
50	0.119	0.018	348	3550	602	6140	759	77	171	51
58	0.141	0.0205	518	5290	904	9230	1180	120	283	84
65	0.160	0.0225	556	5670	1030	10500	1860	190	404	120

* Basic dynamic rated load is a constant radial load where the basic dynamic rated life of CRB is 1 x 106 rotations.
* Basic static rated load is a static load where the value of moment rigidity is the average value.
* The value of the moment stiffness is the average value.

Recommended Tolerances for Assembly

Recommended tolerances for assembly

Fig. 137-1

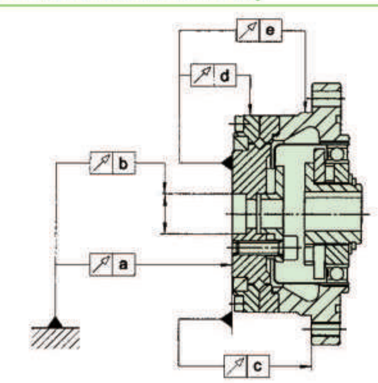


Table 137-1
Unit: mm

Symbol \ Size	14	17	20	25	32	40	45	50	58	65
a	0.010	0.010	0.010	0.015	0.015	0.015	0.018	0.018	0.018	0.018
b	0.010	0.012	0.012	0.013	0.013	0.015	0.015	0.015	0.017	0.017
c	0.024	0.026	0.038	0.045	0.056	0.060	0.068	0.069	0.076	0.085
d	0.010	0.010	0.010	0.010	0.010	0.015	0.015	0.015	0.015	0.015
e	0.038	0.038	0.047	0.049	0.054	0.060	0.065	0.067	0.070	0.075

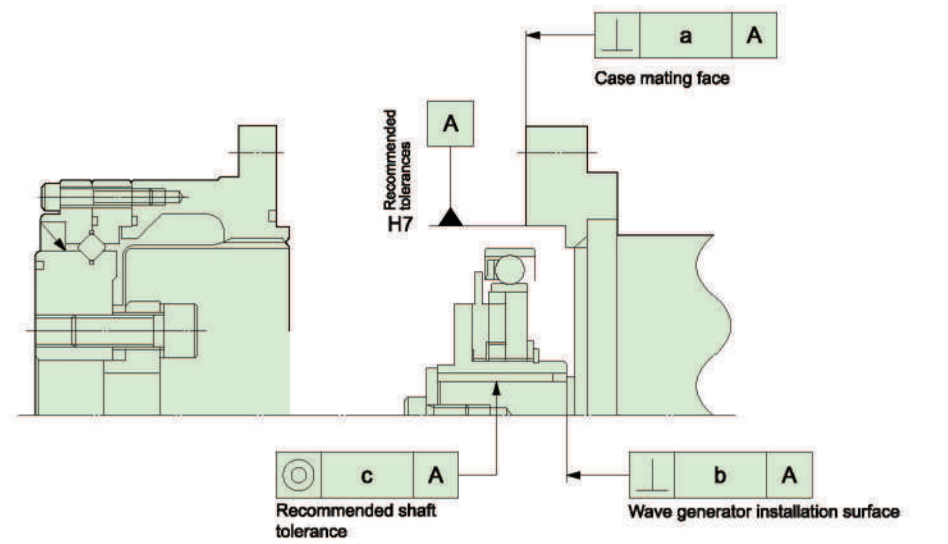
Design Guide

Installation accuracy

For peak performance of your gear, maintain the recommended tolerances shown in Figure 137-1 and Table 137-1.

Recommended tolerances for installation

Fig. 137-2



Recommended Tolerances for Assembly

Table 137-2

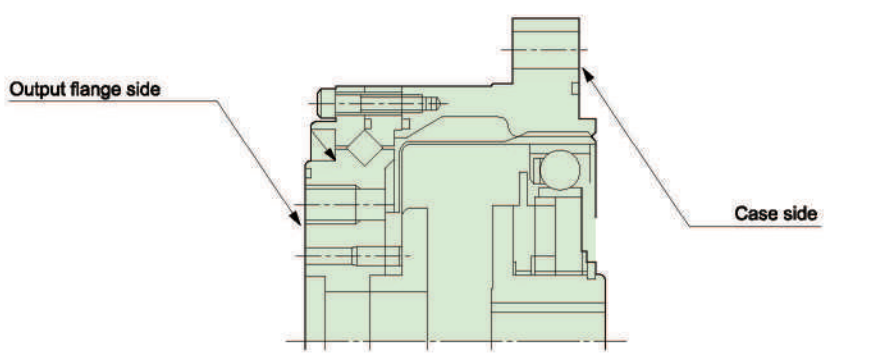
Unit: mm

Symbol \ Size	14	17	20	25	32	40	45	50	58	65
a	0.011	0.015	0.017	0.024	0.026	0.026	0.027	0.028	0.031	0.034
b	0.017	0.020	0.020	0.024	0.024	0.032	0.032	0.032	0.032	0.032
	(0.008)	(0.010)	(0.010)	(0.012)	(0.012)	(0.012)	(0.013)	(0.015)	(0.015)	(0.015)
c	0.030	0.034	0.044	0.047	0.050	0.063	0.065	0.066	0.068	0.070
	(0.016)	(0.018)	(0.019)	(0.022)	(0.022)	(0.024)	(0.027)	(0.030)	(0.033)	(0.035)

* The value in the parentheses indicates that input (wave generator) is a solid wave generator.

Installation and transmission torque

Fig. 138-1



CSG series: Installation of output flange side and transmission torque

Table 138-1

Item \ Size		14	17	20	25	32	40	45	50	58	65
Number of bolts		6	6	8	8	8	8	8	8	8	8
Bolt size		M4	M5	M6	M8	M10	M10	M12	M14	M16	M16
Pitch circle	mm	23	27	32	42	55	68	82	84	100	110
Clamp torque	Nm	5.4	10.8	18.4	45	89	89	154	246	383	383
Torque transmission capacity (bolt only)	Nm	58	109	245	580	1220	1510	2624	3690	5981	6579

CSG series: Installation of case side and transmission torque

Table 138-2

Item \ Size		14	17	20	25	32	40	45	50	58	65
Number of bolts		8	8	8	10	12	10	12	14	12	8
Bolt size		M4	M4	M5	M5	M6	M8	M8	M8	M10	M12
Pitch circle	mm	65	71	82	96	125	144	164	174	206	236
Clamp torque	Nm	4.5	4.5	9.0	9.0	15.3	37	37	37	74	128
Torque transmission capacity (bolt only)	Nm	182	196	365	538	1200	2100	2844	3251	5717	6293

(Table 138-1, 138-2/Notes)
1. The material of the thread must withstand the clamp torque.
2. Recommended bolt: JIS B 1176 socket head cap screw / Strength range: JIS B 1051 over 12.9.
3. Torque coefficient: K=0.2
4. Clamp coefficient: A=1.4
5. Tightening friction coefficient μ=0.15

CSF series: Bolt connection to output flange and resulting transmission torque

Table 139-1

Item \ Size		14	17	20	25	32	40	45	50	58	65
Number of bolts		6	6	8	8	8	8	8	8	8	8
Bolt size		M4	M5	M6	M8	M10	M10	M12	M14	M16	M16
Pitch circle	mm	23	27	32	42	55	68	82	84	100	110
Clamp torque	Nm	4.5	9	15.3	37	74	74	128	205	319	319
Torque transmission capacity (bolt only)	Nm	49	91	204	486	1108	1258	2200	3070	4980	5480

CSF series: Bolt connection to output flange and resulting transmission torque

Table 139-2

Item \ Size		14	17	20	25	32	40	45	50	58	65
Number of bolts		6	6	6	8	12	8	12	12	12	8
Bolt size		M4	M4	M5	M5	M6	M8	M8	M8	M10	M12
Pitch circle	mm	65	71	82	96	125	144	164	174	206	236
Clamp torque	Nm	4.5	4.5	9.0	9.0	15.3	37	37	37	74	128
Torque transmission capacity (bolt only)	Nm	137	147	274	431	1200	1680	2860	3040	5670	6310

(Table 139-1, 139-2/Notes)
1. The material of the thread must withstand the clamp torque.
2. Recommended bolt: JIS B 1176 socket head cap screw / Strength range: JIS B 1051 over 12.9.
3. Torque coefficient: K=0.2
4. Clamp coefficient: A=1.4
5. Tightening friction coefficient μ=0.15

■ Precautions on installing the load to the output flange (Sizes 14 to 25)

As the distance (see the size symbol "L" in Figure 128-1 on Page 128) between the oil seal on the output flange periphery and the edge output flange (rotor) is short for the gear units sizes 14, 17, 20 and 25, the load may interfere with the oil seal. Produce a design so that the load cannot be applied to the oil seal.

Installation of a motor

■ Motor mounting flange

A motor mounting flange is required for installing a motor. The recommended size and precision of the basic part of the motor mounting flange is shown in Table 140-1.

Fig. 140-1

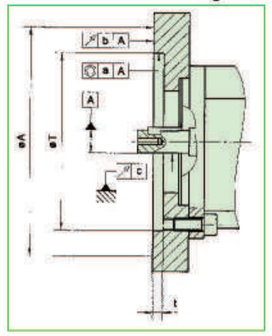


Table 140-1
Unit: mm

Symbol \ Size	14	17	20	25	32	40	45	50	58	65
a	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05
b	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05
c	0.015	0.015	0.018	0.018	0.018	0.018	0.021	0.021	0.021	0.021
φA	73	79	93	107	138	160	180	190	226	260
t	3	3	4.5	4.5	4.5	6	6	6	7.5	7.5
φT	38H7	48H7	56H7	67H7	90H7	110H7	124H7	135H7	156H7	177H7

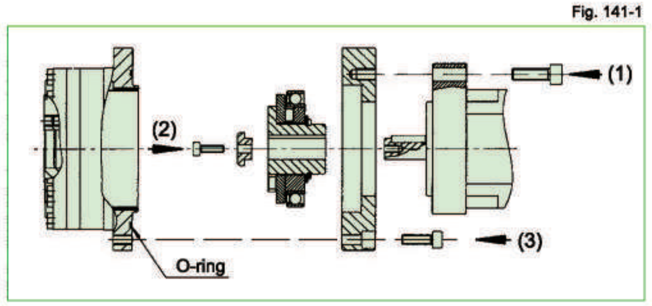
■ Installation procedure

As shown in Figures 141-1 and 141-2, there are two basic procedures to install a motor. Select the installation procedure by the diameter of the pilot hole on the motor mounting surface. Table 141-1 shows the selection standard by the diameter of the pilot hole on the motor mounting surface.

Table 141-1
Unit: mm

Size	14	17	20	25	32	40	45	50	58	65	Reference drawing for installation
The dia. of the pilot hole on the motor mounting surface	<35.5	<43.5	<50.0	<62.5	<81.5	<100.0	<113.5	<124.5	<147	<167	Installation procedure-1 (Fig. 141-1)
	≧35.5	≧43.5	≧50.0	≧62.5	≧81.5	≧100.0	≧113.5	≧124.5	≧147	≧167	Installation procedure-2 (Fig. 141-2)

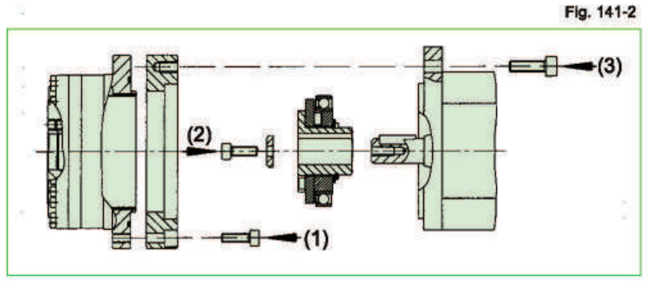
Fig. 141-1



Installation procedure-1

(1) Install the mounting flange on the motor mounting surface.
(2) Install a wave generator on the motor output shaft.
(3) Install the main unit.

Fig. 141-2



Installation procedure-2

(1) Install the mounting flange on the main unit.
(2) Install a wave generator on the motor output shaft.
(3) Install the mounting flange (main unit) on the motor mounting surface.

■ Precautions on assembly

It is extremely important to assemble the gear accurately, in proper sequence. Perform assembly based on the following precautions.

Precautions regarding the wave generator

1. Avoid applying undue axial force to the wave generator during installation. Rotating the wave generator bearing while inserting it is recommended and will ease the process.
2. If the wave generator does not have an Oldham coupling, extra care must be given to ensure that concentricity and inclination are within the specified limits (see "Installation accuracy" of each series on Page 137).

Other precautions

1. Is the flatness of the mounting surface poor or distorted?
2. Is any embossment of the screw hole area, burr or trapped foreign matter found?
3. Have chamfering and relief working of the corner been performed to prevent interference with the area of installation of the unit?

Rust-prevention

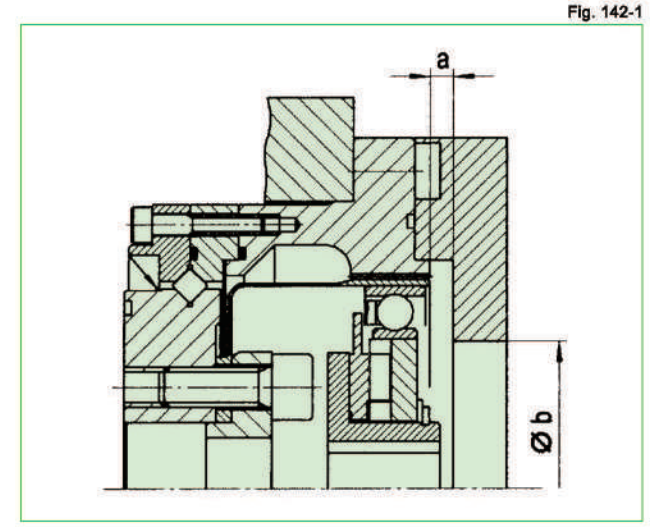
Although Harmonic Drive® gears come with some corrosion protection, the gear can rust if exposed to the environment. The gear external surfaces typically have only a temporary corrosion inhibitor and some oil applied. If an anti-rust product is needed, please contact us to review the options.

Lubrication

Grease lubrication is standard for the CSF/CSG gear units. Harmonic Grease SK-2 is for sizes 14 and 17, and Harmonic Grease SK-1A is for sizes 20 to 65 (Harmonic Grease 4B No.2 for the cross roller bearing). Harmonic Grease 4B No.2 is also available for long-life and for use in a wide temperature range. (see "Engineering data" for the specifications of the grease).

See table below for recommended housing dimensions. These dimensions must be maintained to prevent damage to the gear and to maintain a proper grease cavity.

Fig. 142-1



Recommended housing dimensions

Table 142-1
Unit: mm

Symbol \ Size	14	17	20	25	32	40	45	50	58	65
a*	1	1	1.5	1.5	1.5	2	2	2	2.5	2.5
a**	3	3	4.5	4.5	4.5	6	6	6	7.5	7.5
φb	16	26	30	37	37	45	45	45	56	62

* Horizontal and vertical: when the wave generator is below
** Vertical: when the wave generator is above

■ Other precautions

Fill the gap between the wave generator and the input cover (motor flange) with grease to use the wave generator facing upward or downward (see Figure 048-3 on Page 48).

Sealing

Sealing is needed to maintain the high durability of the gear and prevent grease leakage

- Rotating Parts .... Oil seal (with a spring). Surface should be smooth (no scratches)
- Mating flange .... O-ring and seal adhesive. Take care regarding distortion on the plane and how the O-ring is engaged.
- Screw hole area .... Screws should have a thread lock (LOCKTITE 242 is recommended) or seal adhesive.

(Note) If you use Harmonic Grease 4BNo.2, strict sealing is required.

Sealing area and the recommended sealing method for the unit type

Table 142-2

Area requiring sealing		Recommended sealing method
Output side	Pass-through hole in the center of the output flange and the output flange mating face	Use O-ring (supplied with product)
	Spanner screw area	Screw lock agent with sealing effect (LOCTITE® 242 is recommended)
Input side	Flange mating face	Use O-ring (supplied with product)
	Motor output shaft	Please select a motor which has an oil seal on the output shaft.

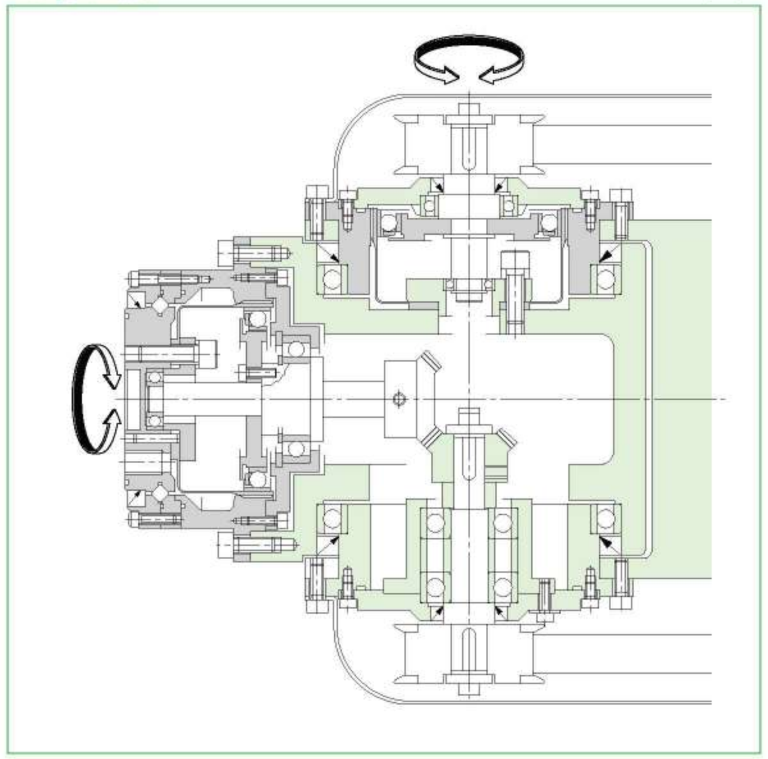
Rust prevention

Although Harmonic Drive® gears come with some corrosion protection, the gear can rust if exposed to the environment. The gear external surfaces typically have only a temporary corrosion inhibitor and some oil applied. If an anti-rust product is needed, please contact us to review the options.

Application

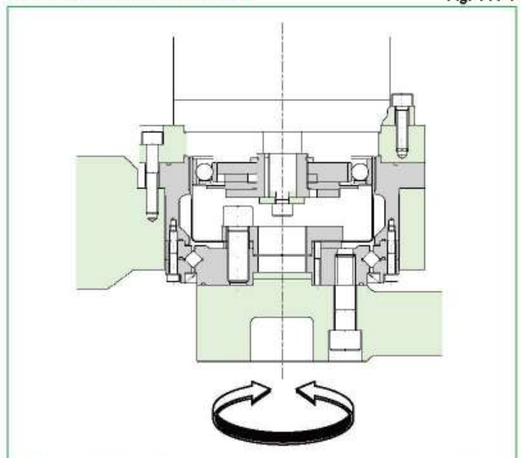
Multi-joint Robot

Fig. 143-1



Horizontal Multi Arm Robot

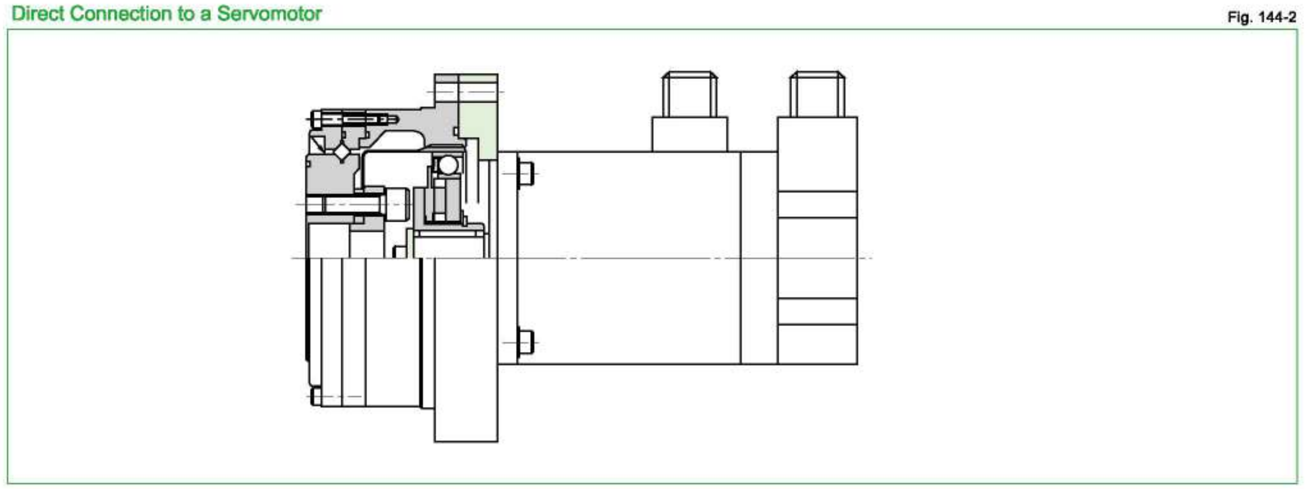
Fig. 144-1



* For usage as this installation example, sealing is required to prevent grease leakage.

Direct Connection to a Servomotor

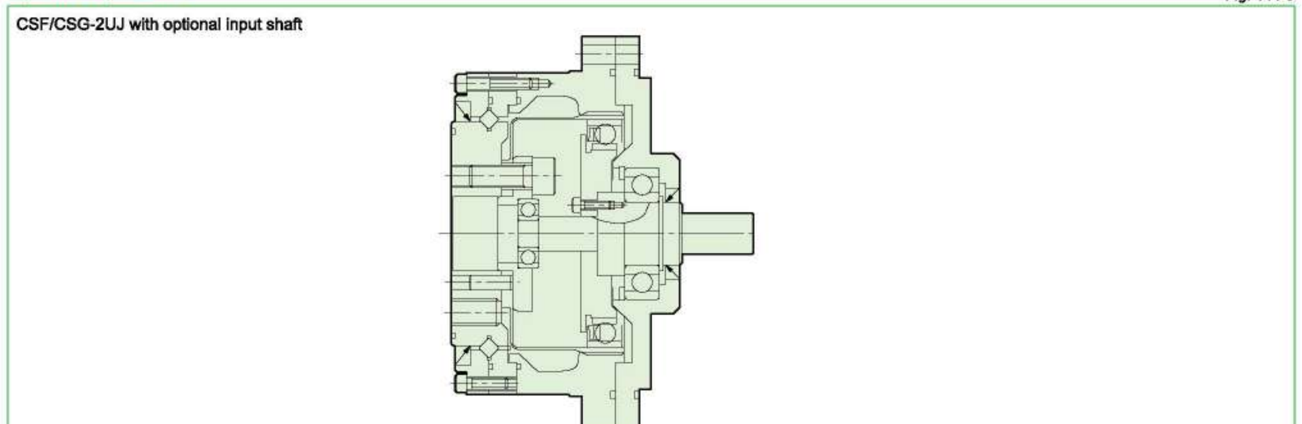
Fig. 144-2



Optional Input Shaft

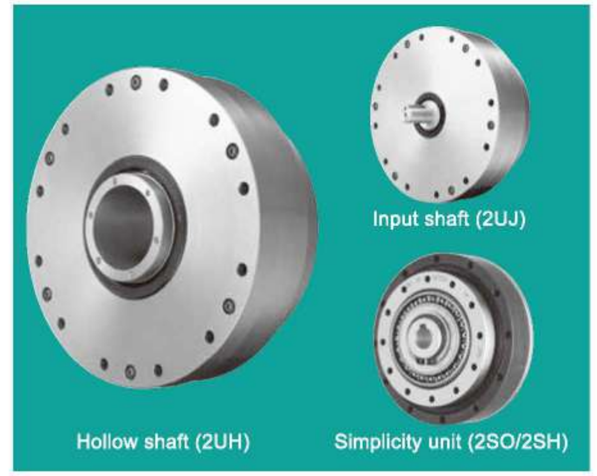
Fig. 144-3

CSF/CSG-2UJ with optional input shaft



* Contact us for details

Features



SHG/SHF series gear units

The SHG/SHF series gear unit is an easy-to-use gearhead solution. An accurate, highly rigid cross roller bearing is built in to directly support the external load.

Features

- Zero backlash
- Large bore with hollow through hole
- Input shaft option available
- Flat shape, compact and simple design
- High-torque capacity
- High stiffness
- High-positional and rotational accuracies
- Coaxial input and output

Configurations

The SHG/SHF gearheads are available in 4 variations allowing the customer to choose the best configuration for their application.

