Harmonic Drive® **GEARS**

Harmonic Drive SE

Gear component sets

Gears with output bearing

Individual solutions

Content

Our inspiration

With either Apollo 15 on the moon or in the depths of the rough oceans, for more than 50 years, we have been providing significant applications across the planet and beyond with our drive solutions. We, as an industry leader in high precision drive technology, have not only continued to expand our portfolio based on the unique Harmonic Drive® Strain Wave Gear but have also recognised the requirements of modern, trend setting markets and applications: The future of drive technology is intelligent, sustainable and efficient.

Thanks to their special characteristics, which have been continuously developed over decades, Harmonic Drive® Gears and Actuators are perfectly suited to important key industries, including robotics, handling & automation, medical technology, special environments, aviation & space and mechanical engineering.

Highest precision and quality for our customers are key principles of our corporate culture. Eighty percent of the products that leave our factory in Limburg/Lahn are customised versions and are therefore specially developed, designed and manufactured according to customer specifications - from space saving gear component sets to intelligent drive systems.

Due to the high complexity in the configuration of suitable drive technology components, we partner and advise our customers comprehensively. The proposed solution for the drive task to be realised is developed in close cooperation to enable the subsequent integration into the application environment without any problems. Vital for this are, on the one hand, the high flexibility and, on the other hand, the customised scope of services and the integration level. The result is an optimal, highly individualised drive solution.

Successfully shaping the future together with, and for our customers, in demanding industries is a sign of our innovative strength in the field of high precision drive technology.

Production and development sites at the highest technological level in Germany, Japan and America, as well as subsidiaries in Europe and Asia, ensure that we can offer highly specialised and intelligent drive solutions as well as mechatronic systems worldwide.

Your global partner

You will find our sophisticated drive solutions all over the globe and even beyond - regardless of whether you are on the Red Planet or the Blue Planet: Motors, actuators and systems from Harmonic Drive SE are used wherever the highest demands are made on quality and reliability. Production and development sites at the highest technological level in Germany, Japan and USA, as well as subsidiaries in Europe and Asia, ensure that we can offer highly specialised and intelligent drive solutions and mechatronic systems worldwide.

Perhaps you will think of us the next time you fly beyond the horizon in an aircraft of the Airbus family: High precision Harmonic Drive® Gears for aviation help you fly safely and have the world at your feet right now.

„It is never a question as to whether it can be done –
it is only whether one cares to spend the time and effort.“

C. Walton Musser, Inventor of the Strain Wave Gear

Your idea, our engineering, your drive solution