- Large-diameter hollow shaft: (2UH)
- Input shaft (2UJ)
- Easier to use: Simplicity unit (2SO)
  Hollow shaft simplicity unit (2SH)

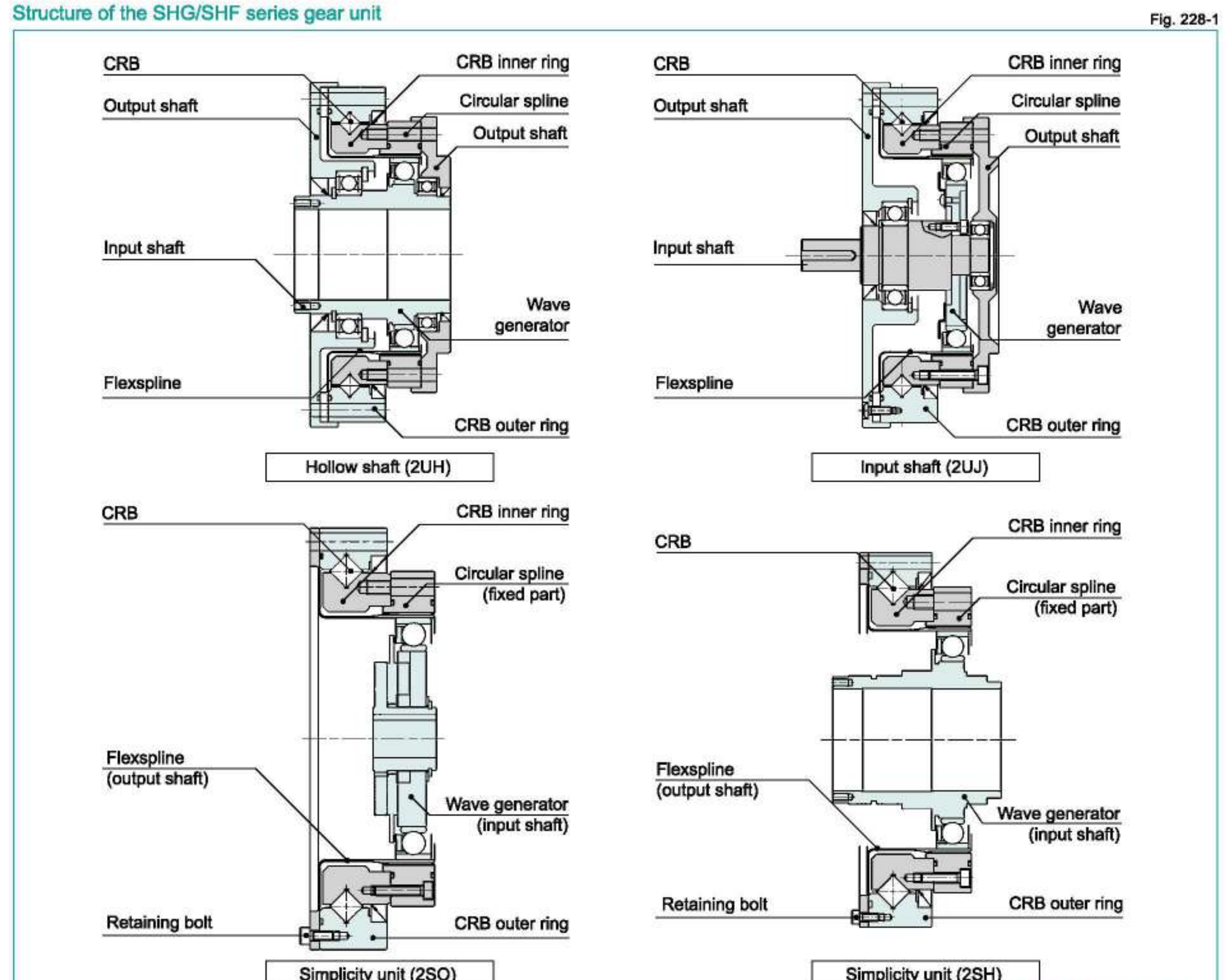
Series

SHG: high torque
- Torque capacity has been improved by 30% compared to the SHF series.
- The life has been improved by 43% (10,000 hours) compared to the SHF series.

SHF: standard torque
- Reduction ratio of 30:1 added for high speed.

Structure of the SHG/SHF series gear unit

Fig. 228-1



* CRB: Cross roller bearing

Ordering Code

SHG - 25 - 100 - 2UH - SP

Table 229-1

Series	Size	Ratio *1					Model	Special specification
SHG	14	50	80	100	—	—	2A-GR = Component set (2A-R for sizes 14, 17) 2UH = Hollow shaft 2UJ = Input shaft 2SO = Simplicity unit (Std. structure) 2SH = Simplicity unit (Hollow shaft)	LW = Lightweight SP = Special specification code Blank = Standard product
	17	50	80	100	120	—		
	20	50	80	100	120	160		
	25	50	80	100	120	160		
	32	50	80	100	120	160		
	40	50	80	100	120	160		
	45	50	80	100	120	160		
	50	—	80	100	120	160		
	58	—	80	100	120	160		
	65	—	80	100	120	160		

*1: The reduction ratio value is based on the following configuration: Input: wave generator, fixed: circular spline, output: flexspline

Technical Data

Rating table

■ SHG series

Table 230-1

Size	Ratio	Rated torque at 2000rpm		Limit for repeated peak torque		Limit for average torque		Limit for momentary peak torque		Maximum input speed (rpm)		Limit for average input speed (rpm)	
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Oil lubricant	Grease lubricant	Oil lubricant	Grease lubricant
14	50	7.0	0.7	23	2.3	9	0.9	46	4.7	14000	8500	6500	3500
	80	10	1.0	30	3.1	14	1.4	61	6.2				
	100	10	1.0	36	3.7	14	1.4	70	7.2				
17	50	21	2.1	44	4.5	34	3.4	91	9	10000	7300	6500	3500
	80	29	2.9	56	5.7	35	3.6	113	12				
	100	31	3.2	70	7.2	51	5.2	143	15				
	120	31	3.2	70	7.2	51	5.2	112	11				
20	50	33	3.3	73	7.4	44	4.5	127	13	10000	6500	6500	3500
	80	44	4.5	96	9.8	61	6.2	165	17				
	100	52	5.3	107	10.9	64	6.5	191	20				
	120	52	5.3	113	11.5	64	6.5	191	20				
	160	52	5.3	120	12.2	64	6.5	191	20				
25	50	51	5.2	127	13	72	7.3	242	25	7500	5600	5600	3500
	80	82	8.4	178	18	113	12	332	34				
	100	87	8.9	204	21	140	14	369	38				
	120	87	8.9	217	22	140	14	395	40				
	160	87	8.9	229	23	140	14	408	42				
32	50	99	10	281	29	140	14	497	51	7000	4800	4600	3500
	80	153	16	395	40	217	22	738	75				
	100	178	18	433	44	281	29	841	86				
	120	178	18	459	47	281	29	892	91				
	160	178	18	484	49	281	29	892	91				
40	50	178	18	523	53	255	26	892	91	5600	4000	3600	3000
	80	268	27	675	69	369	38	1270	130				
	100	345	35	738	75	484	49	1400	143				
	120	382	39	802	82	586	60	1530	156				
	160	382	39	841	86	586	60	1530	156				
45	50	229	23	650	66	345	35	1235	126	5000	3800	3300	3000
	80	407	41	918	94	507	52	1651	168				
	100	459	47	982	100	650	66	2041	208				
	120	523	53	1070	109	806	82	2288	233				
	160	523	53	1147	117	819	84	2483	253				
50	80	484	49	1223	125	675	69	2418	247	4500	3500	3000	2500
	100	611	62	1274	130	866	88	2678	273				
	120	688	70	1404	143	1057	108	2678	273				
	160	688	70	1534	156	1096	112	3185	325				
58	80	714	73	1924	196	1001	102	3185	325	4000	3000	2700	2200
	100	905	92	2067	211	1378	141	4134	422				
	120	969	99	2236	228	1547	158	4329	441				
	160	969	99	2392	244	1573	160	4459	455				
65	80	969	99	2743	280	1352	138	4836	493	3500	2800	2400	1900
	100	1236	126	2990	305	1976	202	6175	630				
	120	1236	126	3263	333	2041	208	6175	630				
	160	1236	126	3419	349	2041	208	6175	630				

(Note) 1. Moment of inertia : $I = \frac{1}{4} GD^2$
2. See Rating Table Definitions on Page 12 for details of the terms.

Ordering Code

SHF - 25 - 100 - 2UH - SP

Table 229-2

Series	Size	Ratio *1						Model	Special specification
SHF	11*2	—	50	—	100	—	—	2A-GR = Component set (2A-R for sizes 14, 17) 2UH = Hollow shaft 2UJ = Input shaft 2SO = Simplicity unit (Std. structure) 2SH = Simplicity unit (Hollow shaft)	LW = Lightweight SP = Special specification code Blank = Standard product
	14	30	50	80	100	—	—		
	17	30	50	80	100	120	—		
	20	30	50	80	100	120	160		
	25	30	50	80	100	120	160		
	32	30	50	80	100	120	160		
	40	—	50	80	100	120	160		
	45	—	50	80	100	120	160		
	50	—	50	80	100	120	160		
	58	—	50	80	100	120	160		

*1: The reduction ratio value is based on the following configuration: Input: wave generator, fixed: circular spline, output: flexspline
*2: Size 11 is only available in SHF-2UH

Rating table

■ SHF series

Table 231-1

Size	Ratio	Rated torque at 2000rpm		Limit for repeated peak torque		Limit for average torque		Limit for momentary peak torque		Maximum input speed (rpm)		Limit for average input speed (rpm)	
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Oil lubricant	Grease lubricant	Oil lubricant	Grease lubricant
11	50	3.5	0.36	8.3	0.85	5.5	0.56	17	1.73	14000	8500	6500	3500
	100	5	0.51	11	1.12	8.9	0.91	25	2.55				
14	30	4.0	0.41	9.0	0.92	6.8	0.69	17	1.7	14000	8500	6500	3500
	50	5.4	0.55	18	1.8	6.9	0.70	35	3.6				
	80	7.8	0.80	23	2.4	11	1.1	47	4.8				
	100	7.8	0.80	28	2.9	11	1.1	54	5.5				
17	30	8.8	0.90	16	1.6	12	1.2	30	3.1	10000	7300	6500	3500
	50	16	1.6	34	3.5	26	2.6	70	7.1				
	80	22	2.2	43	4.4	27	2.7	87	8.9				
	100	24	2.4	54	5.5	39	4.0	110	11				
	120	24	2.4	54	5.5	39	4.0	86	8.8				
20	30	15	1.5	27	2.8	20	2.0	50	5.1	10000	6500	6500	3500
	50	25	2.5	56	5.7	34	3.5	98	10				
	80	34	3.5	74	7.5	47	4.8	127	13				
	100	40	4.1	82	8.4	49	5.0	147	15				
	120	40	4.1	87	8.9	49	5.0	147	15				
	160	40	4.1	92	9.4	49	5.0	147	15				
25	30	27	2.8	50	5.1	38	3.9	95	9.7	7500	5600	5600	3500
	50	39	4.0	98	10	55	5.6	186	19				
	80	63	6.4	137	14	87	8.9	255	26				
	100	67	6.8	157	16	108	11	284	29				
	120	67	6.8	167	17	108	11	304	31				
	160	67	6.8	176	18	108	11	314	32				
32	30	54	5.5	100	10	75	7.7	200	20	7000	4800	4600	3500
	50	76	7.8	216	22	108	11	382	39				
	80	118	12	304	31	167	17	568	58				
	100	137	14	333	34	216	22	647	66				
	120	137	14	353	36	216	22	686	70				
	160	137	14	372	38	216	22	686	70				
40	50	137	14	402	41	196	20	686	70	5600	4000	3600	3000
	80	206	21	519	53	284	29	980	100				
	100	265	27	568	58	372	38	1080	110				
	120	294	30	617	63	451	46	1180	120				
	160	294	30	647	66	451	46	1180	120				
45	50	176	18	500	51	265	27	950	97	5000	3800	3300	3000
	80	313	32	706	72	390	40	1270	130				
	100	353	36	755	77	500	51	1570	160				
	120	402	41	823	84	620	63	1760	180				
	160	402	41	882	90	630	64	1910	195				
50	50	122	12	715	73	175	18	1430	146	4500	3500	3000	2500
	80	372	38	941	96	519	53	1860	190				
	100	470	48	980	100	666	68	2060	210				
	120	529	54	1080	110	813	83	2060	210				
	160	529	54	1180	120	843	86	2450	250				
58	50	176	18	1020	104	260	27	1960	200	4000	3000	2700	2200
	80	549	56	1480	151	770	79	2450	250				
	100	696	71	1590	162	1060	108	3180	325				
	120	745	76	1720	176	1190	121	3330	340				
	160	745	76	1840	188	1210	123	3430	350				

(Note) 1. Oil lubrication is standard for gear units size 50 or larger with a reduction ratio of 50. Use grease lubrication within half the rated torque.
2. Moment of inertia : $I = \frac{1}{4} GD^2$ 3. See Rating Table Definitions on Page 12 for details of the terms. 4. Size 11 is only available in 2UH.

Positional accuracy

See "Engineering data" for a description of terms.

Table 232-1

Ratio	Specification \ Size		11	14	17	20	25	32	40 or more
30	Standard product	× 10^{-4}rad	—	5.8	4.4	4.4	4.4	4.4	—
		arc min	—	2	1.5	1.5	1.5	1.5	—
	Special product	× 10^{-4}rad	—	—	—	2.9	2.9	2.9	—
		arc min	—	—	—	1	1	1	—
50 or more	Standard product	× 10^{-4}rad	5.8(4.4)	4.4	4.4	2.9	2.9	2.9	2.9
		arc min	2(1.5)	1.5	1.5	1	1	1	1
	Special product	× 10^{-4}rad	—	2.9	2.9	1.5	1.5	1.5	1.5
		arc min	—	1	1	0.5	0.5	0.5	0.5

Note 1: * The parenthesized value of size 11 indicates the value for reduction ratio 100.

Hysteresis loss

See "Engineering data" for a description of terms.

Table 232-2

Ratio	Unit \ Size	11	14	17	20	25	32	40 or more
30	× 10^{-4}rad	—	8.7	8.7	8.7	8.7	8.7	—
	arc min	—	3.0	3.0	3.0	3.0	3.0	—
50	× 10^{-4}rad	5.8	5.8	5.8	5.8	5.8	5.8	5.8
	arc min	2.0	2.0	2.0	2.0	2.0	2.0	2.0
80 or more	× 10^{-4}rad	5.8	2.9	2.9	2.9	2.9	2.9	2.9
	arc min	2.0	1.0	1.0	1.0	1.0	1.0	1.0

Backlash

See "Engineering data" for a description of terms.

Table 232-3

Ratio	Size	11	14	17	20	25	32	40	45	50	58	65
30	× 10^{-5}rad	—	29.1	16.0	13.6	13.6	11.2	—	—	—	—	—
	arc sec	—	60	33	28	28	23	—	—	—	—	—
50	× 10^{-5}rad	Note 1	17.5	9.7	8.2	8.2	6.8	6.8	5.8	5.8	4.8	—
	arc sec	Note 1	36	20	17	17	14	14	12	12	10	—
80	× 10^{-5}rad	—	11.2	6.3	5.3	5.3	4.4	4.4	3.9	3.9	2.9	2.9
	arc sec	—	23	13	11	11	9	9	8	8	6	6
100	× 10^{-5}rad	Note 1	8.7	4.8	4.4	4.4	3.4	3.4	2.9	2.9	2.4	2.4
	arc sec	Note 1	18	10	9	9	7	7	6	6	5	5
120	× 10^{-5}rad	—	—	3.9	3.9	3.9	2.9	2.9	2.4	2.4	1.9	1.9
	arc sec	—	—	8	8	8	6	6	5	5	4	4
160	× 10^{-5}rad	—	—	—	2.9	2.9	2.4	2.4	1.9	1.9	1.5	1.5
	arc sec	—	—	—	6	6	5	5	4	4	3	3

Note 1: For size 11, the wave generator is a solid wave generator. See "Engineering data" for details.

Torsional stiffness

See "Engineering data" for a description of terms.

Table 232-4

Symbol		Size	11	14	17	20	25	32	40	45	50	58	65
	T_1	Nm	0.8	2.0	3.9	7.0	14	29	54	76	108	168	235
		kgfm	0.082	0.2	0.4	0.7	1.4	3.0	5.5	7.8	11	17	24
	T_2	Nm	2.0	6.9	12	25	48	108	196	275	382	598	843
		kgfm	0.2	0.7	1.2	2.5	4.9	11	20	28	39	61	86
Reduction ratio 30	K_1	× 10^4Nm/rad	—	0.19	0.34	0.57	1.0	2.4	—	—	—	—	—
		kgfm/arc min	—	0.056	0.10	0.17	0.30	0.70	—	—	—	—	—
	K_2	× 10^4Nm/rad	—	0.24	0.44	0.71	1.3	3.0	—	—	—	—	—
		kgfm/arc min	—	0.07	0.13	0.21	0.40	0.89	—	—	—	—	—
	K_3	× 10^4Nm/rad	—	0.34	0.67	1.1	2.1	4.9	—	—	—	—	—
		kgfm/arc min	—	0.10	0.20	0.32	0.62	1.5	—	—	—	—	—
	θ_1	× 10^{-4}rad	—	10.5	11.5	12.3	14	12.1	—	—	—	—	—
		arc min	—	3.6	4.0	4.1	4.7	4.3	—	—	—	—	—
	θ_2	× 10^{-4}rad	—	31	30	38	40	38	—	—	—	—	—
		arc min	—	10.7	10.2	12.7	13.4	13.3	—	—	—	—	—
Reduction ratio 50	K_1	× 10^4Nm/rad	0.22	0.34	0.81	1.3	2.5	5.4	10	15	20	31	—
		kgfm/arc min	0.066	0.1	0.24	0.38	0.74	1.6	3.0	4.3	5.9	9.3	—
	K_2	× 10^4Nm/rad	0.3	0.47	1.1	1.8	3.4	7.8	14	20	28	44	—
		kgfm/arc min	0.09	0.14	0.32	0.52	1.0	2.3	4.2	6.0	8.2	13	—
	K_3	× 10^4Nm/rad	0.32	0.57	1.3	2.3	4.4	9.8	18	26	34	54	—
		kgfm/arc min	0.096	0.17	0.4	0.67	1.3	2.9	5.3	7.6	10	16	—
	θ_1	× 10^{-4}rad	3.6	5.8	4.9	5.2	5.5	5.5	5.2	5.2	5.5	5.2	—
		arc min	1.2	2.0	1.7	1.8	1.9	1.9	1.8	1.8	1.9	1.8	—
	θ_2	× 10^{-4}rad	8.0	16	12	15.4	15.7	15.7	15.4	15.1	15.4	15.1	—
		arc min	2.6	5.6	4.2	5.3	5.4	5.4	5.3	5.2	5.3	5.2	—

* The values in this table are reference values. The minimum value is approximately 80% of the displayed value.

Table 233-1

Symbol		Size	11	14	17	20	25	32	40	45	50	58	65
	T_1	Nm	0.8	2.0	3.9	7.0	14	29	54	76	108	168	235
		kgfm	0.82	0.2	0.4	0.7	1.4	3.0	5.5	7.8	11	17	24
	T_2	Nm	2	6.9	12	25	48	108	196	275	382	598	843
		kgfm	0.2	0.7	1.2	2.5	4.9	11	20	28	39	61	86
Reduction ratio 80 or more	K_1	× 10^4Nm/rad	0.27	0.47	1	1.6	3.1	6.7	13	18	25	40	54
		kgfm/arc min	0.08	0.14	0.3	0.47	0.92	2.0	3.8	5.4	7.4	12	16
	K_2	× 10^4Nm/rad	0.34	0.61	1.4	2.5	5.0	11	20	29	40	61	88
		kgfm/arc min	0.1	0.18	0.4	0.75	1.5	3.2	6.0	8.5	12	18	26
	K_3	× 10^4Nm/rad	0.44	0.71	1.6	2.9	5.7	12	23	33	44	71	98
		kgfm/arc min	0.13	0.21	0.46	0.85	1.7	3.7	6.8	9.7	13	21	29
	θ_1	× 10^{-4}rad	3	4.1	3.9	4.4	4.4	4.4	4.1	4.1	4.4	4.1	4.4
		arc min	1	1.4	1.3	1.5	1.5	1.5	1.4	1.4	1.5	1.4	1.5
	θ_2	× 10^{-4}rad	6	12	9.7	11.3	11.1	11.6	11.1	11.1	11.1	11.1	11.3
		arc min	2.2	4.2	3.3	3.9	3.8	4.0	3.8	3.8	3.8	3.8	3.9

* The values in this table are reference values. The minimum value is approximately 80% of the displayed value.

Ratcheting torque

See "Engineering data" for a description of terms.

■ SHG series

Table 233-2
Unit:Nm

Ratio \ Size	14	17	20	25	32	40	45	50	58	65
50	110	190	280	580	1200	2300	3500	—	—	—
80	140	260	450	880	1800	3600	5000	7000	10000	14000
100	100	200	330	650	1300	2700	4000	5300	8300	12000
120	—	150	310	610	1200	2400	3600	4900	7500	10000
160	—	—	280	580	1200	2300	3300	4600	7200	10000

■ SHF series

Table 233-3
Unit:Nm

Ratio \ Size	11	14	17	20	25	32	40	45	50	58
30	—	59	100	170	340	720	—	—	—	—
50	34	88	150	220	450	980	1800	2700	3700	5800
80	—	110	200	350	680	1400	2800	3900	5400	8200
100	43	84	160	260	500	1000	2100	3100	4100	6400
120	—	—	120	240	470	980	1900	2800	3800	5800
160	—	—	—	220	450	980	1800	2600	3600	5600

Buckling torque

See "Engineering data" for a description of terms.

■ SHG series

Table 233-4
Unit: Nm

Size	14	17	20	25	32	40	45	50	58	65
Total reduction ratio	210	420	700	1300	2800	5200	7600	10400	16200	22800

■ SHF series

Table 233-5
Unit: Nm

Size	11	14	17	20	25	32	40	45	50	58
Total reduction ratio	90	140	270	440	890	1750	3750	5400	7500	11800

Checking output bearing

A precision cross roller bearing is built in the unit type to directly support the external load (output flange).
Please calculate maximum moment load, life of cross roller bearing,
and static safety factor to fully maximize the performance of housed unit (gearhead).

See Pages 030 to 034 of "Engineering data" for each calculation formula.

■ Checking procedure

(1) Checking the maximum moment load (Mmax)

Calculate the maximum moment load (Mmax). → Maximum moment load (Mmax) ≦ allowable moment (Mc)

(2) Checking the life

Calculate the radial load (Frav) and the average axial load (Faav). → Calculate the radial load coefficient (x) and the axial load coefficient (y). → Calculate the lifetime

(3) Checking the static safety coefficient

Calculate the static equivalent radial load coefficient (Po). → Check the static safety coefficient. (fs)

■ Output bearing specifications

The specifications of the cross roller are shown in Table 234-1.

Specifications

Table 234-1

Size	Pitch circle dp	Offset R	Basic rated load: Basic dynamic rated load C		Basic rated load: Basic static rated load Co		Allowable moment load Mc		Moment stiffness Km	
	m	m	$\times 10^2$ N	kgf	$\times 10^2$ N	kgf	Nm	kgfm	$\times 10^4$ Nm/rad	kgfm/ arc min
11	0.043	0.018	52.9	540	75.5	770	74	7.6	6.5	1.8
14	0.050	0.0217	58	590	86	880	※ 74	7.6	8.5	2.5
17	0.060	0.0239	104	1060	163	1670	※ 124	12.6	15.4	4.6
20	0.070	0.0255	146	1490	220	2250	※ 187	19.1	25.2	7.5
25	0.085	0.0296	218	2230	358	3660	258	26.3	39.2	11.6
32	0.111	0.0364	382	3900	654	6680	580	59.1	100	29.6
40	0.133	0.044	433	4410	816	8330	849	86.6	179	53.2
45	0.154	0.0475	776	7920	1350	13800	1127	115	257	76.3
50	0.170	0.0525	816	8330	1490	15300	1487	152	351	104
58	0.195	0.0622	874	8920	1710	17500	2180	222	531	158
65	0.218	0.072	1300	13300	2230	22700	2740	280	741	220

* The basic dynamic rated load means a certain static radial load so that the basic dynamic rated life of the roller bearing is a million rotations. The basic static rated load means a static load that gives a certain level of contact stress (4 kN/mm^2) in the center of the contact area between the rolling element receiving the maximum load and the orbit.

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

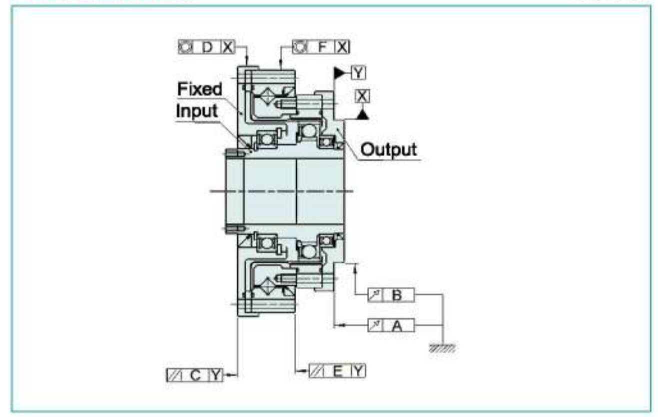
Recommended tolerances for assembly

Recommended tolerances for assembly shown below.

■ Flexspline fixed

Input: Wave generator
Output: Circular spline
Fixed: Flexspline

Hollow Shaft (2UH) — Fig. 235-1



Input shaft (2UJ) — Fig. 235-2

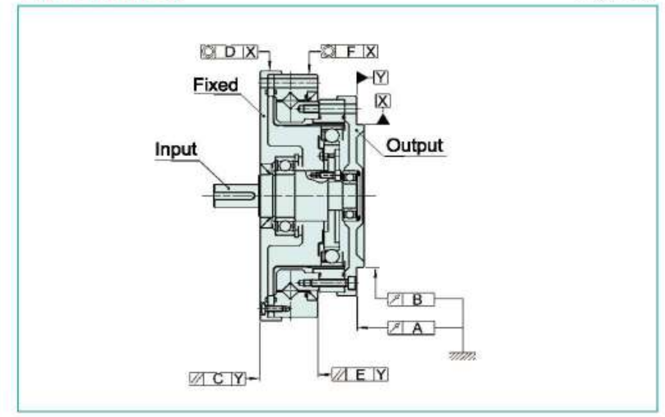


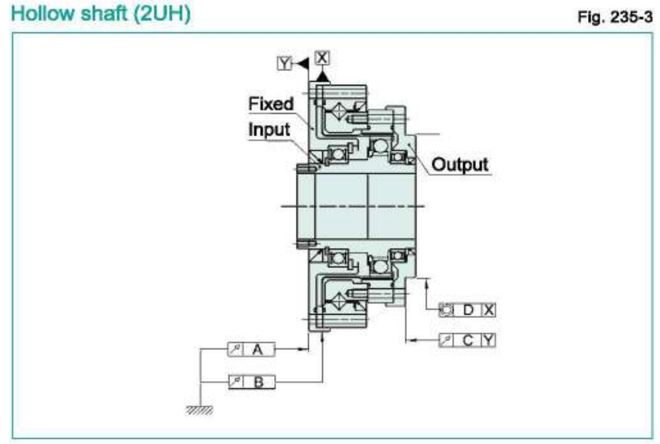
Table 235-1
Unit: mm

Symbol \ Size	11	14	17	20	25	32	40	45	50	58	65
A	0.033	0.033	0.038	0.040	0.046	0.054	0.057	0.057	0.063	0.063	0.067
B	0.035	0.035	0.035	0.039	0.041	0.047	0.050	0.053	0.060	0.063	0.063
C	0.053	0.064	0.071	0.079	0.085	0.104	0.111	0.118	0.121	0.121	0.131
D	0.053	0.053	0.050	0.059	0.061	0.072	0.075	0.078	0.085	0.088	0.089
E	0.039	0.040	0.045	0.051	0.057	0.065	0.071	0.072	0.076	0.076	0.082
F	0.038	0.038	0.038	0.047	0.049	0.054	0.060	0.065	0.067	0.070	0.072

■ Circular spline fixed

Input: Wave generator
Output: Flexspline
Fixed: Circular spline

Hollow shaft (2UH) — Fig. 235-3



Input shaft (2UJ) — Fig. 235-4

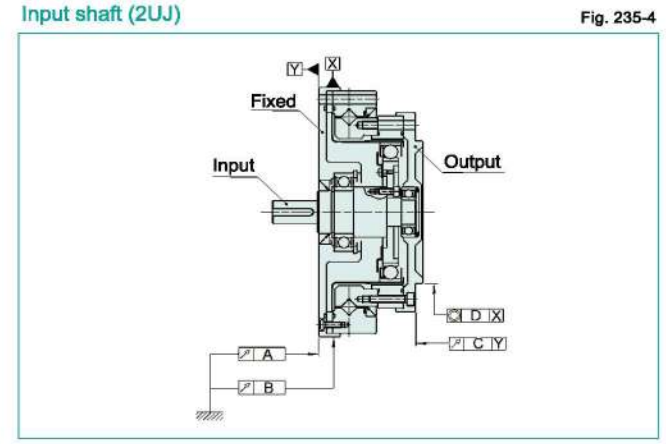


Table 171-2
Unit: mm

Symbol \ Size	11	14	17	20	25	32	40	45	50	58	65
A	0.027	0.037	0.039	0.046	0.047	0.059	0.060	0.070	0.070	0.070	0.076
B	0.031	0.031	0.031	0.038	0.038	0.045	0.048	0.050	0.050	0.050	0.054
C	0.053	0.064	0.071	0.079	0.085	0.104	0.111	0.118	0.121	0.121	0.131
D	0.053	0.053	0.053	0.059	0.061	0.072	0.075	0.078	0.085	0.088	0.089

Rotational direction and reduction ratio of a unit type

The rotational direction and the reduction ratio vary depending on the flange to be fixed for the unit type.

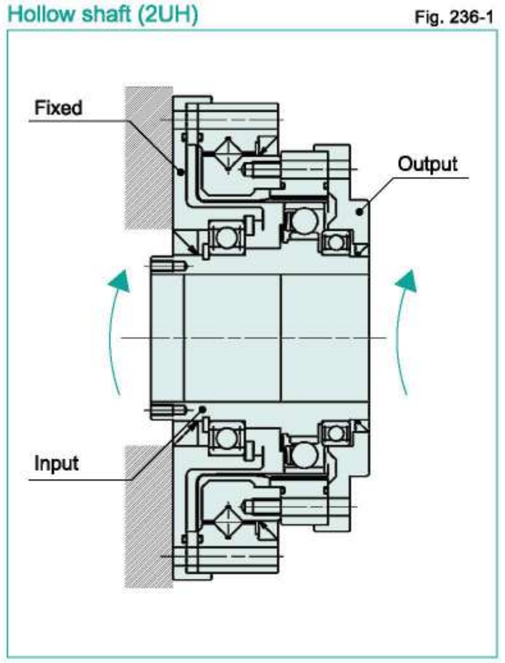
■ Flexspline fixed

Input: Wave generator
Output: Circular spline
Fixed: Flexspline

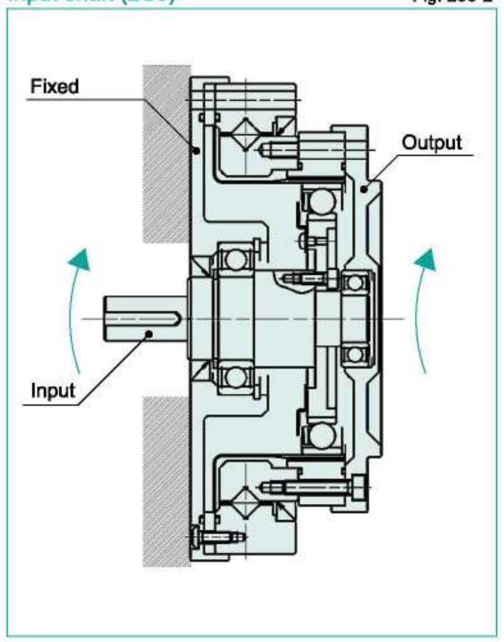
Output rotational direction: Same rotational direction as the input

Reduction ratio (i): $i = \frac{1}{R+1}$

Hollow shaft (2UH) Fig. 236-1



Input shaft (2UJ) Fig. 236-2



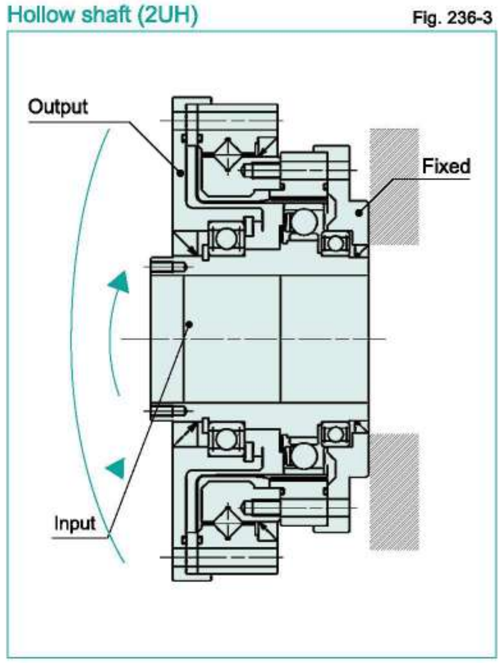
■ Circular spline fixed

Input: Wave generator
Output: Flexspline
Fixed: Circular spline

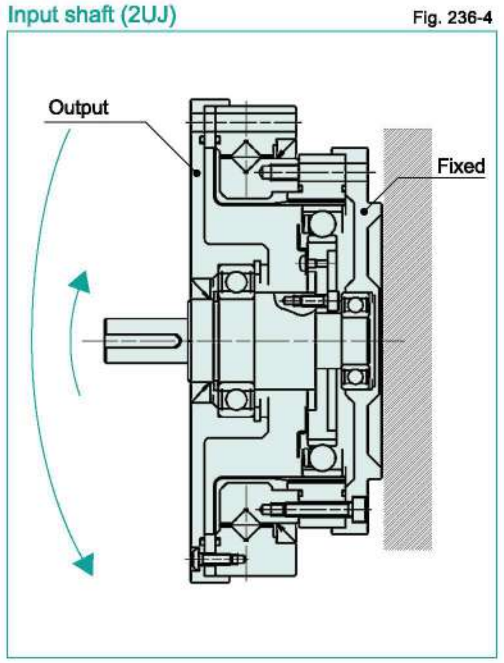
Output rotational direction: Opposite rotational direction to the input

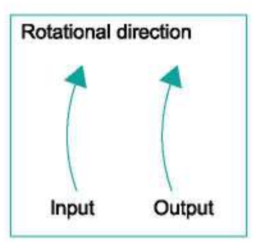
Reduction ratio (i): $i = \frac{-1}{R}$

Hollow shaft (2UH) Fig. 236-3



Input shaft (2UJ) Fig. 236-4





Design Guide

Lubrication

The standard lubricant for Harmonic Drive® gear units is Harmonic Grease SK-1A and SK-2 (Harmonic Grease 4B No.2 for the cross roller bearing). Harmonic Grease 4B No.2 is also available for long-life. The specifications of the grease are described on Page 016.

■ Sealing mechanism

- Rotating and sliding area .... Oil seal (with a spring). Take care regarding flaws on the shaft.
- Flange mating face and mating .... O-ring and seal adhesive. distortion on the plane and how the O-ring is engaged.
- Screw hole area .... Use a screw lock agent (LOCKTITE 242 is recommended) or seal tape.

(Note) If you use Harmonic Grease 4BNo.2, strict sealing is required.

Rust prevention

Although Harmonic Drive® gears come with some corrosion protection, the gear can rust if exposed to the environment. The gear external surfaces typically have only a temporary corrosion inhibitor and some oil applied. If an anti-rust product is needed, please contact us to review the options.

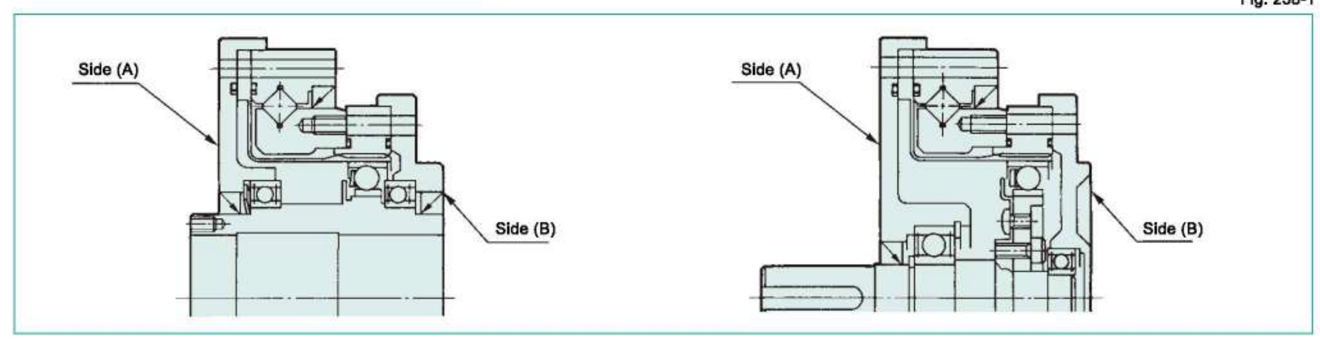
Installation accuracy

For peak performance of the gear, it is essential that the following tolerances be observed when assembly is complete.
Pay careful attention to the following points and maintain the recommended assembly tolerances.
In addition, perform the appropriate installation according to each series, because the torque capacity of SHG series is larger than SHF series.

- Warp and deformation on the mounting surface
- Blocking of foreign matter
- Problems caused by burrs, raised surfaces and location around the tap area of the mounting holes
- Insufficient chamfering on the housing mount
- Insufficient radii on the housing mount

Installation and transmission torque

Fig. 238-1



SHG series: (A) Side-installation and Torque Transmission Capacity

Table 238-1

Item \ Size		14	17	20	25	32	40	45	50	58	65
Number of bolts		8	12	12	12	12	12	18	12	16	16
Bolt size		M3	M3	M3	M4	M5	M6	M6	M8	M8	M10
Pitch circle	mm	64	74	84	102	132	158	180	200	226	258
Clamp torque	Nm	2.4	2.4	2.4	5.4	10.8	18.4	18.4	44	44	74
Transmission torque	Nm	128	222	252	516	1069	1813	3098	4163	6272	9546

SHF series: (A) Side-installation and Torque Transmission Capacity

Table 238-2

Item \ Size		11	14	17	20	25	32	40	45	50	58
Number of bolts		4	8	12	12	12	12	12	18	12	16
Bolt size		M3	M3	M3	M3	M4	M5	M6	M6	M8	M8
Pitch circle	mm	56.4	64	74	84	102	132	158	180	200	226
Clamp torque	Nm	2.0	2.0	2.0	2.0	4.5	9.0	15.3	15.3	37	37
Transmission torque	Nm	47	108	186	206	431	892	1509	2578	3489	5236

(Table 238-1, 238-2/Notes)
1. The material of the thread must withstand the clamp torque.
2. Recommended bolt: JIS B 1176 socket head cap screw / Strength Range: JIS B 1051 12.9 or more
3. Torque coefficient: K=0.2
4. Clamp coefficient: A=1.4
5. Friction coefficient on the surface contacted: μ=0.15
6. Use washers for SHG/SHF-LW.

SHG series: (B) Side-installation and Torque Transmission Capacity

Table 239-1

Item \ Size		14	17	20	25	32	40	45	50	58	65
Number of bolts		8	16	16	16	16	16	12	16	12	16
Bolt size		M3	M3	M3	M4	M5	M6	M8	M8	M10	M10
Pitch circle	mm	44	54	62	77	100	122	140	154	178	195
Clamp torque	Nm	2.4	2.4	2.4	5.4	10.8	18.36	44	44	89	89
Transmission torque	Nm	88	216	248	520	1080	1867	2914	4274	5927	8658

SHF series: (B) Side-installation and Torque Transmission Capacity

Table 239-2

Item \ Size		11	14	17	20	25	32	40	45	50	58
Number of bolts		6	8	16	16	16	16	16	12	16	12
Bolt size		M3	M3	M3	M3	M4	M5	M6	M8	M8	M10
Pitch circle	mm	37	44	54	62	77	100	122	140	154	178
Clamp torque	Nm	2	2.0	2.0	2.0	4.5	9.0	15.3	37	37	74
Transmission torque	Nm	46	72	176	206	431	902	1558	2440	3587	4910

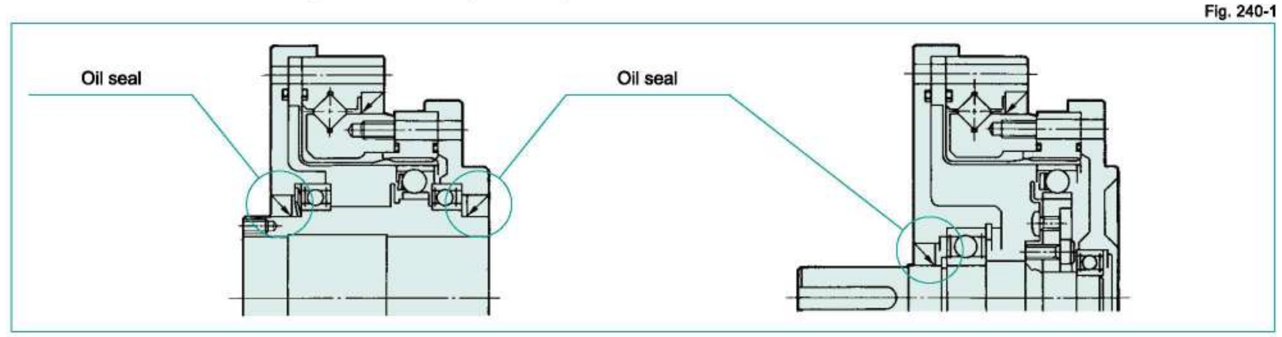
(Table 239-1, 239-2/Notes)
1. The material of the thread must withstand the clamp torque.
2. Recommended bolt: JIS B 1176 hexagonal bolt / Strength: JIS B 1051 12.9 or more
3. Torque coefficient: K=0.2
4. Clamp coefficient A=1.4
5. Friction coefficient on the surface contacted: μ=0.15

Installation Recommendations

■ Installation on the periphery of the oil seal

Install an oil seal on the mounting face so that they have a space of at least 1 mm between them to avoid interference with each other.

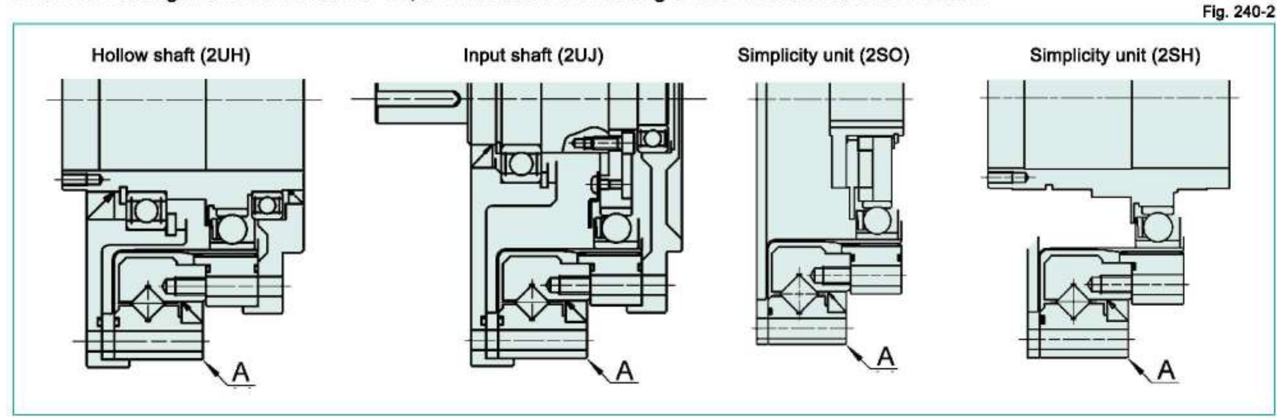
Fig. 240-1



■ Manufacturing for Mating Part and Housing

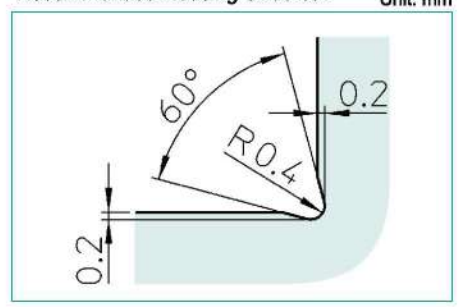
When the housing interferes with corner "A", an undercut in the housing is recommended as shown below.

Fig. 240-2



Recommended Housing Undercut

Fig. 240-3
Unit: mm



Main markets

Industrial robot

Various mechanical equipment

Vertical multi-joint robot

Multi-joint robot

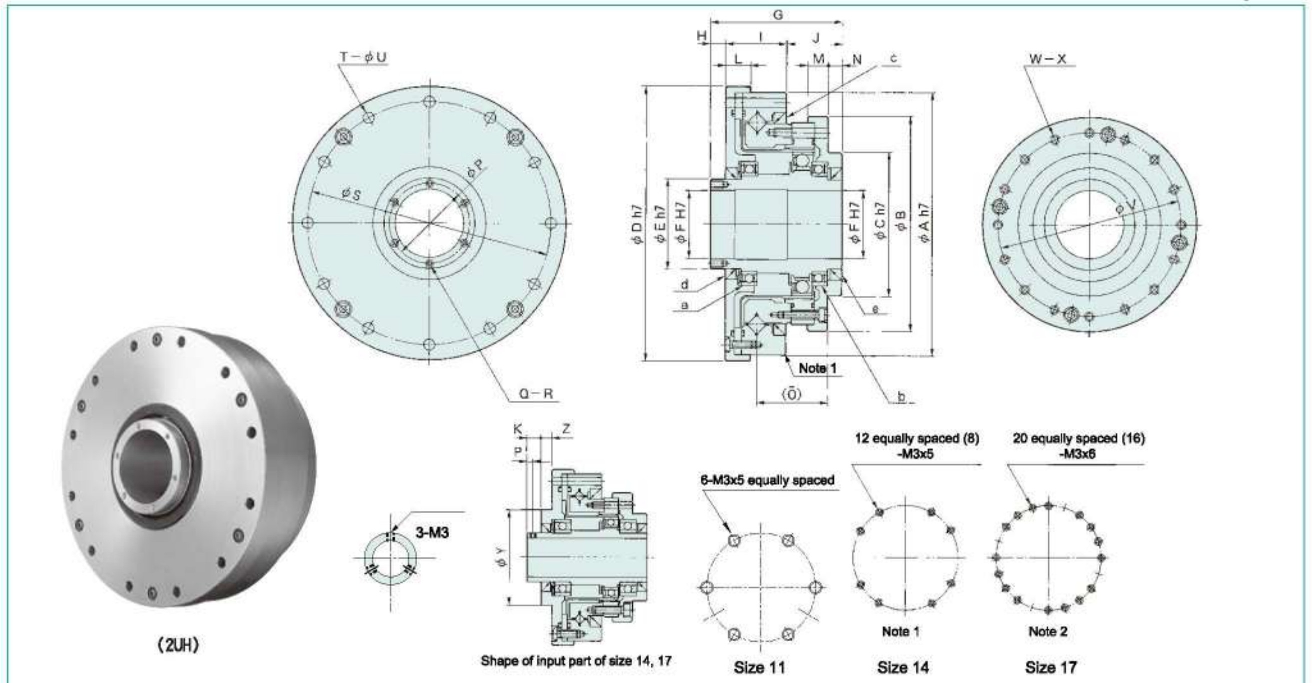
Wafer adsorption handling device

Outline Dimensions (2UH)

Outline dimensions (2UH)

You can download the CAD files from our website: www.3fgearbox.com

Fig. 241-1



Note 1: See recommended housing undercut on previous page. The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the co nfirmation drawing or contact us for dimension tolerances not shown on the drawing.

* Please refer to the confirmation drawing for detailed dimensions.

Dimensions (2UH)

Table 241-1 Unit: mm

Symbol \ Size		11	14	17	20	25	32	40	45	50	58	65
φ A h7		62	70	80	90	110	142	170	190	214	240	276
φ B	SHG/SHF Series	45.3	54	64	75	90	115	140	160	175	201	221
	SHG/SHF-LW Series	—	52	62	73	88	115	140	160	168	195	213
φC h7		30.5	36	45	50	60	85	100	120	130	150	160
φD h7		64	74	84	95	115	147	175	195	220	246	284
φE h7		18	20	25	30	38	45	59	64	74	84	96
φF H7		14	14	19	21	29	36	46	52	60	70	80
G		48	52.5	56.5	51.5	55.5	65.5	79	85	93	106	128
H		14	12	12	5	6	7	8	8	9	10	14
I		19	20.5	23	25	26	32	38	42	45	52	56.5
J		15	20	21.5	21.5	23.5	26.5	33	35	39	44	57.5
K		6.5	6.5	6.5	—	—	—	—	—	—	—	—
L		8	9	10	10.5	10.5	12	14	15	16	17	18
M	SHG/SHF Series	6.5	8	8.5	9	8.5	9.5	13	12	12	15	19.5
	SHG/SHF-LW Series	—	11.5	12	13.5	15.5	20.5	25	27	30	35	42.5
N		6.5	7.5	8.5	7	6	5	7	7	7	7	12
O		17.5	21.7	23.9	25.5	29.6	36.4	44	47.5	52.5	62.2	72
φP (P)		—	(2.5)	(2.5)	25.5	33.5	40.5	52	58	67	77	88
Q		—	3	3	6	6	6	6	6	6	8	6
R		—	M3	M3	M3×6	M3×6	M3×6	M4×8	M4×8	M4×8	M4×8	M5×10
φS		56.4	64	74	84	102	132	158	180	200	226	258
T		4	8	12	12	12	12	12	18	12	16	16
φU		3.5	3.5	3.5	3.5	4.5	5.5	6.6	6.6	9	9	11
φV		37	44	54	62	77	100	122	140	154	178	195
W		6	12 E. A. 8	20 E. A. 16	16	16	16	16	12	16	12	16
X	SHG/SHF Series	M3X5	M3×5	M3×6	M3×6	M4×7	M5×8	M6×10	M8×10	M8×11	M10×15	M10×15
		φ3.4X4	φ3.5×11.5	φ3.5×12	φ3.5×13.5	φ4.5×15.5	φ5.5×20.5	φ6.6×25	φ9×28	φ9×30	φ11×35	φ11×42.5
	SHG/SHF-LW Series	—	M3×5	M3×6	M3×6	M4×7	M5×8	M6×10	M8×10	M8×11	M10×15	M10×15
		—	φ3.5×11.5	φ3.5×12	φ3.5×13.5	φ5×15.5	φ6×20.5	φ7×25	φ9×27	φ9×30	φ11×35	φ11×42.5
φY		36	36	45	—	—	—	—	—	—	—	—
Z		7.5	5.5	5.5	—	—	—	—	—	—	—	—
a		6804 ZZ	6804 ZZ	6805 ZZ	6806 ZZ	6808 ZZ	6909 ZZ	6912 ZZ	6913 ZZ	6915 ZZ	6917 ZZ	6920 ZZ
b	SHG/SHF Series	6704 ZZ	6804 ZZ	6805 ZZ	6806 ZZ	6808 ZZ	6809 ZZ	6812 ZZ	6813 ZZ	6815 ZZ	6817 ZZ	6820 ZZ
	SHG/SHF-LW Series	—	6804 ZZ	6805 ZZ	6806 ZZ	6808 ZZ	6809 ZZ	6812 ZZ	6813 ZZ	6815 ZZ	6817 ZZ	6820 ZZ
c		D41.950.95	D49585	D59685	D69785	D84945	D1101226	D1321467	D1521707	D1681868	D1932129	D21623811
d	SHG/SHF Series	S18274	S20304.5	S25356	S30405	S38475	S45607	S60789	S658510	S759510	S8511012	S10012513
	SHG/SHF-LW Series	—	S20304.5	S25356	S30405	S38475	S45607	S60789	S658510	S759510	S8511012	S10012513
e	SHG/SHF Series	S18274	S20304.5	S25356	S30405	S38475	S45555	S59685	S59685	S69785	S84945	S961128
	SHG/SHF-LW Series	—	S20304.5	S25356	S30405	S38475	S45555	S59685	S59685	S69785	S84945	S961128

Mass (2UH)

Table 242-1
Unit: kg

Symbol \ Size	11	14	17	20	25	32	40	45	50	58	65
2UH	0.53	0.71	1.00	1.38	2.1	4.5	7.7	10.0	14.5	20.0	28.5
2UH-LW (Lightweight)	—	0.55	0.8	1.1	1.6	3.6	6.2	8	11.8	16.4	23.3

Moment of Inertia (2UH)

Table 242-2

Symbol \ Size			11	14	17	20	25	32	40	45	50	58	65
Moment of inertia	I	$\times 10^{-4}kgm^2$	0.080	0.091	0.193	0.404	1.070	2.85	9.28	13.8	25.2	49.5	94.1
	J	$\times 10^{-5}kgfms^2$	0.082	0.093	0.197	0.412	1.090	2.91	9.47	14.1	25.7	50.5	96.0

Starting torque (2UH)

See "Engineering data" for a description of terms. Please use as reference values; the values vary based on use conditions.

Table 242-3
Unit: Ncm

Ratio \ Size	11	14	17	20	25	32	40	45	50	58	65
30	—	11	30	43	64	112	—	—	—	—	—
50	7.1	8.8	27	36	56	85	136	165	216	297	—
80	—	7.5	25	33	50	74	117	138	179	244	314
100	5.9	6.9	24	32	49	72	112	131	171	231	297
120	—	—	24	31	48	68	110	126	165	223	287
160	—	—	—	31	47	67	105	122	156	213	276

Backdriving torque (2UH)

See "Engineering data" for a description of terms. Please use as reference values; the values vary based on use conditions.

Table 242-4
Unit: Nm

Ratio \ Size	11	14	17	20	25	32	40	45	50	58	65
30	—	5.4	17	23	35	57	—	—	—	—	—
50	4.6	5.3	16	22	34	51	82	99	129	178	—
80	—	7.2	24	31	48	70	112	133	172	234	301
100	7.6	8.2	29	38	59	86	134	158	205	278	356
120	—	—	34	45	69	97	158	182	237	322	413
160	—	—	—	59	90	128	201	233	299	408	530

Continuous Operating Time (2UH)

The internal temperature rises due to the effect of the oil seal and the supporting bearing used for the input shaft (high-speed rotation side) for SHF-2UH. Observe the operating time shown in Table 246-2 for continuous operation.
The operating time shown in Table 246-2 is calculated based on the time required for the temperature inside the unit to rise to 80ºC and for the oil seal temperature to rise to 100ºC. Take care not to exceed the temperature given above in conducting continuous operation. The following review will be necessary if the temperature exceeds the value given above.
Contact us in such an event.

- Change of timing to replace lubricant
- Change of lubricant
- Measures against lubricant leakage accompanied by the pressure rise inside the unit
- Measures against deterioration due to heat on the oil seal area

Continuous operating time

Table246-2

Size \ Operating time	Continuous operating time at no-load operation (min)	Continuous operating time at the rated load (min)
11	90	60
14	90	60
17	90	60
20	90	60
25	60	45
32	45	35
40	40	30
45	35	25
50	30	20
58	20	15
65	15	10

* Contact us as the continuous operating time may vary significantly depending on the operating condition.

Performance Data for the Input Bearing for Hollow Shaft (2UH)

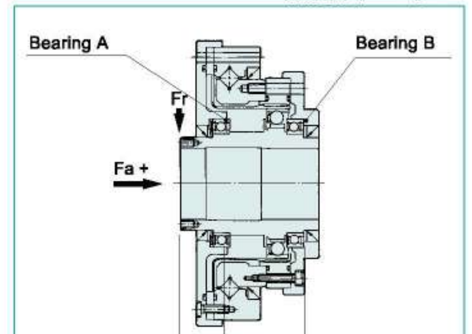
The internal temperature rises due to the effect of the oil seal and the supporting bearing used for the input shaft (high-speed rotation side) for SHF-2UH. Observe the operating time shown in Table 246-2 for continuous operation.The operating time shown in Table 246-2 is calculated based on the time required for the temperature inside the unit to rise to 80ºC and for the oil seal temperature to rise to 100ºC. Take care not to exceed the temperature given above in conducting continuous operation. The following review will be necessary ifthe temperature exceeds the value given above. Contact us insuch an event.

Input bearing specifications

Table 247-1

Size	Bearing A			Bearing B			a	b	Maximum radial load
	Model	Basic dynamic rated load Cr(N)	Basic static rated load Cor(N)	Model	Basic dynamic rated load Cr(N)	Basic static rated load Cor(N)	(mm)	(mm)	Fr(N)
11	6804ZZ	4000	2470	6704ZZ	1400	720	25.7	15.5	—
14	6804ZZ	4000	2470	6804ZZ	4000	2470	27	16.5	230
17	6805ZZ	4300	2950	6805ZZ	4300	2950	29	17.5	250
20	6806ZZ	4500	3450	6806ZZ	4500	3450	27	15.5	275
25	6808ZZ	4900	4350	6808ZZ	4900	4350	29.5	16.5	250
32	6909ZZ	14100	10900	6809ZZ	5350	5250	33	23	770
40	6912ZZ	19400	16300	6812ZZ	11500	10900	39.5	27.5	1060
45	6913ZZ	17400	16100	6813ZZ	11900	12100	44	28.5	900
50	6915ZZ	24400	22600	6815ZZ	12500	13900	49	31.5	1370
58	6917ZZ	32000	29600	6817ZZ	18700	20000	56.2	36.5	1720
65	6920ZZ	42500	36500	6820ZZ	19600	21200	67	44.5	2300

Fig 247-1



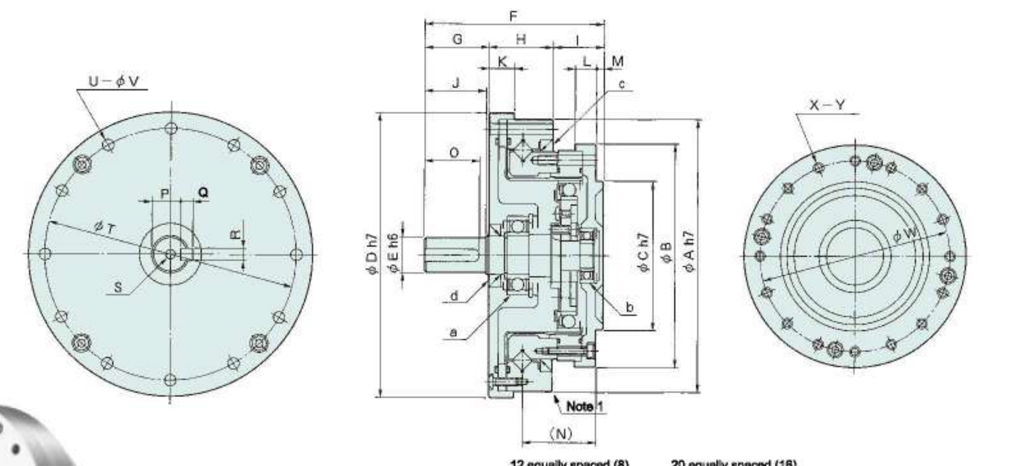
Fa: Axial load (N)
Fr: Radial load (N)

Outline Dimensions (2UJ)

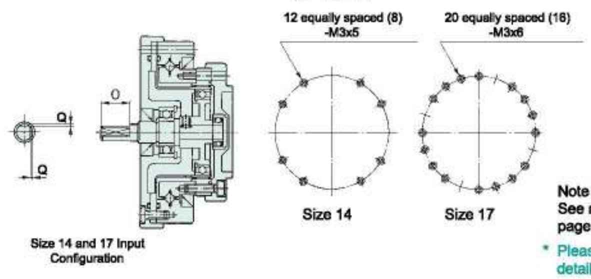
Outline Dimensions (2UJ)

You can download the CAD files from our website: www.3fgearbox.com

Fig. 248-1



(2UJ)



Note 1:
See recommended housing undercut on page 240 for details.

* Please refer to the confirmation drawing for detailed dimensions.

Dimensions (2UJ)

Table 248-1 Unit: mm

Symbol \ Size	14	17	20	25	32	40	45	50	58	65
φA h7	70	80	90	110	142	170	190	214	240	276
φB	54	64	75	90	115	140	160	175	201	221
φC h7	36	45	50	60	85	100	120	130	150	160
φD h7	74	84	95	115	147	175	195	220	246	284
φE h6	6	8	10	14	14	16	19	22	22	25
F	50.5	56	63.5	72.5	84.5	100	108	121	133	156
G	15	17	21	26	26	31	31	37	37	42
H	20.5	23	25	26	32	38	42	45	52	56.5
I	15	16	17.5	20.5	26.5	31	35	39	44	57.5
J	14	16	20	25	25	30	30	35	35	40
K	9	10	10.5	10.5	12	14	15	16	17	18
L	8	8.5	9	8.5	9.5	13	12	12	15	19.5
M	2.5	3	3	3	5	5	7	7	7	12
N	21.7	23.9	25.5	29.6	36.4	44	47.5	52.5	62.2	72
O	11	12	16.5	22.5	22.5	27.5	28	33	33	39
P	—	—	8.2 $^{+0.1}_{0}$	11 $^{+0.1}_{0}$	11 $^{+0.1}_{0}$	13 $^{+0.1}_{0}$	15.5 $^{+0.1}_{0}$	18.5 $^{+0.1}_{0}$	18.5 $^{+0.1}_{0}$	21 $^{+0.1}_{0}$
Q	0.5	0.5	3 $^{0}_{-0.025}$	5 $^{0}_{-0.030}$	5 $^{0}_{-0.030}$	5 $^{0}_{-0.030}$	6 $^{0}_{-0.030}$	6 $^{0}_{-0.030}$	6 $^{0}_{-0.030}$	7 $^{0}_{-0.036}$
R	—	—	3 $^{0}_{-0.025}$	5 $^{0}_{-0.030}$	5 $^{0}_{-0.030}$	5 $^{0}_{-0.030}$	6 $^{0}_{-0.030}$	6 $^{0}_{-0.030}$	6 $^{0}_{-0.030}$	8 $^{0}_{-0.036}$
S	—	—	M3×6	M5×10	M5×10	M5×10	M6×12	M6×12	M6×12	M8×16
φT	64	74	84	102	132	158	180	200	226	258
U	8	12	12	12	12	12	18	12	16	16
φV	3.5	3.5	3.5	4.5	5.5	6.6	6.6	9	9	11
φW	44	54	62	77	100	122	140	154	178	195
X	12 E. A. 8	20 E. A. 16	16	16	16	16	12	16	12	16
Y	M3×5	M3×6	M3×6	M4×7	M5×8	M6×10	M8×10	M8×11	M10×15	M10×15
	φ3.5×11.5	φ3.5×12	φ3.5×13.5	φ4.5×15.5	φ5.5×20.5	φ6.6×25	φ9×28	φ9×30	φ11×35	φ11×42.5
a	698 ZZ	6900 ZZ	6902 ZZ	6002 ZZ	6004 ZZ	6006 ZZ	6206 ZZ	6207 ZZ	6208 ZZ	6209 ZZ
b	695 ZZ	697 ZZ	698 ZZ	6900 ZZ	6902 ZZ	6003 ZZ	6004 ZZ	6005 ZZ	6006 ZZ	6007 ZZ
c	D49585	D59685	D69785	D84945	D1101226	D1321467	D1521707	D1681868	D1932129	D21623811
d	G8184	D10205	D15255	D15255	D20355	D30457	D30457	D35557	D40607	D45607

Mass (2UJ)

Table 249-1
Unit: kg

Symbol \ Size	14	17	20	25	32	40	45	50	58	65
Mass (kg)	0.66	0.94	1.38	2.1	4.4	7.3	9.8	13.9	19.4	26.5

Moment of Inertia (2UJ)

Table 249-2

Symbol \ Size			14	17	20	25	32	40	45	50	58	65
Moment of inertia	I	$\times 10^{-4}$ kgm²	0.025	0.059	0.137	0.320	1.20	3.41	5.80	9.95	20.5	35.5
	J	$\times 10^{-5}$ kgfms²	0.026	0.060	0.140	0.327	1.22	3.48	5.92	10.2	20.9	36.2

Starting torque (2UJ)

See "Engineering data" for a description of terms. Please use as reference values; the values vary based on use conditions.

Table 249-3
Unit: Ncm

Ratio \ Size	14	17	20	25	32	40	45	50	58	65
30	6.8	11	19	26	63	—	—	—	—	—
50	5.7	9.7	14	22	41	72	94	125	178	—
80	4.4	7.2	11	15	29	52	68	88	125	163
100	3.7	6.5	9.9	14	27	47	60	80	113	147
120	—	6.2	9.3	13	24	44	55	74	105	137
160	—	—	8.6	12	23	39	50	66	94	122

Backdriving torque (2UJ)

See "Engineering data" for a description of terms. Please use as reference values; the values vary based on use conditions.

Table 249-4
Unit: Nm

Ratio \ Size	14	17	20	25	32	40	45	50	58	65
30	3.5	5.9	10	16	31	—	—	—	—	—
50	3.4	5.8	8.4	13	25	43	56	75	107	—
80	4.2	6.9	10	15	28	50	65	85	120	154
100	4.5	7.8	12	17	33	56	72	96	135	176
120	—	8.9	13	19	34	63	79	106	151	198
160	—	—	17	23	43	75	96	126	181	235

Performance Data for the Input bearing (2UJ)

The input shaft of the 2UJ is supported by two single-row deep-groove bearings. For peak performance of the SHF-2UJ it is essential that the following Specification for Input Bearing be observed -Figure 254-1 shows the points of application of forces. See Table 254-1 for the dimensions (a) and (b). Graphs 254-1 and 254-2 show the Maximum Allowable Radial and Axial Loads. The values in Graph 254-1 and 254-2 are based on an average input speed of 2,000 rpm and a mean bearing life of L10=7,000h.

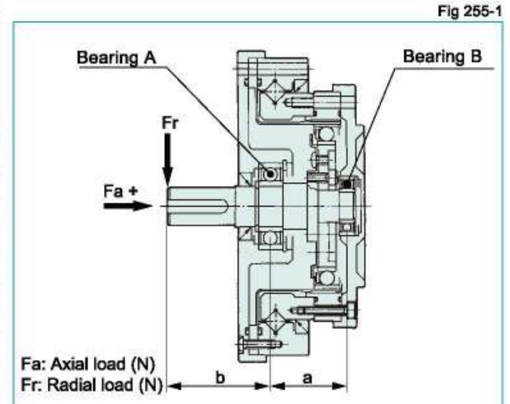
Example: If the input shaft of a SHF-40-2UJ unit is subjected to an axial load (Fa) of 500 N. The maximum allowable radial force will be 400 N.

Input bearing specifications

Table 254-1

Size	Bearing A			Bearing B			a	b	Maximum radial load
	Model	Basic dynamic rated load Cr(N)	Basic static rated load Cor(N)	Model	Basic dynamic rated load Cr(N)	Basic static rated load Cor(N)	(mm)	(mm)	Fr(N)
14	698ZZ	2240	910	695ZZ	1080	430	20	14	110
17	6900ZZ	2700	1270	697ZZ	1610	710	23.5	21	135
20	6902ZZ	4350	2260	698ZZ	2240	910	26.5	23.3	210
25	6002ZZ	5600	2830	6900ZZ	2700	1270	28	28	270
32	6004ZZ	9400	5000	6902ZZ	4350	2260	36	27	490
40	6006ZZ	13200	8300	6003ZZ	6000	3250	43	32.5	660
45	6206ZZ	19500	11300	6004ZZ	9400	5000	47.5	34.5	1030
50	6207ZZ	25700	15300	6005ZZ	10100	5850	53	39	1330
58	6208ZZ	29100	17800	6006ZZ	13200	8300	62.5	40	1600
65	6209ZZ	32500	20500	6007ZZ	16000	10300	79	63	1650

Fig 255-1

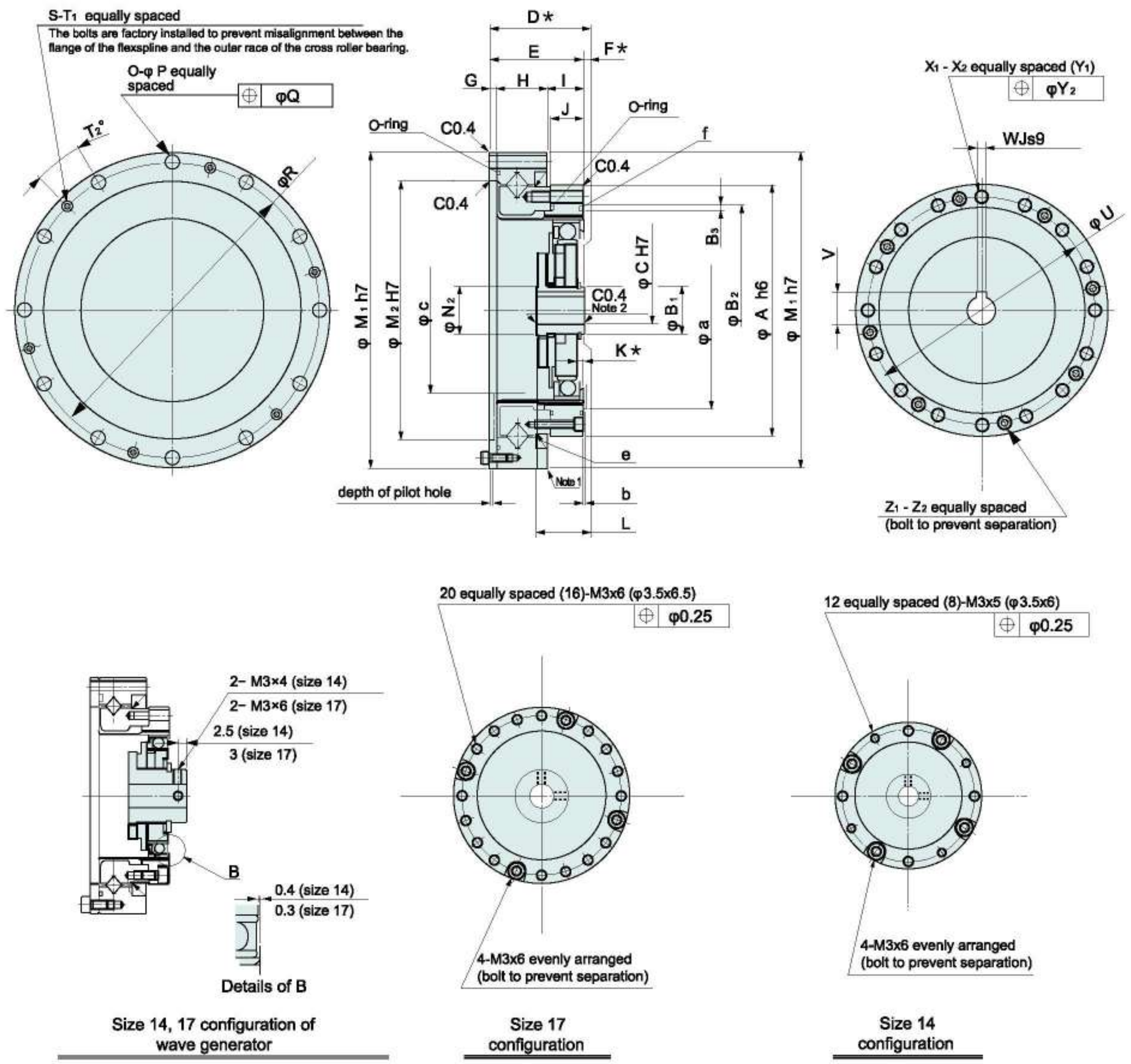


Outline Dimensions(2SO、2SH)

Outline Dimensions (2SO)

You can download the CAD files from our website: www.3fgearbox.com

Fig. 255-1



Size 14, 17 configuration of wave generator

Size 17 configuration

Size 14 configuration

(2SO/2SH)

Note 1: See undercutting the housing on Page 240 for details.
Note 2: For size 14, C0.5.

* Refer to the confirmation drawing for detailed dimensions
* See Fig. 084-2 on Page 084 for the configurations of the wave generator.

Dimensions (2SO)

Table 256-1
Unit : mm

Symbol		14	17	20	25	32	40	45	50	58	65
φA h6		50	60	70	85	110	135	155	170	195	215
φB₁		14	18	21	26	26	32	32	32	40	48
φB₂		—	—	—	—	—	—	128	141	163	180.4
φB₃		—	—	—	—	—	—	2.7	2.7	2.7	2.7
φC	Standard (H7)	6	8	9	11	14	14	19	19	22	24
	Max. dimen.	8	10	13	15	15	20	20	20	25	30
D*	SHF Series	$28.5^{0}_{-0.8}$	$32.5^{0}_{-0.9}$	$33.5^{0}_{-1.0}$	$37^{0}_{-1.1}$	$44^{0}_{-1.1}$	$53^{0}_{-1.1}$	$58^{0}_{-1.2}$	$64^{0}_{-1.3}$	$75.5^{0}_{-1.3}$	—
	SHG Series	$28.5^{0}_{-0.4}$	$32.5^{0}_{-0.4}$	$33.5^{0}_{-0.4}$	$37^{0}_{-0.5}$	$44^{0}_{-0.6}$	$53^{0}_{-0.6}$	$58^{0}_{-0.8}$	$64^{0}_{-0.7}$	$75.5^{0}_{-0.7}$	$83^{0}_{-0.7}$
E		23.5	26.5	29	34	42	51	56.5	63	73	81.5
F*		5	6	4.5	3	2	2	1.5	1	2.5	1.5
G		2.4	3	3	3.3	3.6	4	4.5	5	5.8	6.5
H		14.1	16	17.5	18.7	23.4	29	32	34	40.2	43
I		7	7.5	8.5	12	15	18	20	24	27	32
J		6	6.5	7.5	10	14	17	19	22	25	29
K*	SHF Series	0.4	0.3	0.1	2.1	2.5	3.3	3.7	4.2	4.8	—
	SHG Series	1.4	1.6	1.5	3.5	4.2	5.6	6.3	7	8.2	9.5
L	SHF Series	$17.6^{0}_{-0.1}$	$19.5^{0}_{-0.1}$	$20.1^{0}_{-0.1}$	$20.2^{0}_{-0.1}$	$22^{0}_{-0.1}$	$27.5^{0}_{-0.1}$	$27.9^{0}_{-0.1}$	$32^{0}_{-0.1}$	$34.9^{0}_{-0.1}$	—
	SHG Series	$18.5^{0}_{-0.1}$	$20.7^{0}_{-0.1}$	$21.5^{0}_{-0.1}$	$21.6^{0}_{-0.1}$	$23.6^{0}_{-0.1}$	$29.7^{0}_{-0.1}$	$30.5^{0}_{-0.1}$	$34.8^{0}_{-0.1}$	$38.3^{0}_{-0.1}$	$44.6^{0}_{-0.1}$
φM₁ h7		70	80	90	110	142	170	190	214	240	276
φM₂ H7		48	60	70	88	114	140	158	175	203	232
φN₂		—	—	—	—	—	32	—	32	—	48
O		8	12	12	12	12	12	18	12	16	16
φP		3.5	3.5	3.5	4.5	5.5	6.6	6.6	9	9	11
φQ		0.25	0.25	0.25	0.25	0.25	0.3	0.3	0.5	0.5	0.5
φR		64	74	84	102	132	158	180	200	226	258
S		2	4	4	4	4	6	6	6	8	8
T₁		M3×6	M3×6	M3× 8	M3× 8	M4× 8	M4× 10	M4× 8	M5× 12	M5× 12	M6× 16
T₂ (angle)		22.5°	15°	15°	15°	15°	15°	10°	15°	11.25°	11.25°
φU		44	54	62	77	100	122	140	154	178	195
V		—	—	10.4	12.8	16.3	16.3	21.8	21.8	24.8	27.3
W Js9		—	—	3	4	5	5	6	6	6	8
X₁		12 E. A. 8	12E. A. 16	16	16	16	16	12	16	12	16
X₂		M3×5	M3×6	M3× 6	M4× 7	M5× 8	M6× 10	M8× 10	M8× 11	M10× 15	M10× 15
Y₁		φ3.5×6	φ3.5×6.5	φ 3.5× 7.5	φ 4.5× 10	φ 5.5× 14	φ 6.6× 17	φ 9× 19	φ 9× 22	φ 11× 25	φ 11× 29
Y₂		0.25	0.25	0.25	0.25	0.25	0.3	0.5	0.5	0.5	0.5
Z₁		4	4	4	4	4	4	4	8	6	8
Z₂		M3×6	M3×6	M3× 8	M3× 10	M4× 16	M5× 20	M5× 20	M5× 25	M6× 25	M6× 30
Minimum housing clearance	φa	38	45	53	66	86	106	119	133	154	172
	b	1	1	1.5	1.5	1.5	2	2	2	2.5	2.5
	φc	31	38	45	56	73	90	101	113	131	150
d		1.7	2.1	2	2	2	2	2.3	2.5	2.9	3.5
e		D49585	D59685	D69785	D84945	D1101226	D1321467	D1521707	D1681868	D1932129	D21623811
f		—	—	—	—	—	—	d1 121.5 d2 2.0	S135	d1 157.0 d2 2.0	S175

- The following dimensions can be modified to accommodate customer-specific requirements.

  Wave Generator : C
  Flexspline : O and P
  Circular Spline : X_1 and X_2

- *The D, F and K values indicate relative position of individual gearing components (wave generator, flexpline, circular spline). Please strictly adhere to these values when designing your housing and mating parts.
- Please note that the circular spline face of sizes 14 through 40 does not incorporate an O-ring groove. Please provide alternate sealing arrangements.
- Due to the deformation of the Flexspline during operation, it is necessary to provide a minimum housing clearance, dimensions φa, b, c.

Wave generator is removed when the product is delivered.

Mass (2SO)

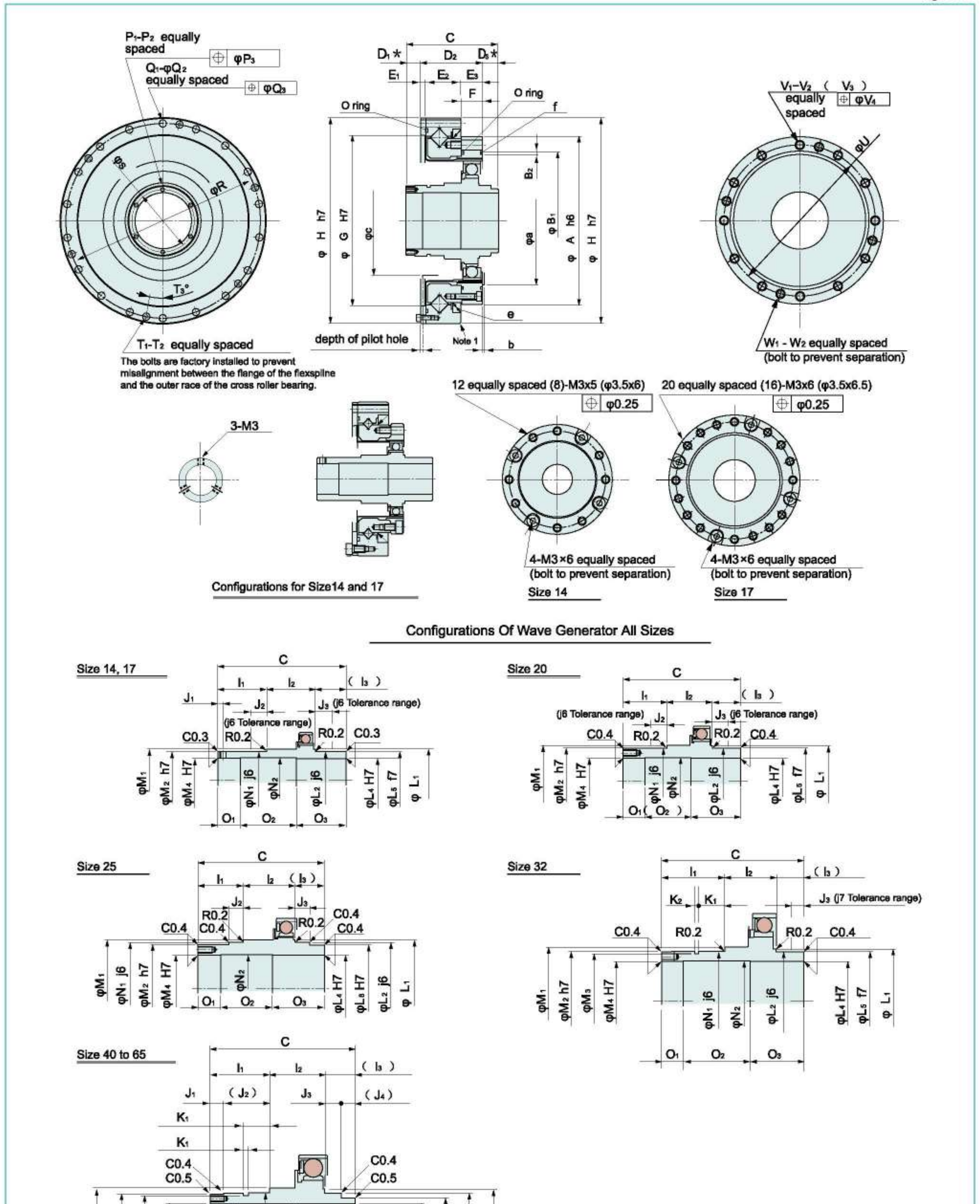
Table 256-2
Unit: kg

Symbol	14	17	20	25	32	40	45	50	58	65
Mass (kg)	0.41	0.57	0.81	1.31	2.94	5.1	6.5	9.6	13.5	19.5

Outline Dimensions (2SH)

You can download the CAD files from our website: www.3fgearbox.com

Fig. 257-1



Note 1:
See undercutting the housing on Page 240 for details.

* Refer to the confirmation drawing for detailed dimensions. Especially be certain to check the delivered specifications since the configuration of the wave generator varies depends on the size. (* Also see Fig. 084-2 on Page 084.)

Dimensions (2SH)

Table 258-1
Unit : mm

Symbol		Size 14	17	20	25	32	40	45	50	58	65
φA h6		50	60	70	85	110	135	155	170	195	215
φB1		—	—	—	—	—	—	128	141	163	180.4
B2		—	—	—	—	—	—	2.7	2.7	2.7	2.7
C		$52.5^{0}_{-0.1}$	$56.5^{0}_{-0.1}$	$51.5^{0}_{-0.1}$	$55.5^{0}_{-0.1}$	$65.5^{0}_{-0.1}$	$79^{0}_{-0.1}$	$85^{0}_{-0.1}$	$93^{0}_{-0.1}$	$106^{0}_{-0.1}$	$128^{0}_{-0.1}$
D1 ★	SHF	$16^{+0.8}_{0}$	$16^{+0.9}_{0}$	$9.5^{+1.0}_{0}$	$10^{+1.1}_{0}$	$12^{+1.1}_{0}$	$13^{+1.1}_{0}$	$13.5^{+1.2}_{0}$	$15^{+1.3}_{0}$	$16^{+1.3}_{0}$	$21^{+1.3}_{0}$
	SHG	$16^{+0.4}_{0}$	$16^{+0.4}_{0}$	$9.5^{+0.4}_{0}$	$10^{+0.5}_{0}$	$12^{+0.6}_{0}$	$13^{+0.6}_{0}$	$13.5^{+0.6}_{0}$	$15^{+0.7}_{0}$	$16^{+0.7}_{0}$	$21^{+0.7}_{0}$
D2		23.5	26.5	29	34	42	51	56.5	63	73	81.5
D3 ★		13	14	13	11.5	11.5	15	15	15	17	25.5
E1		2.4	3	3	3.3	3.6	4	4.5	5	5.8	6.5
E2		14.1	16	17.5	18.7	23.4	29	32	34	40.2	43
E3		7	7.5	8.5	12	15	18	20	24	27	32
F		6	6.5	7.5	10	14	17	19	22	25	29
φG H6		48	60	70	88	114	140	158	175	203	232
φH h6		70	80	90	110	142	170	190	214	240	276
Wave generator dimensions	l1	20 ±0.1	21.5 ±0.1	19 ±0.1	20 ±0.1	29 ±0.1	34 ±0.1	35 ±0.1	39.5 ±0.1	45.3 ±0.1	54.5 ±0.1
	l2	20 ±0.1	21.5 ±0.1	20 ±0.1	22.5 ±0.1	23.5 ±0.1	28 ±0.1	32.5 ±0.1	36 ±0.1	40.7 ±0.1	—
	l3	(12.5)	(13.5)	(12.5)	(13)	(13)	(17)	(17.5)	(17.5)	(20)	—
	J1	2.5	2.5	—	—	—	—	8	9	10	14
	J2	7	7	7	6.5	—	—	(27)	(30.5)	(35.3)	(40.5)
	J3	7	7	7	6.5	—	9.5	9.5	9.5	12.5	11.5
	J4	—	—	—	—	—	(7.5)	(8)	(8)	(7.5)	(11.5)
	K1	—	—	—	—	13.9	15.1	15.6	18.6	21.1	23.1
	K2	—	—	—	—	1.9	2.2	2.7	2.7	3.2	3.1
	φL1	22	27	32	42	47	62	69	79	90	106
	φL2 j6	20	25	30	40	45	60	65	75	85	100
	φL3 h9	—	—	—	38	—	59	59	69	84	96
	φL4 H7	14	19	21	29	36	46	52	60	70	80
	φL5 f7	20	25	30	—	45	—	—	—	—	—
	φM1	22	27	32	42	49	65	70	80	91.5	111
	φM2 h7	20	25	30	38	45	59	64	74	84	96
	φM3	—	—	—	—	42.5	57	62	72	81.5	96.5
	φM4 H7	14	19	21	29	36	46	52	60	70	80
	φN1 j6	20	25	30	40	45	60	65	75	85	100
	φN2	14.5	19.5	21.5	29.5	36.5	46.5	52.5	60.5	70.5	80.5
	O1	10	10	10	10	10	12	15	15	15	20
	O2	22.5	24.5	(19.5)	22.5	(30.5)	(35)	35	41	48	54
	O3	20	22	22	23	25	32	35	37	43	54
P1		3	3	6	6	6	6	6	6	8	6
P2		M3	M3	M3×6	M3×6	M3×6	M4×8	M4×8	M4×8	M4×8	M5×10
φP3		—	—	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Q1		8	12	12	12	12	12	18	12	16	16
φQ2		3.5	3.5	3.5	4.5	5.5	6.6	6.6	9	9	11
φQ3		0.25	0.25	0.25	0.25	0.25	0.3	0.3	0.5	0.5	0.5
φR		64	74	84	102	132	158	180	200	226	258
φS		—	—	25.5	33.5	40.5	52	58	67	77	88
T1		2	4	4	4	4	6	6	6	8	8
T2		M3×6	M3×6	M3×8	M3×8	M4×8	M4×10	M4×10	M5×12	M5×12	M6×16
T3 (angle)		22.5°	15°	15°	15°	15°	15°	10°	15°	11.25°	11.25°
φU		44	54	62	77	100	122	140	154	178	195
V1		12 E.A. 8	20 E. A. 16	16	16	16	16	12	16	12	16
V2		M3×5	M3×6	M3×6	M4×7	M5×8	M6×10	M8×10	M8×11	M10×15	M10×15
V3		φ3.5×6	φ3.5×6.5	φ3.5×7.5	φ4.5×10	φ5.5×14	φ6.6×17	φ9×19	φ9×22	φ11×25	φ11×29
V4		0.25	0.25	0.25	0.25	0.25	0.3	0.5	0.5	0.5	0.5
W1		4	4	4	4	4	4	4	8	6	8
W2		M3×6	M3×6	M3×8	M3×10	M4×16	M5×20	M5×20	M5×25	M6×25	M6×30
Minimum housing clearance	φa	38	45	53	66	86	106	119	133	154	172
	b	1	1	1.5	1.5	1.5	2	2	2	2.5	2.5
	φc	31	38	45	56	73	90	101	113	131	150
d		1.7	2.1	2	2	2	2	2.3	2.5	2.9	3.5
e		D49585	D59685	D69785	D84945	D1101226	D1321467	D1521707	D1681868	D1932129	D21623811
f		—	—	—	—	—	—	d1 121.5 d2 2.0	S135	d1 157.0 d2 2.0	S175

- As the flexspline is subject to elastic deformation, the housing clearance should be φa, b, c or more and it should not exceed.
- *The D1 and D3 sizes indicated by an asterisk are the mounting positions in the shaft direction and allowance of the three parts (wave generator, flexspline, circular spline). Strictly observe these tolerances.
- The circular spline of sizes 14 to 40 does not have an O-ring groove (symbol: f) for sealing. Account for sealing during design and installation.

Mass (2SH)

Table 259-1
Unit: kg

Symbol \ Size	14	17	20	25	32	40	45	50	58	65
Mass	0.45	0.63	0.89	1.44	3.1	5.4	6.9	10.2	14.1	20.9

Lubrication

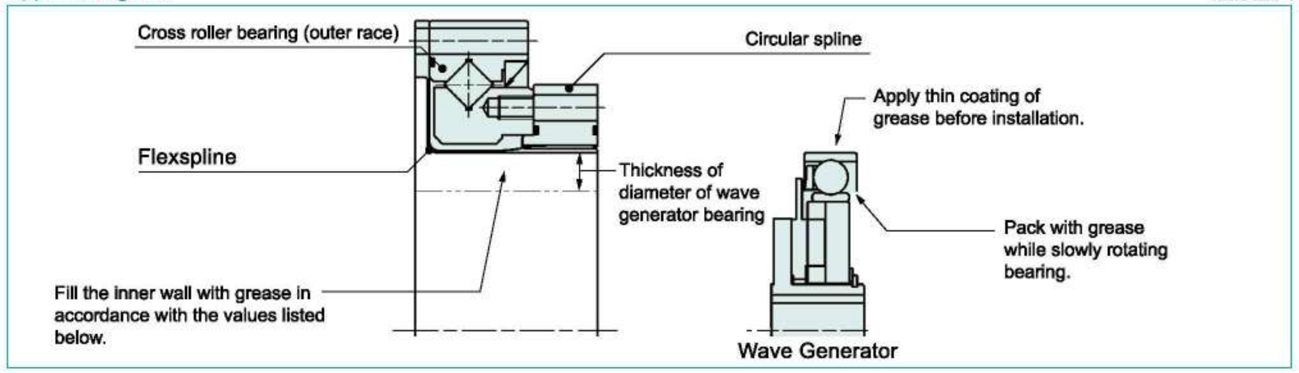
Standard lubrication for SHG/SHF series is grease.
See "Engineering data" on Page 016 for details of the lubricant.

Application guide

As the gear unit is shipped with the outer race of the cross roller bearing and the flexspline temporarily bolted together, grease is not applied other than the gear teeth. Refer to the following application guide for grease application instructions

Application guide

Table 259-1



Application quantity

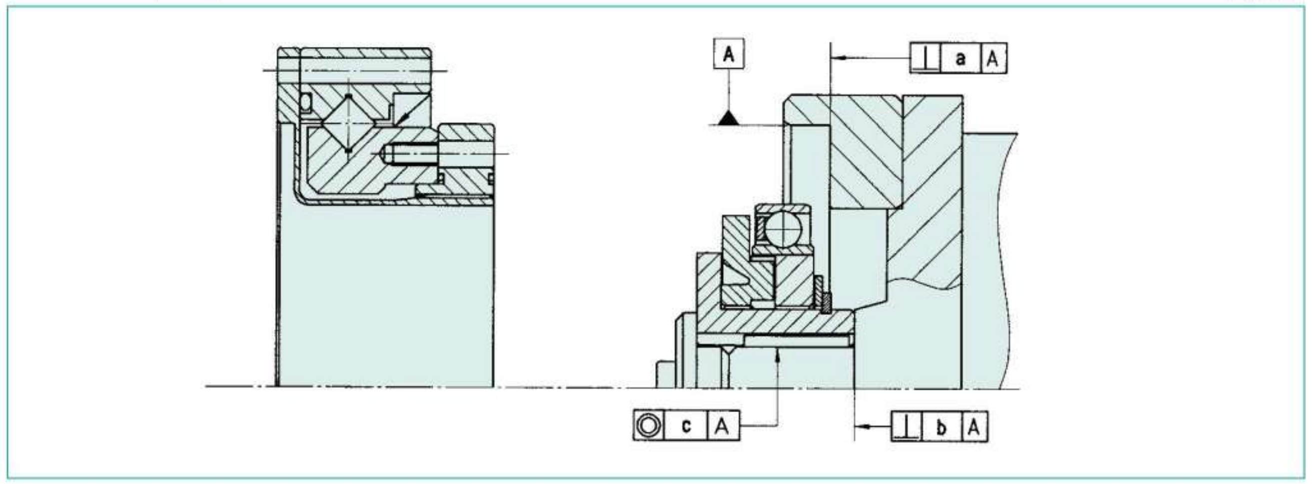
Table 259-2
Unit: g

Application \ Size		14	17	20	25	32	40	45	50	58	65
Horizontal use		5.8	11	18	32	64	120	185	235	385	495
Vertical use	Output shaft facing up	7.5	13	19	37	74	130	200	255	400	530
	Output shaft facing down	8.9	15	22	42	84	150	230	290	480	630

Installation accuracy

Maintain the recommended tolerances shown in Figure 260-1 and Table 260-1 for peak performance.

Fig. 260-1



Unit: mm

Size	14	17	20	25	32	40	45	50	58
a	0.011	0.015	0.017	0.024	0.026	0.026	0.027	0.028	0.031
b	0.017	0.020	0.020	0.024	0.024	0.024	0.032	0.032	0.032
	(0.008)	(0.010)	(0.010)	(0.012)	(0.012)	(0.012)	(0.012)	(0.015)	(0.015)
c	0.030	0.034	0.044	0.047	0.047	0.050	0.063	0.066	0.068
	(0.016)	(0.018)	(0.019)	(0.022)	(0.022)	(0.022)	(0.024)	(0.030)	(0.033)

* The value in the parentheses indicates that Wave Generator does not have an Oldham coupling.

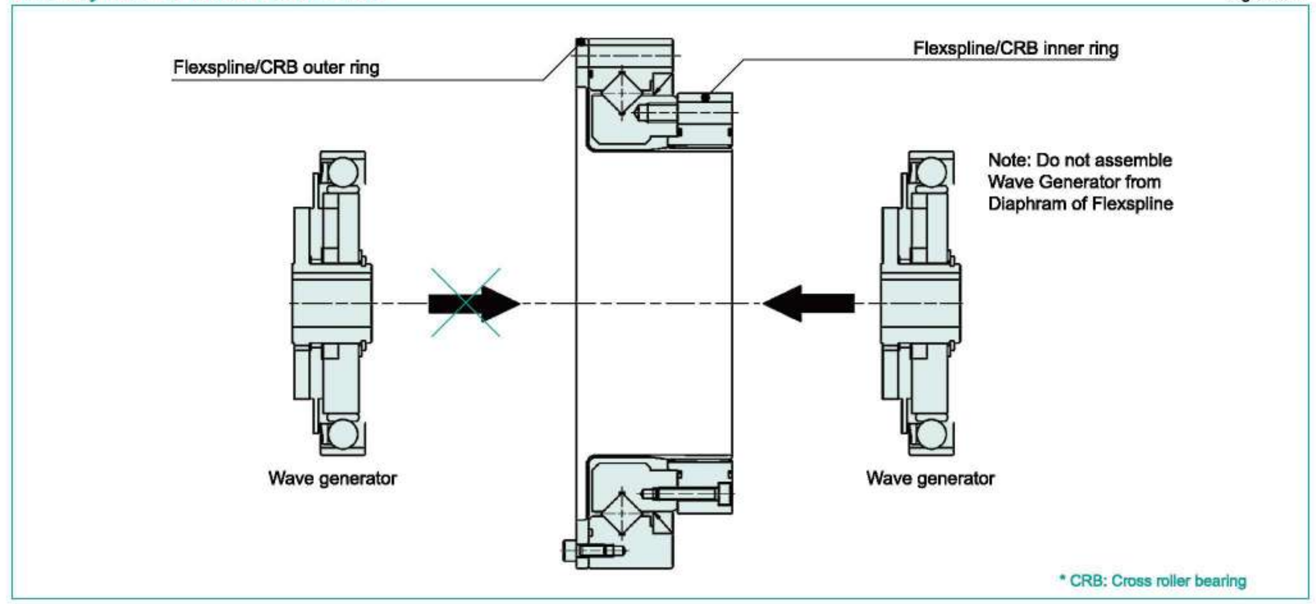
Installation Recommendations

■ Installation sequence

The wave generator is installed after the flexspline and circular spline. If the wave generator is not inserted into the flexspline last, gear teeth scuffing damage or improper eccentric gear mesh may result. Installation resulting in an eccentric tooth mesh (Dedoidal) will cause noise and vibration, and can lead to early failure of the gear. For proper function, the teeth of the flexspline and Circular Spline mesh symmetrically.

Assembly order for basic three elements

Fig. 260-2



▪ Precautions on assembly

It is extremely important to assemble the gear accurately and in proper sequence. For each of the three components, utilize the following precautions.

Wave generator

1. Avoid applying undue axial force to the wave generator during installation. Rotating the wave generator bearing while inserting it is recommended and will ease the process.
2. Extra care must be given to ensure that concentricity and inclination are within the specified limits (see page 253).
3. Installation bolts on the Wave Generator and Flexspline should not interfere each other.

Circular spline

The circular Spline must not be deformed in any way during the assembly. It is particularly important that the mounting surfaces are prepared correctly.

1. Mounting surfaces need to have adequate flatness, smoothness, and no distortion.
2. Especially in the area of the screw holes, burrs or foreign matter should not be present.
3. Adequate relief in the housing corners is needed to prevent interference with the corner of the circular spline.
4. The circular spline should be rotatable within the housing. Be sure there is not interference and that it does not catch on anything.
5. Bolts should not rotate freely when tightening and should not have any irregularity due to the bolt hole being misaligned or oblique.
6. Do not tighten the bolts with the specified torque all at once. Tighten the bolts temporarily with about half the specified torque, and then tighten them with the specified torque. Tighten them in an even, crisscross pattern.
7. Avoid pinning the circular spline if possible as it can reduce the rotational precision and smoothness of operation.

Flexspline

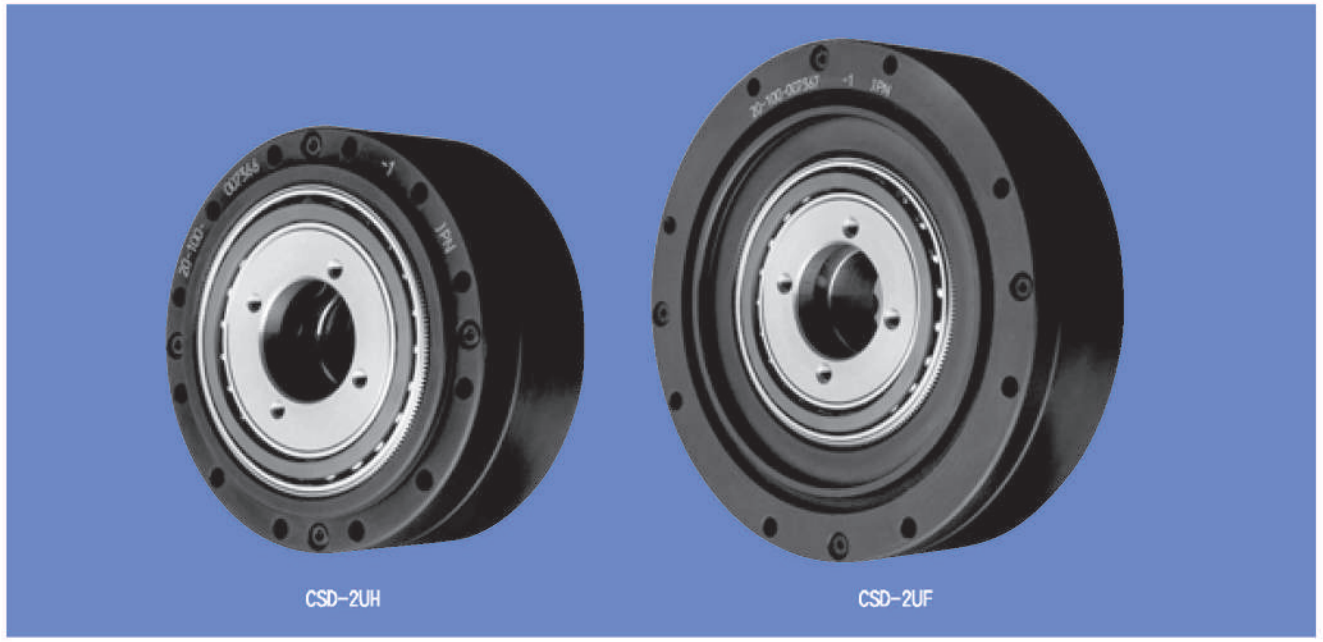
1. Mounting surfaces need to have adequate flatness, smoothness, and no distortion.
2. Especially in the area of the screw holes, burrs or foreign matter should not be present.
3. Adequate clearance with the housing is needed to ensure no interference especially with the major axis of flexspline
4. Bolts should rotate freely when installing through the mounting holes of the flexspline and should not have any irregularity due to the shaft bolt holes being misaligned or oblique.
5. Do not tighten the bolts with the specified torque all at once. Tighten the bolts temporarily with about half the specified torque, and then tighten them to the specified torque. Tighten them in an even, crisscross pattern.
6. The flexspline and circular spline are concentric after assembly. After installing the wave generator bearing, if it rotates in unbalanced way, check the mounting for dedoidal or non-concentric installation.
7. Care should be taken not to damage the flexspline diaphragm or gear teeth during assembly.

   Avoid hitting the tips of the flexpline teeth and circular spline teeth. Avoid installing the CS from the open side of the flexspline after the wave generator has been installed.

Rust prevention

Although Harmonic Drive® gears come with some corrosion protection, the gear can rust if exposed to the environment. The gear external surfaces typically have only a temporary corrosion inhibitor and some oil applied. If an anti-rust product is needed, please contact us to review the options.

Features



CSD Gear Units

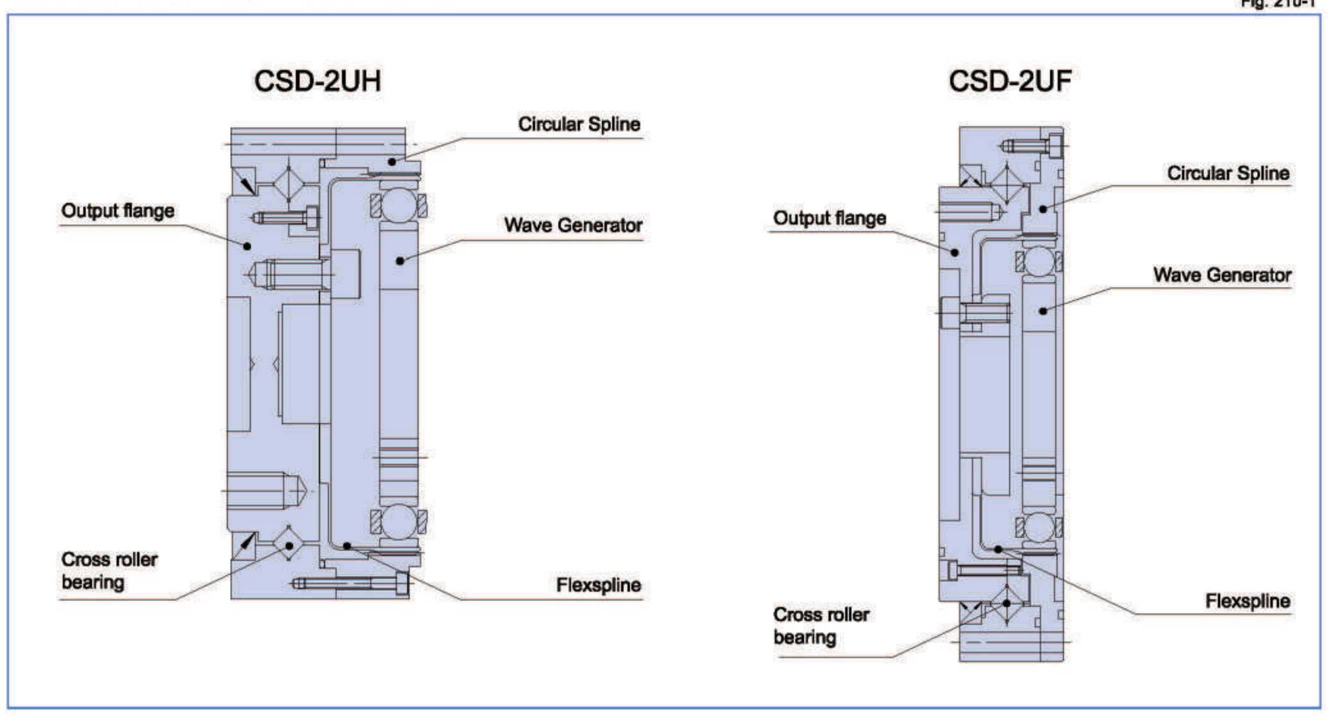
Available in two form factors, the CSD series gear units offer zero backlash while remaining lightweight and compact. These units are ideal for humanoid robots, aerospace, semiconductor equipment and many other critical applications. Ratios available are from 50:1 to 160:1.

Features

- Zero backlash
- Compact design
- Hollow shaft (2UF only)
- High-load capacity
- Lightweight

Structure of CSD Gear Unit

Fig. 210-1



Ordering Code

CSD - 20 - 100 - 2UH - SP

Table 211-1

Series	Size	Ratio*			Model	Special specification
CSD	14	50	100	—	2UH= Unit type (Size 14 to 50) 2UF= Hollow shaft (Size 14 to 40)	Blank= Standard product SP = Special specification code
	17	50	100	—		
	20	50	100	160		
	25	50	100	160		
	32	50	100	160		
	40	50	100	160		
	50	50	100	160		

* The reduction ratio value is based on the following configuration: Input: wave generator, fixed: circular spline, output: flexspline

Technical Data

Rating table

■ CSD-2UH

Table 211-2

Size	Ratio	Rated Torque at 2000rpm		Limit for Repeated Peak Torque		Limit for Average Torque		Limit for Momentary Peak Torque		Maximum Input Speed (rpm)	Limit for Average Input Speed (rpm)	Moment of Inertia	
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Grease lubricant	Grease lubricant	$I(\times10^{-4}kgm^2)$	$J(\times10^{-4}kgfms^2)$
14	50	3.7	0.38	12	1.2	4.8	0.49	24	2.4	8500	3500	0.021	0.021
	100	5.4	0.55	19	1.9	7.7	0.79	35	3.6				
17	50	11	1.1	23	2.3	18	1.9	48	4.9	7300	3500	0.054	0.055
	100	16	1.6	37	3.8	27	2.8	71	7.2				
20	50	17	1.7	39	4.0	24	2.4	69	7.0	6500	3500	0.090	0.092
	100	28	2.9	57	5.8	34	3.5	95	9.7				
	160	28	2.9	64	6.5	34	3.5	95	9.7				
25	50	27	2.8	69	7.0	38	3.9	127	13	5600	3500	0.282	0.288
	100	47	4.8	110	11	75	7.6	184	19				
	160	47	4.8	123	13	75	7.6	204	21				
32	50	53	5.4	151	15	75	7.6	268	27	4800	3500	1.09	1.11
	100	96	10	233	24	151	15	420	43				
	160	96	10	261	27	151	15	445	45				
40	50	96	10	281	29	137	14	480	49	4000	3000	2.85	2.91
	100	185	19	398	41	260	27	700	71				
	160	206	21	453	46	316	32	765	78				
50	50	172	18	200	51	247	25	1000	102	3500	2500	8.61	8.78
	100	329	34	686	70	466	48	1440	147				
	160	370	38	823	84	590	60	1715	175				

(Note) Moment of inertia: $I=\frac{1}{4}GD^2$

■ CSD-2UF

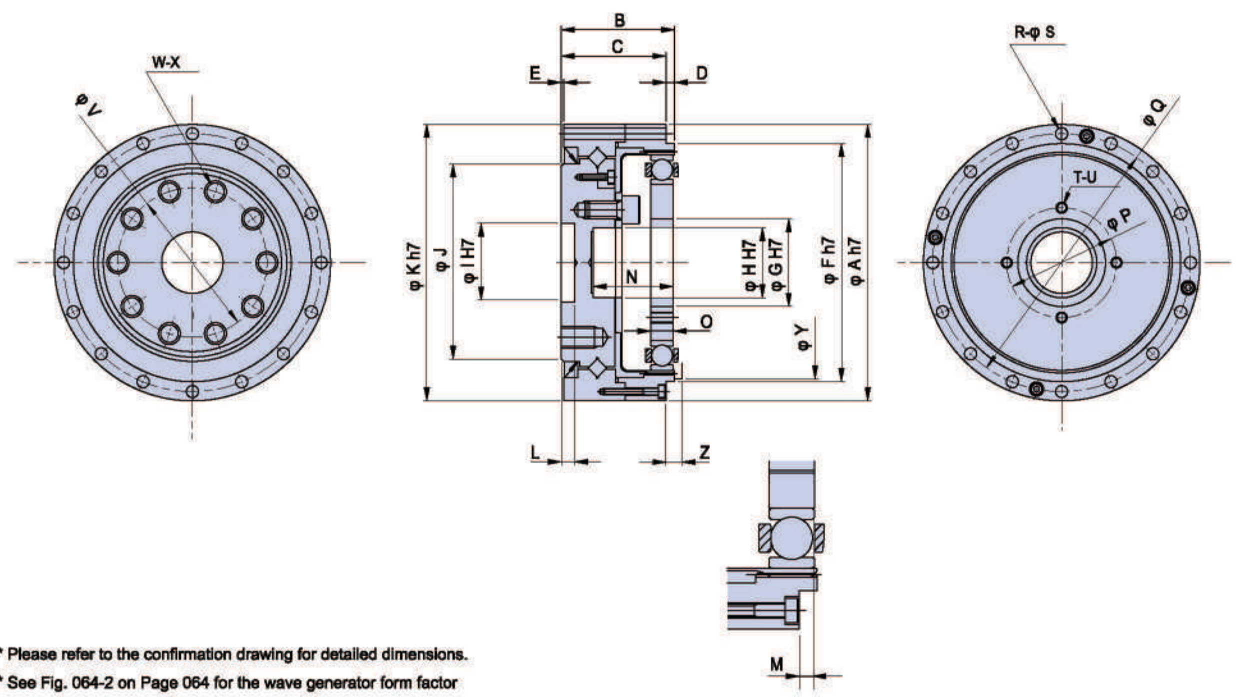
Table 211-3

Size	Ratio	Rated Torque at 2000rpm		Limit for Repeated Peak Torque		Limit for Average Torque		Limit for Momentary Peak Torque		Maximum Input Speed (rpm)	Limit for Average Input Speed (rpm)	Moment of Inertia	
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Grease lubricant	Grease lubricant	$I(\times10^{-4}kgm^2)$	$J(\times10^{-4}kgfms^2)$
14	50	3.7	0.38	12	1.2	4.8	0.49	24	2.4	8500	3500	0.021	0.021
	100	5.4	0.55	19	1.9	7.7	0.79	35	3.6				
17	50	11	1.1	23	2.3	18	1.9	48	4.9	7300	3500	0.054	0.055
	100	16	1.6	37	3.8	27	2.8	71	7.2				
20	50	17	1.7	39	4.0	24	2.4	69	7.0	6500	3500	0.090	0.092
	100	28	2.9	57	5.8	34	3.5	95	9.7				
	160	28	2.9	64	6.5	34	3.5	95	9.7				
25	50	27	2.8	69	7.0	38	3.9	127	13	5600	3500	0.282	0.288
	100	47	4.8	110	11	75	7.6	184	19				
	160	47	4.8	123	13	75	7.6	204	21				
32	50	53	5.4	151	15	75	7.6	268	27	4800	3500	1.09	1.11
	100	96	10	233	24	151	15	420	43				
	160	96	10	261	27	151	15	445	45				
40	50	96	10	281	29	137	14	480	49	4000	3000	2.85	2.91
	100	185	19	398	41	260	27	700	71				
	160	206	21	453	46	316	32	765	78				

(Note) Moment of inertia: $I=\frac{1}{4}GD^2$

Outline dimensions CSD-2UH

Fig. 212-1



* Please refer to the confirmation drawing for detailed dimensions.
* See Fig. 064-2 on Page 064 for the wave generator form factor

Dimensions CSD-2UH

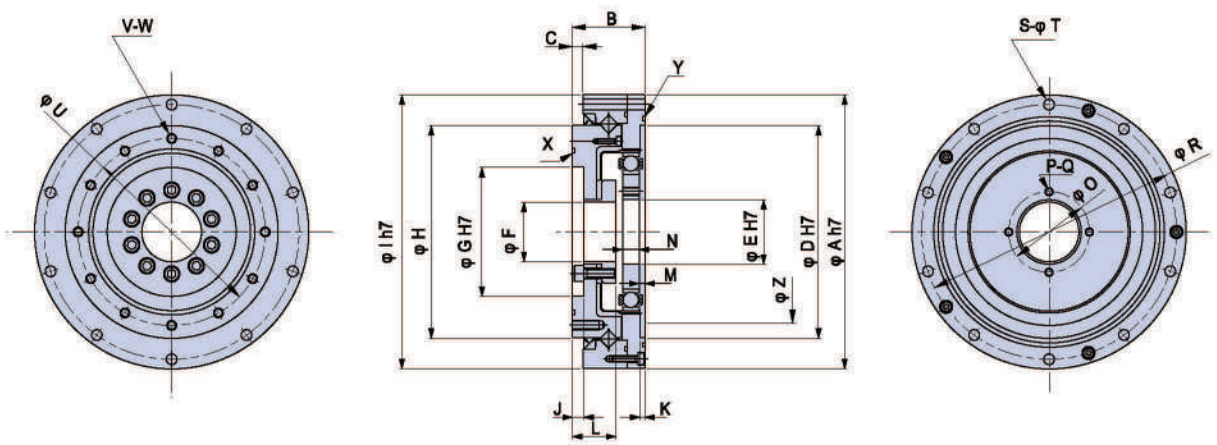
Table 212-1
Unit : mm

Symbol \ Size	14	17	20	25	32	40	50
φA h7	55	62	70	85	112	126	157
B	25	26.5	29.7	37.1	43	51.7	62.5
C	23	24.5	27.7	34.1	40	47.7	58.5
D	2	2	2	3	3	4	4
E	0.5	0.5	0.5	0.5	1	1	1
φF h7	42.5	49.5	58	73	96	108.5	136
φG H7	11	15	20	24	32	40	50
φH H7	11	11	16	20	30	32	44
φI H7	12	14	18	24	32	36	48
φJ	31	38	45	58	78	90	112
φK h7	55	62	70	85	112	126	157
L	5	5	5	5.5	5.5	6	7
M	$1.7^{+0.2}_{0}$	$1.7^{+0.2}_{0}$	$1.7^{+0.2}_{0}$	$2.6^{+0.2}_{0}$	$2.5^{+0.2}_{0}$	$3.4^{+0.2}_{0}$	$3.2^{+0.2}_{0}$
N	14.8	16.3	18.8	23.7	30.6	36.5	44.3
O	$4^{0}_{-0.1}$	$5^{0}_{-0.1}$	$5.2^{0}_{-0.1}$	$6.3^{0}_{-0.1}$	$8.6^{0}_{-0.1}$	$10.3^{0}_{-0.1}$	$12.7^{0}_{-0.1}$
φP(PCD)	17	21	26	30	40	50	60
φQ(PCD)	49	56	64	79	104	117.5	147
R	6	10	12	18	18	18	22
φS	3.4	3.4	3.4	3.4	4.5	5.5	6.6
T	4	4	4	4	4	4	4
U	M3	M3	M3	M3	M4	M5	M6
φV(PCD)	25	27	34	42	57	72	88
W	10	8	8	8	10	10	10
X	M3×7	M5×8	M6×9	M8×12	M8×12	M10×15	M12×18
φY	38	45	53	66	86	106	133
Z	3	3	3.5	4.5	5	6.5	7.5
Mass (kg)	0.35	0.46	0.65	1.2	2.4	3.6	6.9

● Due to different manufacturing methods (casting, machining) of components, tolerances also vary. For dimensions without specified tolerances, please consult our company or authorized agents for the tolerance range

Outline dimensions CSD-2UF

Fig. 213-1



* Please refer to the confirmation drawing for detailed dimensions.
* See Fig. 064-2 on Page 064 for the wave generator form factor

Dimensions CSD-2UF

Table 213-1
Unit : mm

Symbol \ Size	14	17	20	25	32	40
φA h7	70	80	90	110	142	170
B	22	22.7	26.8	31.5	37	45
C	0.5	0.5	2.3	2.1	2.8	6.5
φD H7	48	56	64	80	106	132
φE H7	11	15	20	24	32	40
φF	9	9	18	22	29	37
φG H7	30	34	40	52	70	80
φH	49	59	69	84	110	132
φI h7	70	80	90	110	142	170
J	4.9	5.4	4.8	5.5	6	7
K	2.5	2.5	2.5	3	3	3
L	12.9	13.4	16.8	19.5	22	27
M	$2.8^{+0.2}_{0}$	$2.8^{+0.2}_{0}$	$2.8^{+0.2}_{0}$	$3.4^{+0.2}_{0}$	$3.5^{+0.2}_{0}$	$3.6^{+0.2}_{0}$
N	$4^{0}_{-0.1}$	$5^{0}_{-0.1}$	$5.2^{0}_{-0.1}$	$6.3^{0}_{-0.1}$	$8.6^{0}_{-0.1}$	$10.3^{0}_{-0.1}$
φO(PCD)	17	21	26	30	40	50
P	4	4	4	4	4	4
Q	M3	M3	M3	M3	M4	M5
φR(PCD)	64	74	84	102	132	158
S	6	8	8	10	10	10
φT	3.4	3.4	3.4	4.5	5.5	6.6
φU(PCD)	42	50	60	73	96	116
V	8	10	8	8	8	12
W	M3×5	M3×6	M4×8	M5×8	M6×10	M6×10
X	34.5×0.80	38.0×1.50	S48	S60	S80	S100
Y	49.0×1.50	59.4×1.20	S70	S85	S115	S140
φZ	38	45	53	66	86	106
Mass (kg)	0.50	0.66	0.94	1.7	3.3	5.7

●由于零部件的制造方法（铸造、机械加工）不同，公差也存在差异。关于没有注明公差的尺寸，如需了解公差范围，请咨询本公司或授权代理商。

Positional accuracy

See "Engineering data" for a description of terms.

Table 214-1

Size		14	17	20	25	32	40	50
Positional Accuracy	$\times10^{-4}$ rad	4.4	4.4	2.9	2.9	2.9	2.9	2.9
	arc min	1.5	1.5	1.0	1.0	1.0	1.0	1.0

Hysteresis loss

See "Engineering data" for a description of terms.

Table 214-2

Ratio	Unit \ Size	14	17	20	25	32	40	50
50	$\times10^{-4}$ rad	7.3	4.4	4.4	4.4	4.4	4.4	4.4
	arc min	2.5	1.5	1.5	1.5	1.5	1.5	1.5
100 or more	$\times10^{-4}$ rad	5.8	2.9	2.9	2.9	2.9	2.9	2.9
	arc min	2.0	1.0	1.0	1.0	1.0	1.0	1.0

Torsional stiffness

See "Engineering data" for a description of terms.

Table 214-3

Item		Unit \ Size	14	17	20	25	32	40	50
	T_1	Nm	2.0	3.9	7.0	14	29	54	108
		kgfm	0.2	0.4	0.7	1.4	3.0	5.5	11
	T_2	Nm	6.9	12	25	48	108	196	382
		kgfm	0.7	1.2	2.5	4.9	11	20	39
Reduction ratio 50	K_1	$\times10^4$ Nm/rad	0.29	0.67	1.1	2.0	4.7	8.8	17
		kgfm/arc min	0.085	0.2	0.32	0.6	1.4	2.6	5.0
	K_2	$\times10^4$ Nm/rad	0.37	0.88	1.3	2.7	6.1	11	21
		kgfm/arc min	0.11	0.26	0.4	0.8	1.8	3.4	6.3
	K_3	$\times10^4$ Nm/rad	0.47	1.2	2.0	3.7	8.4	15	30
		kgfm/arc min	0.14	0.34	0.6	1.1	2.5	4.5	9.0
	θ_1	$\times10^{-4}$ rad	6.9	5.8	6.4	7.0	6.2	6.1	6.4
		arc min	2.4	2.0	2.2	2.4	2.1	2.1	2.2
	θ_2	$\times10^{-4}$ rad	19	14	19	18	18	18	18
		arc min	6.4	4.6	6.6	6.1	6.1	5.9	6.2
Reduction ratio 100 or more	K_1	$\times10^4$ Nm/rad	0.4	0.84	1.3	2.7	6.1	11	21
		kgfm/arc min	0.12	0.25	0.4	0.8	1.8	3.2	6.3
	K_2	$\times10^4$ Nm/rad	0.44	0.94	1.7	3.7	7.8	14	29
		kgfm/arc min	0.13	0.28	0.5	1.1	2.3	4.2	8.5
	K_3	$\times10^4$ Nm/rad	0.61	1.3	2.5	4.7	11	20	37
		kgfm/arc min	0.18	0.39	0.75	1.4	3.3	5.8	11
	θ_1	$\times10^{-4}$ rad	5.0	4.6	5.4	5.2	4.8	4.9	5.1
		arc min	1.7	1.6	1.8	1.8	1.7	1.7	1.7
	θ_2	$\times10^{-4}$ rad	16	13	15	13	14	14	13
		arc min	5.4	4.3	5.0	4.5	4.8	4.8	4.6

* The values in this table are reference values. The minimum value is approximately 80% of the displayed value.

Starting torque

See "Engineering data" for a description of terms. The values in the table below vary depending on the use conditions, use them as reference values.

■ CSD-2UH

Table 214-4 Unit: Ncm

Ratio \ Size	14	17	20	25	32	40	50
50	4.4	6.7	8.9	16	32	55	102
100	2.8	3.8	5.1	9.1	20	32	60
160	—	—	3.9	7.2	15	26	47

■ CSD-2UF

Table 214-5 Unit: Ncm

Ratio \ Size	14	17	20	25	32	40
50	5.3	7.5	9.7	17	34	58
100	3.2	4.2	5.5	9.6	21	33
160	—	–	4.1	7.4	16	27

Backdriving torque

See "Engineering data" for a description of terms. The values in the table below vary depending on the use conditions, use them as reference values.

■ CSD-2UH

Table 215-1 Unit: Nm

Ratio \ Size	14	17	20	25	32	40	50
50	2.9	4.3	5.2	9.5	19	33	61
100	3.5	4.6	6.0	11	23	38	71
160	—	—	7.4	13	30	48	89

■ CSD-2UF

Table 215-2 Unit: Nm

Ratio \ Size	14	17	20	25	32	40
50	3.3	4.7	5.6	10	20	34
100	3.9	5.0	6.4	11	24	39
160	—	–	7.8	14	31	49

Ratcheting torque

See "Engineering data" for a description of terms.

Table 215-3 Unit: Nm

Ratio \ Size	14	17	20	25	32	40	50
50	88	150	220	450	980	1800	3700
100	84	160	260	500	1000	2100	4100
160	—	—	220	450	980	1800	3600

Buckling torque

See "Engineering data" for a description of terms.

Table 215-4 Unit: Nm

Size	14	17	20	25	32	40	50
Total reduction ratio	190	330	560	1000	2200	4300	8000

Checking output bearing

A precision cross roller bearing is built in the gear unit to directly support the external load (output flange).Check the maximum moment load, life of the bearing and static safety coefficient to fully bring out the performance of the unit type. See Page 030 to 034 of "Engineering data" for each calculation formula.

■ Checking procedure

(1) Checking the maximum moment load (Mmax)

Calculate the maximum moment load (M max). → Maximum moment load (M max) ≦ allowable moment (Mc)

(2) Checking the life

Calculate the radial load (Frav) and the average axial load (Fav). → Calculate the radial load coefficient (x) and the axial load coefficient (y). → Calculate the lifetime

(3) Checking the static safety coefficient

Calculate the static equivalent radial load coefficient (Po). → Check the static safety coefficient. (fs)

■ Output bearing specifications

The specifications of the cross roller bearing are shown in Table 220-1 and -2.

■ CSD-2UH

Table 220-1

Size	Pitch circle dia. of a roller dp	Offset R	Basic rated load: Basic dynamic rated load C		Basic static rated load Co		Allowable moment load Mc		Moment stiffness Km		Allowable axial load Fa	Allowable radial load Fr
	m	m	$\times10^2$N	kgf	$\times10^2$N	kgf	Nm	kgfm	$\times10^4$ Nm / rad	kgfm / arc-min	$\times10^2$N	$\times10^2$N
14	0.035	0.0095	47	480	60.7	620	41	4.2	4.38	1.3	10.1	6.74
17	0.0425	0.0099	52.9	540	75.5	770	64	6.5	7.75	2.3	11.3	7.58
20	0.050	0.0102	57.8	590	90	920	91	9.3	12.8	3.8	12.4	8.28
25	0.062	0.0130	96.0	980	151	1540	156	16	24.2	7.2	20.5	13.8
32	0.080	0.0144	150	1530	250	2550	313	32	53.9	16	32.1	2.15
40	0.096	0.0151	213	2170	365	3720	450	46	91	27	45.6	3.05
50	0.119	0.0192	348	3550	602	6140	759	77	171	51	74.4	4.99

■ CSD-2UF

Table 220-2

Size	Pitch circle dia. of a roller dp	Offset R	Basic rated load: Basic dynamic rated load C		Basic static rated load Co		Allowable moment load Mc		Moment stiffness Km		Allowable axial load Fa	Allowable radial load Fr
	m	m	$\times10^2$N	kgf	$\times10^2$N	kgf	Nm	kgfm	$\times10^4$ Nm / rad	kgfm / arc-min	$\times10^2$N	$\times10^2$N
14	0.050	0.0118	57.8	590	90	920	91	9.3	12.8	3.8	12.4	8.28
17	0.060	0.0123	104	1060	163	1670	124	12.6	15.4	4.6	22.2	14.9
20	0.070	0.0128	146	1490	220	2250	187	19.1	25.2	7.5	31.2	20.9
25	0.085	0.0134	218	2230	358	3660	258	26.3	39.2	11.6	46.6	31.2
32	0.111	0.0168	382	3900	654	6680	580	59.1	100	29.6	81.7	54.7
40	0.133	0.0215	433	4410	816	8330	849	86.6	179	53.2	92.6	62.0

(Note)
* The basic dynamic rated load means a certain static radial lo ad so that the basic dynamic rated life of the roller bearing is one million rotations.
* The basic static rated load means a static load that gives a certain level of contact stress (4 kN/mm²) in the center of the contact area between the rolling element receiving the maximum load and the orbit.
* The value of the moment stiffness is the average value.
* Allowable moment load is the maximum moment load that may be applied to the output shaft. Please adhere to these values for optimum performance. The value of the moment stiffness is the reference value. The lower-limit value is approximate 80% of the displayed value. Allowable axial or radial load is the value that satisfies the reducer life when either a genuine radial load or an axial load is applied to the main shaft. (When radial load is Lr+R=0mm, and axial load is La=0mm)

Recommended tolerances for assembly

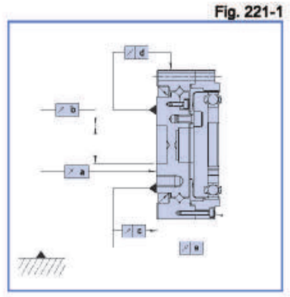
Recommended tolerances for assembly
Input: Wave generator
Output: Circular spline
Fixed: Flexspline

■ CSD-2UH

Table 221-1
Unit: mm

Symbol \ Size	14	17	20	25	32	40	50
a	0.010	0.010	0.010	0.015	0.015	0.015	0.018
b	0.010	0.012	0.012	0.013	0.013	0.015	0.015
c	0.007	0.007	0.007	0.007	0.007	0.007	0.007
d	0.010	0.010	0.010	0.010	0.010	0.015	0.015
e	0.025	0.025	0.025	0.035	0.037	0.037	0.040

Fig. 221-1

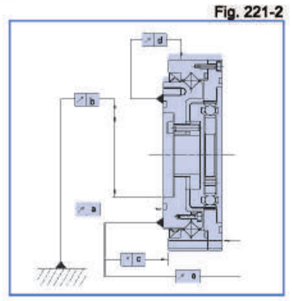


■ CSD-2UF

Table 221-2
Unit: mm

Symbol \ Size	14	17	20	25	32	40
a	0.010	0.010	0.010	0.015	0.015	0.015
b	0.010	0.010	0.010	0.010	0.013	0.013
c	0.010	0.010	0.010	0.010	0.013	0.013
d	0.010	0.010	0.010	0.010	0.013	0.013
e	0.031	0.031	0.031	0.041	0.047	0.047

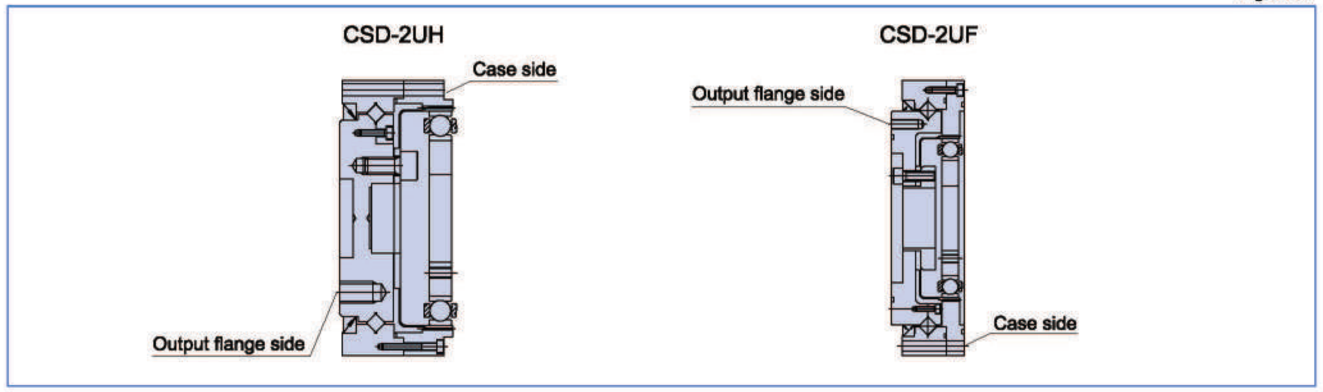
Fig. 221-2



Design Guide

Installation and transmission torque

Fig. 223-1



■ Installation on output flange side and resulting transmission torque

■ CSD-2UH

Table 223-1

Item \ Size		14	17	20	25	32	40	50
Number of bolts		10	8	8	8	10	10	10
Bolt size		M3	M5	M6	M8	M8	M10	M12
Pitch circle	mm	25	27	34	42	57	72	88
Bolt tightening torque	Nm	2.4	10.8	18.4	44	44	74	128
Torque transmission capacity (bolt only)	Nm	50	122	217	486	824	1665	2933

■ CSD-2UF

Table 223-2

Item \ Size		14	17	20	25	32	40
Number of bolts		8	10	8	8	8	12
Bolt size		M3	M3	M4	M5	M6	M6
Pitch circle	mm	42	50	60	73	96	116
Bolt tightening torque	Nm	2.4	2.4	5.4	10.8	18.4	18.4
Torque transmission capacity (bolt only)	Nm	70	104	167	329	765	1109

■ Bolt connection to housing and resulting transmission torque

■ CSD-2UH

Table 223-3

Item \ Size		14	17	20	25	32	40	50
Number of bolts		6	10	12	18	18	18	22
Bolt size		M3	M3	M3	M3	M4	M5	M6
Pitch circle	mm	49	56	64	79	104	117.5	147
Bolt tightening torque	Nm	2.4	2.4	2.4	2.4	5.4	10.8	18.4
Torque transmission capacity (bolt only)	Nm	43	82	112	207	461	833	1804

■ CSD-2UF

Table 223-4

Item \ Size		14	17	20	25	32	40
Number of bolts		6	8	8	10	10	10
Bolt size		M3	M3	M3	M4	M5	M6
Pitch circle	mm	64	74	84	102	132	158
Bolt tightening torque	Nm	2.4	2.4	2.4	5.4	10.8	18.4
Torque transmission capacity (bolt only)	Nm	80	123	140	359	743	1259

(Table 223-1 to 223-4/Notes)
1. The material of the thread must withstand the clamp torque.
2. Recommended bolt: JIS B 1176 socket head cap screw / Strength range : JIS B 1051 over 12.9
3. Torque coefficient: K=0.2
4. Clamp coefficient: A=1.4
5. Tightening friction coefficient μ=0.15

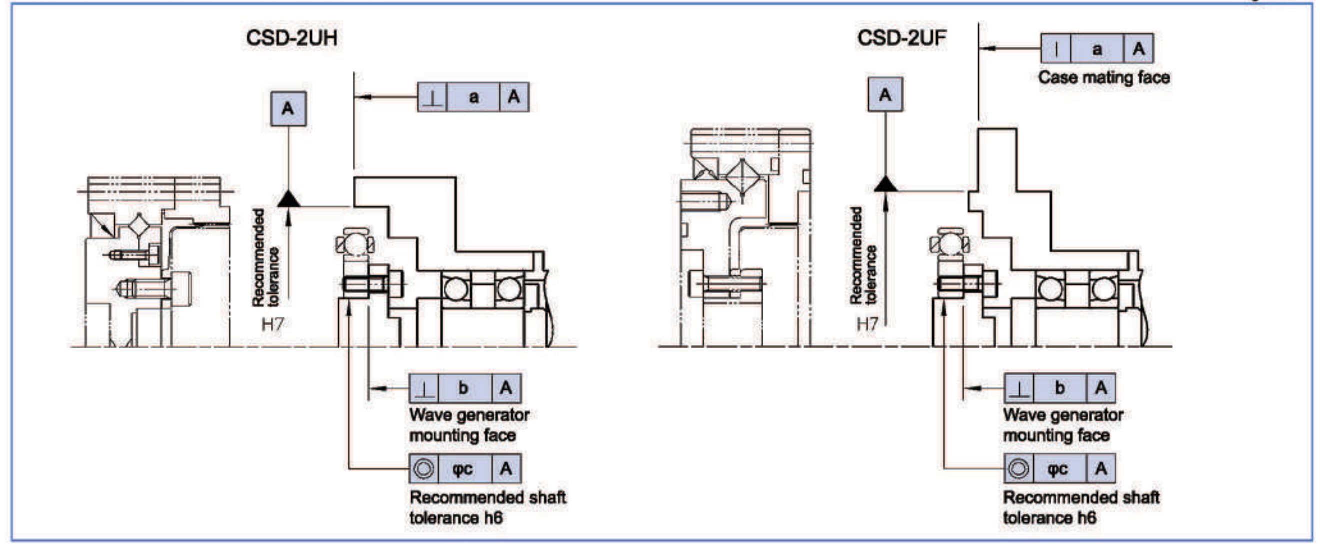
Recommended tolerances for assembly

For peak performance of the gear, it is essential that the following tolerances be observed when assembly is complete. Pay careful attention to the following points and maintain the recommended assembly tolerances to avoid grease leakage.

- Warp and deformation on the mounting surface
- Blocking of foreign matter
- Problems caused by burrs, raised surfaces and location around the tap area of the mounting holes
- Insufficient chamfering on the housing mount
- Insufficient radii on the housing mount

Recommended Tolerances for Assembly

Fig. 222-1



Tolerances for Assembly CSD-2UH

Table 222-1 Unit: mm

Symbol \ Size	14	17	20	25	32	40	50
a	0.011	0.015	0.017	0.024	0.026	0.026	0.028
b	0.008	0.010	0.012	0.012	0.012	0.012	0.015
φc	0.016	0.018	0.019	0.022	0.022	0.024	0.030

Tolerances for Assembly CSD-2UF

Table 222-2 Unit: mm

Symbol \ Size	14	17	20	25	32	40
a	0.011	0.015	0.017	0.024	0.026	0.026
b	0.008	0.010	0.012	0.012	0.012	0.012
φc	0.016	0.018	0.019	0.022	0.022	0.024

Lubrication

Grease lubrication is standard for the CSD-2UH and CSD-2UF. There is no need to add or apply grease upon installation since the products are shipped with the grease applied.
See table below for recommended housing dimensions. These dimensions must be maintained to prevent damage to the gear and to maintain a proper grease cavity.

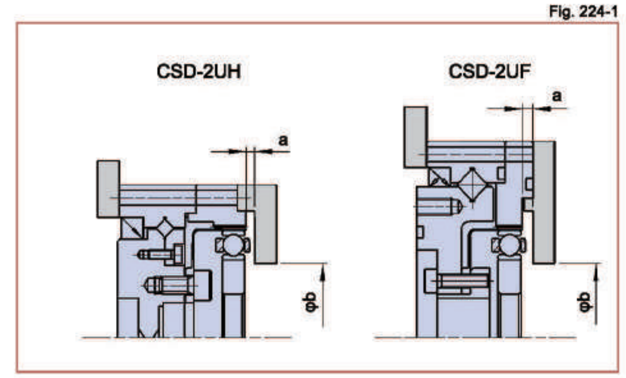
■ Recommended housing dimensions

Table 224-1 Unit: mm

Symbol \ Size	14	17	20	25	32	40	50
a*	1	1	1.5	1.5	2	2.5	3.5
a**	3	3	4.5	4.5	6	7.5	10.5
$\varphi b^{+0.5}_{0}$	16	26	30	37	37	45	45

* For the wave generator facing downward
** For the wave generator facing upward

Fig. 224-1



Sealing

The following sealing mechanism is required to prevent grease leakage and maintain the high durability of the gear.

- Rotating Parts .... Oil seal (with a spring). Surface should be smooth (no scratches)
- Mating flange .... O-ring and seal adhesive. Take care regarding distortion on the plane and how the O-ring is engaged.
- Screw hole area................ Screws should have a thread lock (Locktite 242 is recommended) or seal adhesive.

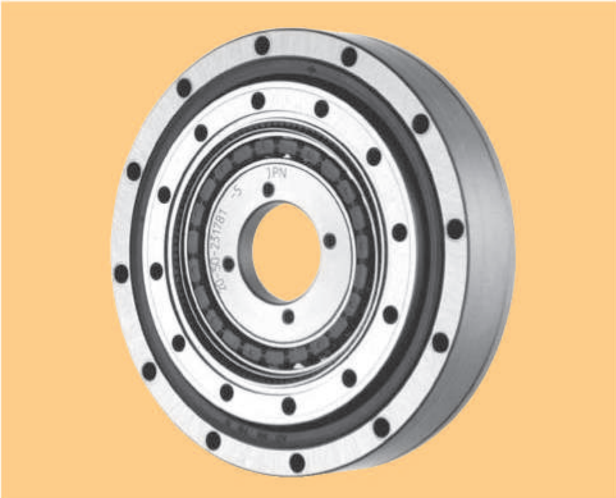
(Note) If you use Harmonic Grease® 4BNo.2 lubrication, strict sealing is required.

Sealing area and the recommended sealing method for the unit type

Table 224-3

Area requiring sealing		Recommended sealing method
Output side	Pass-through hole in the center of the output flange and the output flange mating face	Use O-ring (supplied with the product)
	Mounting screw area	Screw lock agent with sealing effect (Locktite 242 is recommended)
Input side	Flange mating face	Use O-ring (supplied with the product)
	Motor output shaft	Please select a motor which has an oil seal on the output shaft.

Features



SHD series

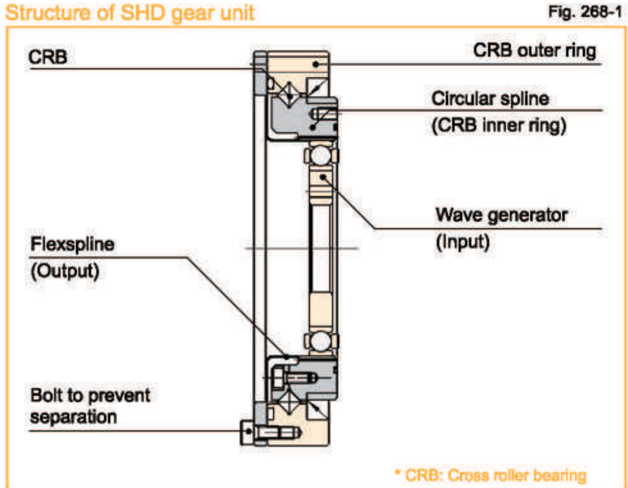
Axially compact, these gear units feature a large hollow input shaft and a robust cross roller bearing so loads can be mounted directly to the unit without the need for additional support bearings

Features of SHD series

- Zero Backlash
- Ultra-flat design - 15% thinner than the SHF Series
- Large Hollow Input Shaft
- Accuracy <1 arc-min (most sizes)
- Rigid cross roller output bearing
- Lightweight - 30% lower weight than Standard SHF Series

Structure of SHD gear unit

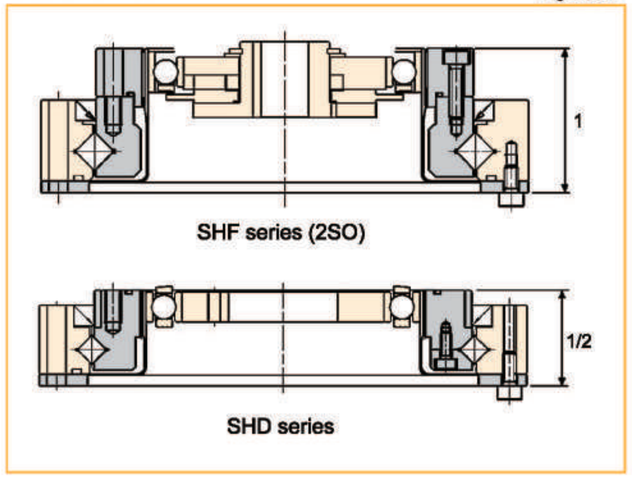
Fig. 268-1



* CRB: Cross roller bearing

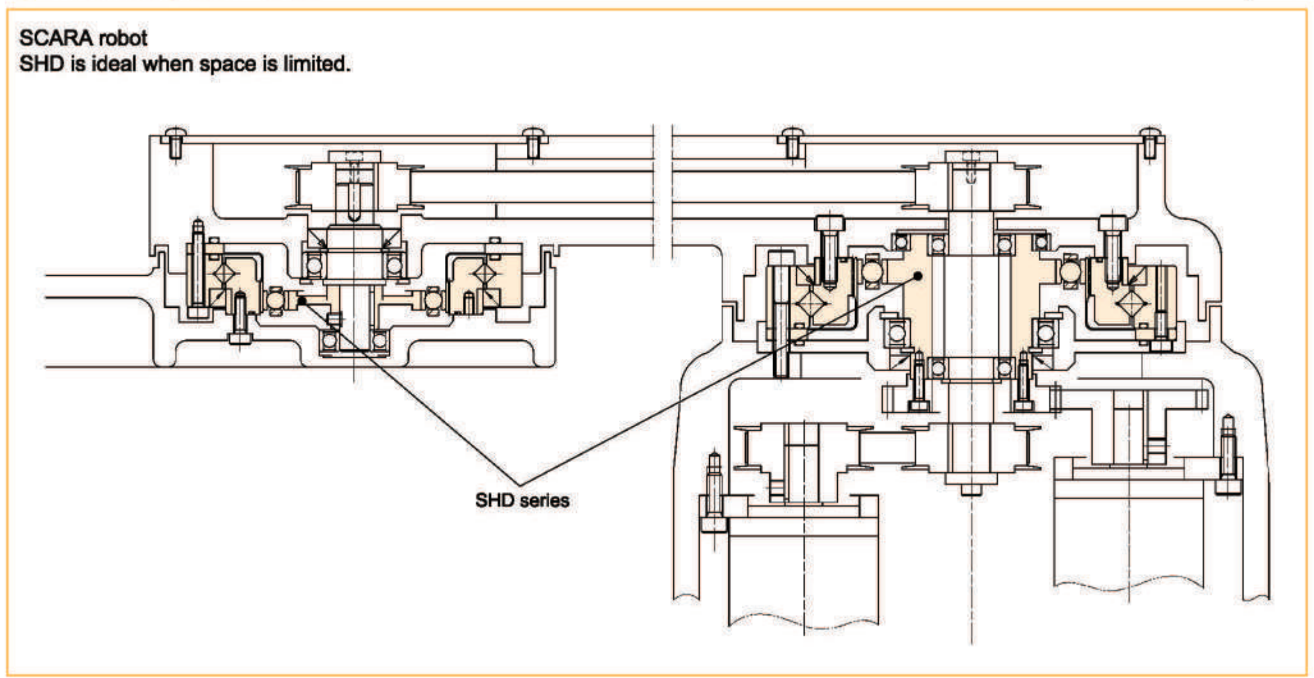
Shaft thickness

Fig. 268-2



Application example, SHD series

Fig. 269-1



Ordering Code

SHD - 20 - 100 - 2SH - SP

Table 269-1

Series	Size	Ratio[*1]			Model	Special specification
SHD	14	50	100	—	2SH = Simplicity Unit 2UH = Gear Unit	LW = Lightweight SP= Special specification code Blank=Standard product
	17	50	100	—		
	20	50	100	160		
	25	50	100	160		
	32	50	100	160		
	40	50	100	160		

*1 The reduction ratio value is based on the following configuration:
Input: wave generator, fixed: circular spline, output: flexspline

Technical Data

Rating table

Table 270-1

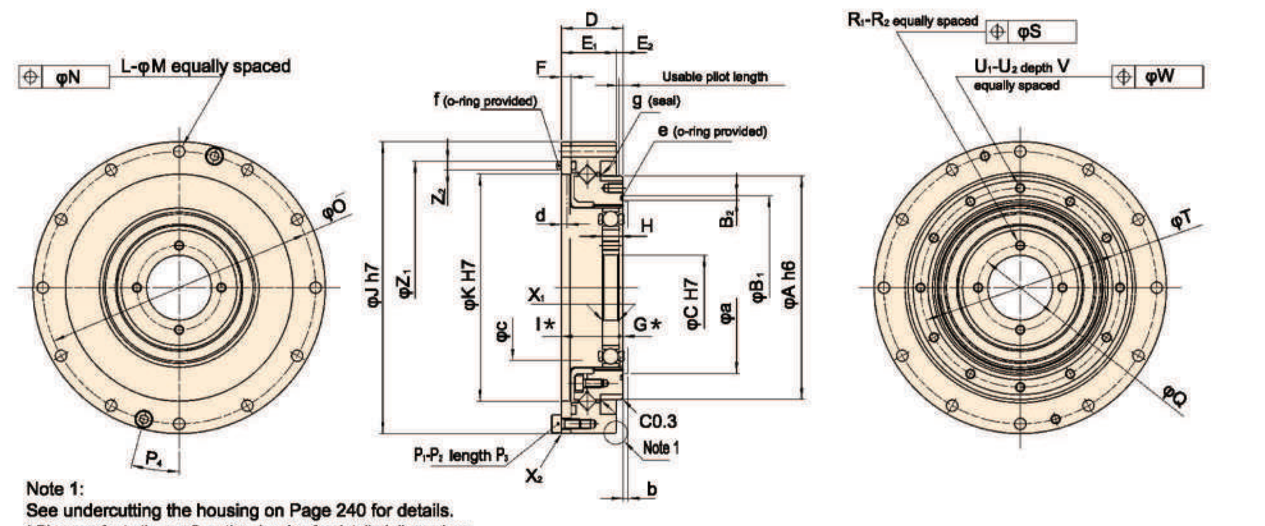
Size	Ratio	Rated Torque at 2000pm		Limit for Repeated Peak Torque		Limit for Average Torque		Limit for Momentary Peak Torque		Maximum Input Speed (rpm)	Limit for Average Input Speed (rpm)	Moment of Inertia	
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Grease lubricant	Grease lubricant	I $\times10^{-4}$ kgm^2	J $\times10^{-5}$ kgfms^2
14	50	3.7	0.38	12	1.2	4.8	0.49	23	2.3	8500	3500	0.021	0.021
	100	5.4	0.55	19	1.9	7.7	0.79	35	3.6				
17	50	11	1.1	23	2.3	18	1.9	48	4.9	7300	3500	0.054	0.055
	100	16	1.6	37	3.8	27	2.8	71	7.2				
20	50	17	1.7	39	4.0	24	2.4	69	7.0	6500	3500	0.090	0.092
	100	28	2.9	57	5.8	34	3.5	95	10				
	160	28	2.9	64	6.5	34	3.5	95	10				
25	50	27	2.8	69	7.0	38	3.9	127	13	5600	3500	0.282	0.288
	100	47	4.8	110	11	75	7.6	184	19				
	160	47	4.8	123	13	75	7.6	204	21				
32	50	53	5.4	151	15	75	7.6	268	27	4800	3500	1.09	1.11
	100	96	10	233	24	151	15	420	43				
	160	96	10	261	27	151	15	445	45				
40	50	96	10	281	29	137	14	480	49	4000	3000	2.85	2.91
	100	185	19	398	41	260	27	700	71				
	160	206	21	453	46	316	32	765	78				

(Note) 1. Moment of Inertia: $I=\frac{1}{4}GD^2$
2. See Rating Table Definitions on Page 12 for details of the terms.

Outline Dimensions SHD-2SH

You can download the CAD files from our website: www.3fgearbox.com

Fig. 270-1



Note 1:
See undercutting the housing on Page 240 for details.
* Please refer to the confirmation drawing for detailed dimensions.
* See Fig. 040-3 on Page 040 for the shapes of the wave generator

Dimensions SHD-2SH

Table 271-1 Unit : mm

Symbol \ Size		14	17	20	25	32	40
	φA h6	$49^{0}_{-0.016}$	$59^{0}_{-0.019}$	$69^{0}_{-0.019}$	$84^{0}_{-0.022}$	$110^{0}_{-0.022}$	$132^{0}_{-0.025}$
	φB₁	$39.1^{+0.1}_{0}$	$48^{+0.1}_{0}$	$56.8^{+0.1}_{0}$	$70.5^{+0.1}_{0}$	$92^{+0.1}_{0}$	$112.4^{+0.1}_{0}$
	B_2	$0.8^{+0.15}_{0}$	$1.1^{+0.25}_{0}$	$1.4^{+0.25}_{0}$	$1.7^{+0.25}_{0}$	$2^{+0.25}_{0}$	$2.2^{+0.25}_{0}$
	φC H7	$11^{+0.018}_{0}$	$15^{+0.018}_{0}$	$20^{+0.021}_{0}$	$24^{+0.021}_{0}$	$32^{+0.025}_{0}$	$40^{+0.025}_{0}$
	D	17.5 ±0.1	18.5 ±0.1	19 ±0.1	22 ±0.1	27.9 ±0.1	33 ±0.1
	E_1	15.5	16.5	17	20	23.6	28
	E_2	2	2	2	2	4.3	5
	F	2.4	3	3	3.3	3.6	4
	G★	1.8	1.6	1.2	0.4	0.6	0.8
	H	$4^{0}_{-0.1}$	$5^{0}_{-0.1}$	$5.2^{0}_{-0.1}$	$6.35^{0}_{-0.1}$	$8.6^{0}_{-0.1}$	$10.3^{0}_{-0.1}$
	I★	$15.7^{0}_{-0.2}$	$16.9^{0}_{-0.2}$	$17.8^{0}_{-0.2}$	$21.6^{0}_{-0.2}$	$27.3^{0}_{-0.2}$	$32.2^{0}_{-0.2}$
	φJ h7	$70^{0}_{-0.030}$	$80^{0}_{-0.030}$	$90^{0}_{-0.035}$	$110^{0}_{-0.035}$	$142^{0}_{-0.040}$	$170^{0}_{-0.040}$
	φK H7	$50^{+0.025}_{0}$	$61^{+0.030}_{0}$	$71^{+0.030}_{0}$	$88^{+0.035}_{0}$	$114^{+0.035}_{0}$	$140^{+0.040}_{0}$
	L	8	12	12	12	12	12
	φM	3.5	3.5	3.5	4.5	5.5	6.6
	φN	0.25	0.25	0.25	0.25	0.25	0.3
	φO	64	74	84	102	132	158
	P_1	2	2	2	4	4	4
	P_2	M3	M3	M3	M3	M4	M4
	P_3	6	6	6	8	10	10
	P_4	22.5°	15°	15°	15°	15°	15°
	φQ	17	21	26	30	40	50
	R_1	4	4	4	4	4	4
	R_2	M3	M3	M3	M3	M4	M5
	φS	0.25	0.25	0.25	0.25	0.25	0.25
	φT	43	52	61.4	76	99	120
	U_1	8	12	12	12	12	12
	U_2	M3	M3	M3	M4	M5	M6
	V	4.5	4.5	4.5	6	8	9
	φW	0.25	0.25	0.25	0.25	0.25	0.3
	X_1	C0.4	C0.4	C0.5	C0.5	C0.5	C0.5
	X_2	C0.4	C0.4	C0.5	C0.5	C0.5	C0.5
	Z_1	$57^{+0.1}_{0}$	$68.1^{+0.1}_{0}$	$78^{+0.1}_{0}$	$94.8^{+0.1}_{0}$	$123^{+0.1}_{0}$	$148^{+0.1}_{0}$
	Z_2	$2^{+0.25}_{0}$	$2^{+0.25}_{0}$	$2.7^{+0.25}_{0}$	$2.4^{+0.25}_{0}$	$2.7^{+0.25}_{0}$	$2.7^{+0.25}_{0}$
Minimum housing clearance	φa	36.5	45	53	66	86	106
	b	1	1	1.5	1.5	2	2.5
	φc	31	38	45	56	73	90
	d	1.4	1.8	1.7	1.8	1.8	1.8
	e	d37.1d0.6	d45.4d0.8	d53.28d0.99	d66.5d1.3	d87.5d1.5	d107.5d1.6
	f	d54.38d1.19	d64.0d1.5	d72.0d2.0	d88.62d1.78	d117.0d2.0	d142d2.0
	g	D49585	D59685	D69785	D84945	D1101226	D1321467
	h	1.5	1.5	1.5	1.5	3.3	4
	Mass (kg)	0.33	0.42	0.52	0.91	1.87	3.09

- The following dimensions can be modified to accommodate:
  Wave Generator: C
  Flexspline: O and P
  Circular Spline: X_1 and X_2
- *The G and I sizes indicated by an asterisk are the mounting positions in the shaft direction and allowance of the three parts (wave generator, flexspline, circular spline). Strictly observe these sizes as they affect the performance and strength.
- As the flexspline is subject to elastic deformation, the inner wall should be φa, b, c or more and it should not exceed φd to prevent possible contact with the housing.

Positional Accuracy

See "Engineering data" for a description of terms.

Table 273-1
Unit: X10⁻⁴rad (arc·min)

Size		14	17	20	25	32	40
Positional Accuracy	$\times10^{-4}$rad	4.4	4.4	2.9	2.9	2.9	2.9
	arc min	1.5	1.5	1.0	1.0	1.0	1.0

Hysteresis loss

See "Engineering data" for a description of terms.

Table 273-2

Ratio \ Size		14	17	20	25	32	40
50	$\times10^{-4}$rad	7.3	5.8	5.8	5.8	5.8	5.8
	arc min	2.5	2.0	2.0	2.0	2.0	2.0
100 or more	$\times10^{-4}$rad	5.8	2.9	2.9	2.9	2.9	2.9
	arc min	2.0	1.0	1.0	1.0	1.0	1.0

Torsional Stiffness

See "Engineering data" for a description of terms.

Table 273-3

Symbol \ Size			14	17	20	25	32	40
	T_1	Nm	2.0	3.9	7.0	14	29	54
		kgfm	0.2	0.4	0.7	1.4	3.0	5.5
	T_2	Nm	6.9	12	25	48	108	196
		kgfm	0.7	1.2	2.5	4.9	11	20
Ratio 50	K_1	$\times10^4$Nm/rad	0.29	0.67	1.1	2.0	4.7	8.8
		kgfm/arc min	0.085	0.2	0.32	0.6	1.4	2.6
	K_2	$\times10^4$Nm/rad	0.37	0.88	1.3	2.7	6.1	11
		kgfm/arc min	0.11	0.26	0.4	0.8	1.8	3.4
	K_3	$\times10^4$Nm/rad	0.47	1.2	2.0	3.7	8.4	15
		kgfm/arc min	0.14	0.34	0.6	1.1	2.5	4.5
	θ_1	$\times10^{-4}$rad	6.9	5.8	6.4	7.0	6.2	6.1
		arc min	2.4	2.0	2.2	2.3	2.1	2.1
	θ_2	$\times10^{-4}$rad	19	14	19	18	18	18
		arc min	6.4	4.6	6.3	6.1	6.1	5.9
Ratio 100 or more	K_1	$\times10^4$Nm/rad	0.4	0.84	1.3	2.7	6.1	11
		kgfm/arc min	0.12	0.25	0.4	0.8	1.8	3.2
	K_2	$\times10^4$Nm/rad	0.44	0.94	1.7	3.7	7.8	14
		kgfm/arc min	0.13	0.28	0.5	1.1	2.3	4.2
	K_3	$\times10^4$Nm/rad	0.61	1.3	2.5	4.7	11	20
		kgfm/arc min	0.18	0.39	0.75	1.4	3.3	5.8
	θ_1	$\times10^{-4}$rad	5.0	4.6	5.4	5.2	4.8	4.9
		arc min	1.7	1.6	1.8	1.8	1.7	1.7
	θ_2	$\times10^{-4}$rad	16	13	15	13	14	14
		arc min	5.4	4.3	5.0	4.5	4.8	4.8

* The values in this table are reference values. The minimum value is approximately 80% of the displayed value.

Simplicity unit (2SH) Starting torque

See "Engineering data" for a description of terms. The values are reference values.

Table 274-1
Unit: Ncm

Ratio \ Size	14	17	20	25	32	40
50	6.2	19	25	39	60	95
100	4.8	17	22	34	50	78
160	—	—	22	33	47	74

Simplicity unit (2SH) Backdriving torque

See "Engineering data" for a description of terms. The values are reference values.

Table 274-3
Unit: Ncm

Ratio \ Size	14	17	20	25	32	40
50	3.7	11	15	24	36	57
100	5.8	21	27	41	60	94
160	—	—	42	64	91	143

Ratcheting torque

See "Engineering data" for a description of terms.

Table 274-5
Unit: Nm

Ratio \ Size	14	17	20	25	32	40
50	88	150	220	450	980	1800
100	84	160	260	500	1000	2100
160	—	—	220	450	980	1800

Buckling torque

See "Engineering data" for a description of terms.

Table 274-6
Unit: Nm

Size	14	17	20	25	32	40
Total reduction ratio	130	260	470	850	1800	3600

Checking output bearing

A precision cross roller bearing is built in the unit type to directly support the external load (output flange).
Check the maximum moment load, life of the cross roller bearing and static safety coefficient to fully bring out the performance of the unit type.
See page 030 to 034 of "Engineering data" for each calculation formula.

■ Checking procedure

(1) Checking the maximum moment load (M max)

Calculate the maximum moment load (Mmax). → Maximum moment load (Mmax) ≦ allowable moment (Mc)

(2) Checking the life

Calculate the average radial load (Frav) and the average axial load (Faav). → Calculate the radial load coefficient (x) and the axial load coefficient (y). → Calculate the lifetime

(3) Checking the static safety coefficient

Calculate the static equivalent radial load coefficient (Po). → Check the static safety coefficient. (fs)

■ Output bearing specifications

The specifications of the cross roller are shown in Table 280-1.

Specifications

Table 280-1

Size	Pitch circle dia. of a roller	Offset	Basic rated load				Allowable moment load Mc		Moment stiffness Km	
	dp	R	Basic dynamic rated load C		Basic static rated load Co				$\times10^4$ Nm/rad	kgf m/arc min
	m	m	$\times10^2$N	kgf	$\times10^2$N	kgf	Nm	kgfm		
14	0.0503	0.0111	29	296	43	438	37	3.8	7.08	2.1
17	0.061	0.0115	52	530	81	826	62	6.3	12.7	3.8
20	0.070	0.011	73	744	110	1122	93	9.5	21	6.2
25	0.086	0.0121	109	1111	179	1825	129	13.2	31	9.2
32	0.112	0.0173	191	1948	327	3334	290	29.6	82.1	24.4
40	0.133	0.0195	216	2203	408	4160	424	43.2	145	43.0

(Note) * The basic dynamic rated load means a certain static radial load so that the basic dynamic rated life of the roller bearing is one million rotations.
* The basic static rated load means a static load that gives a certain level of contact stress (4 kN/mm ^{2}) in the center of the contact area between the rolling element receiving the maximum load and the orbit.
* The value of the moment stiffness is the average value.

* As the life of the cross roller bearing of the unit of the reduction ratio corresponding to the table below (Table 280-2) is shorter than that (note) of the gear during operation under the allowable moment load, consideration should be made in designing the load condition and the lifetime.

(Note) The life of the gear indicates the life (L_{10}=7000 hours) of the wave generator bearing when it operates at 2000rpm input rotational speed and the rated torque (see "Life of the wave generator" on Page 012).

Design Guide

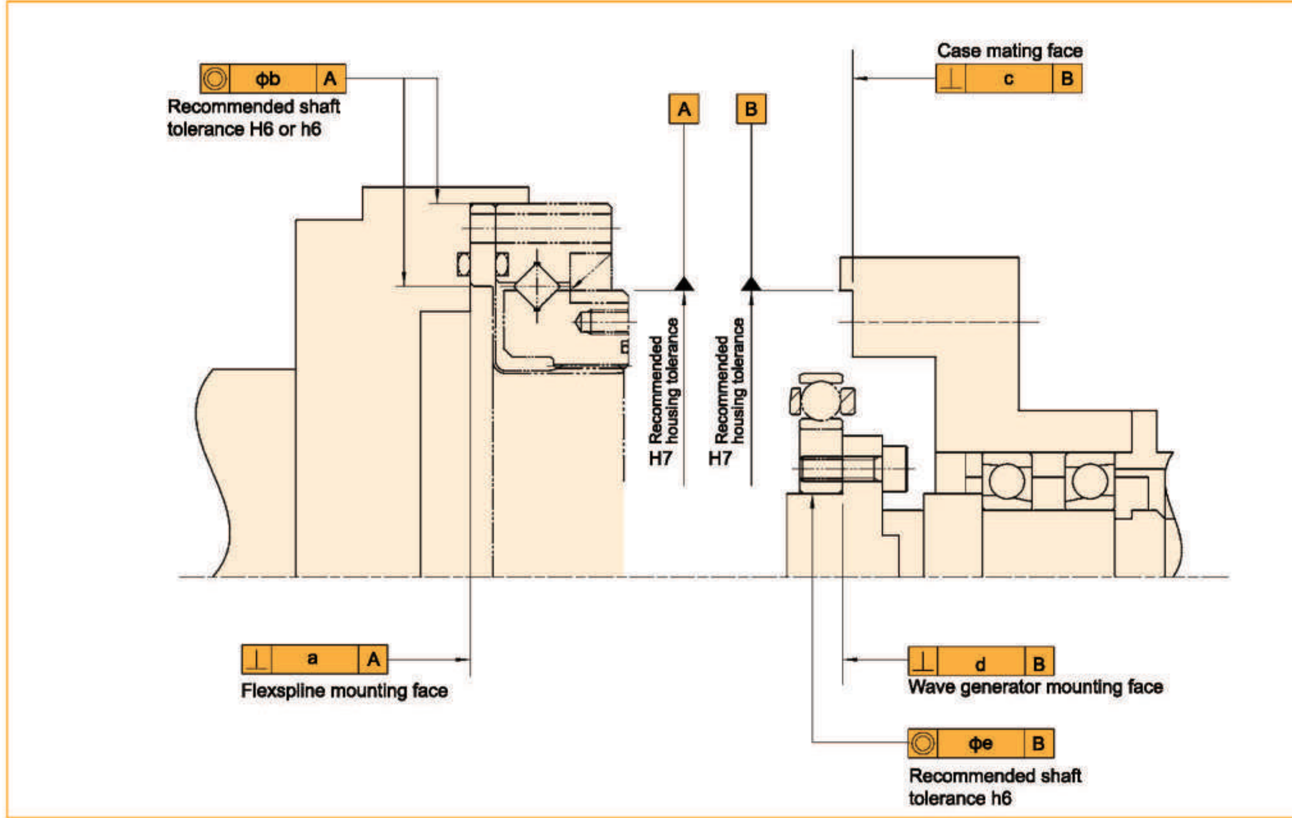
Installation accuracy

For peak performance of the gear, it is essential that the following tolerances be observed when assembly is complete.
Pay careful attention to the following points and maintain the recommended assembly tolerances to avoid grease leakage.

- Warp and deformation on the mounting surface
- Blocking of foreign matter
- Problems caused by burrs, raised surfaces and location around the tap area of the mounting holes
- Insufficient chamfering on the housing mount
- Insufficient radii on the housing mount

Recommended tolerances for assembly

Fig. 281-1



Recommended tolerances for assembly

Table 281-1

Unit: mm

Symbol \ Size	14	17	20	25	32	40
a	0.016	0.021	0.027	0.035	0.042	0.048
ϕb	0.015	0.018	0.019	0.022	0.022	0.024
c	0.011	0.012	0.013	0.014	0.016	0.016
d	0.008	0.010	0.012	0.012	0.012	0.012
ϕe	0.016	0.018	0.019	0.022	0.022	0.024

Installation and transmission torque

Installation and transmission torque on (A) side

Table 282-2

Item \ Size		14	17	20	25	32	40
Number of bolts		8	12	12	12	12	12
Bolt size		M3	M3	M3	M4	M5	M6
Pitch Circle Diameter	mm	64	74	84	102	132	158
Clamp torque	Nm	2.0	2.0	2.0	4.5	9.0	15.3
Transmission torque	Nm	108	186	210	431	892	1509

(Notes) 1. The material of the thread must withstand the clamp torque.
2. Recommended bolt: JIS B 1176 socket head cap screw. Strength range : JIS B 1051 over 12.9.
3. Torque coefficient: K=0.2
4. Tightening coefficient: A=1.4
5. Tightening friction coefficient μ=0.15

Installation and transmission torque on (B) side

Table 282-3

Item \ Size		14	17	20	25	32	40
Number of bolts		8	12	12	12	12	12
Bolt size		M3	M3	M3	M4	M5	M6
Pitch Circle Diameter	mm	43	52	61.4	76	99	120
Effective depth of screw part	mm	4.5	4.5	4.5	6	8	9
Clamp torque	Nm	2.0	2.0	2.0	4.5	9.0	15.3
Transmission torque	Nm	72	130	154	321	668	1148

(Notes) 1. The material of the thread must withstand the clamp torque.
2. Recommended bolt: JIS B 1176 socket head cap screw. Strength range : JIS B 1051 over 12.9.
3. Torque coefficient: K=0.2
4. Tightening coefficient: A=1.4
5. Tightening friction coefficient μ =0.15

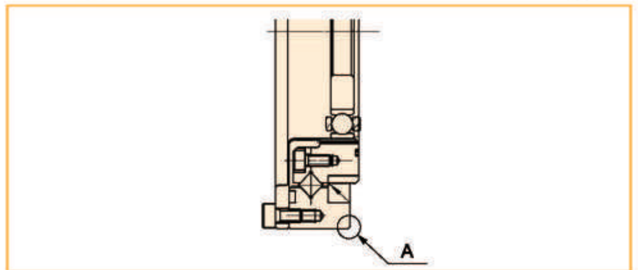
* Since the flange material on the case side is AL (aluminum), be sure to tighten the bolt to the specified torque as described above. If the tightening torque exceeds the above value, the correct transmission torque may not be secured or the bolt may be loosened. Use washers instead of putting the aluminum directly on the bolt-bearing surface when tightening with the bolt from the A side.

Recessing of the mounting pilot

When the housing interferes with corner "A" shown below, an undercut in the housing is recommended.

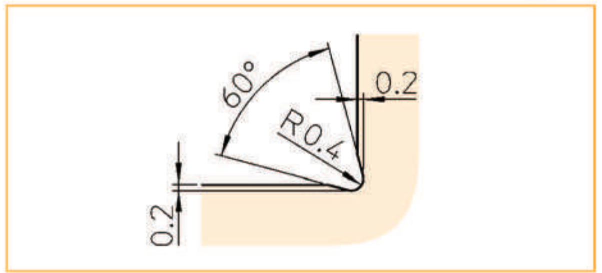
Mounting pilot

Fig. 283-1



Recommended housing undercut

Fig. 283-2



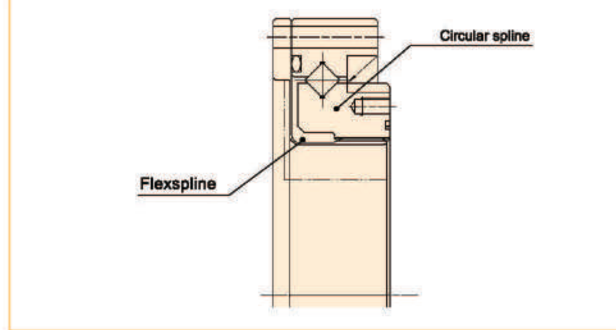
Output part and fixed part

The output part of SHD series varies from the fixed position.
In addition, the reduction ratio and direction of rotation also change, and the relationship is shown in the following figure

表216-1

Fixed part	Output part	Rotary direction and ratio
Flexspline	Circular spline	② on page 9
Circular spline	Flexspline	① on page 9

表216-1



Lubrication

Standard lubrication for SHD series is grease lubrication.
See "Engineering data" on Page 016 for details of the lubricant .

Recommended minimum housing clearance

These dimensions must be maintained to prevent damage to the gear and to maintain a proper grease cavity.

Minimum housing clearance

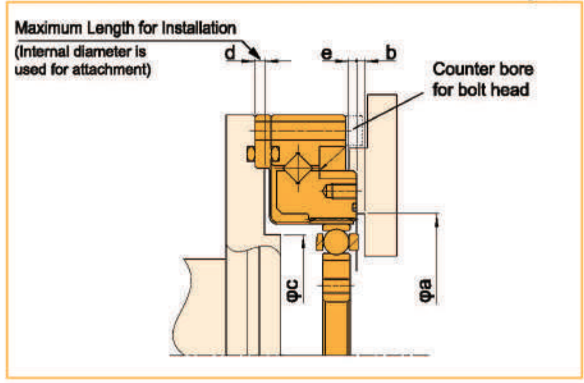
Table 283-5
Unit: mm

Symbol \ Size	14	17	20	25	32	40
φa	36.5	45	53	66	86	106
b	1(3)	1(3)	1.5(4.5)	1.5(4.5)	2(6)	2.5(7.5)
φc	31	38	45	56	73	90
d	1.4	1.8	1.7	1.8	1.8	1.8
e	1.5	1.5	1.5	1.5	3.3	4

(Note) The value in parenthesis is the value when the wave generator is facing upward.

Recommended minimum housing clearance

Fig. 283-4

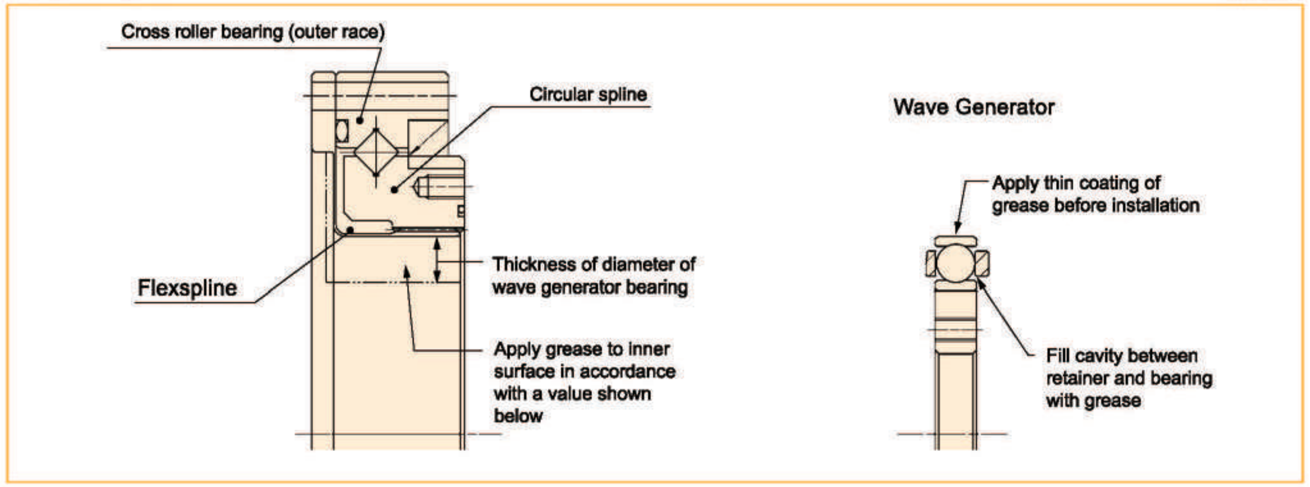


Application guide

As the SHD series is shipped with the outer race of the cross roller bearing and the flexspline temporarily bolted together, grease is applied to the gear teeth, the periphery of the flexspline and the tooth groove of the circular spline. Refer to the following application guide for grease application instructions.

Application guide

Table 284-1



Application quantity

Table 284-1
Unit: g

Size	14	17	20	25	32	40
Application qty	5	9	13	24	51	99

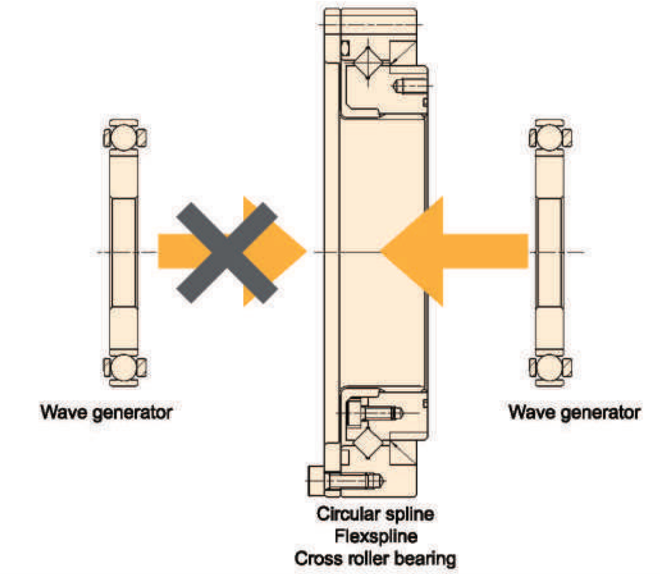
Precautions on installation

■ Assembly order of the three basic elements

The wave generator is installed after the flexspline and circular spline. If the wave generator is not inserted into the flexspline last, gear teeth scuffing damage or improper eccentric gear mesh may result. Installation resulting in an eccentric tooth mesh (Dedoidal) will cause noise and vibration, and can lead to early failure of the gear. For proper function, the teeth of the flexspline and Circular Spline mesh symmetrically.

Assembly order for basic three elements

Fig. 285-1



(Note)
Do not build in the wave generator from the diaphragm side of flexspline.

■ Precautions on assembly

It is extremely important to assemble the gear accurately and in proper sequence. For each of the three components, utilize the following precautions.

Wave generator

1. Avoid applying undue axial force to the wave generator during installation. Rotating the wave generator bearing while inserting it is recommended and will ease the process.
2. Extra care must be given to ensure that concentricity and inclination are within the specified limits (see page 281).
3. Installation bolts on the Wave Generator and Flexspline should not interfere each other.

Circular spline

The circular Spline must not be deformed in any way during the assembly. It is particularly important that the mounting surfaces are prepared correctly.

1. Mounting surfaces need to have adequate flatness, smoothness, and no distortion.
2. Especially in the area of the screw holes, burrs or foreign matter should not be present.
3. Adequate relief in the housing corners is needed to prevent interference with the corner of the circular spline.
4. The circular spline should be rotatable within the housing. Be sure there is not interference and that it does not catch on anything.
5. Bolts should not rotate freely when tightening and should not have any irregularity due to the bolt hole being misaligned or oblique.
6. Do not tighten the bolts with the specified torque all at once. Tighten the bolts temporarily with about half the specified torque, and then tighten them with the specified torque. Tighten them in an even, crisscross pattern.
7. Avoid pinning the circular spline if possible as it can reduce the rotational precision and smoothness of operation.

Flexspline

1. Mounting surfaces need to have adequate flatness, smoothness, and no distortion.
2. Especially in the area of the screw holes, burrs or foreign matter should not be present.
3. Adequate clearance with the housing is needed to ensure no interference especially with the major axis of flexspline
4. Bolts should rotate freely when installing through the mounting holes of the flexspline and should not have any irregularity due to the shaft bolt holes being misaligned or oblique.
5. Do not tighten the bolts with the specified torque all at once. Tighten the bolts temporarily with about half the specified torque, and then tighten them to the specified torque. Tighten them in an even, crisscross pattern.
6. The flexspline and circular spline are concentric after assembly. After installing the wave generator bearing, if it rotates in unbalanced way, check the mounting for dedoidal or non-concentric installation.
7. Care should be taken not to damage the flexspline diaphragm or gear teeth during assembly.

   Avoid hitting the tips of the flexpline teeth and circular spline teeth. Avoid installing the CS from the open side of the flexspline after the wave generator has been installed.

Rust prevention

Although Harmonic Drive® gears come with some corrosion protection, the gear can rust if exposed to the environment. The gear external surfaces typically have only a temporary corrosion inhibitor and some oil applied. If an anti-rust product is needed, please contact us to review the options.

Major Applications of Our Products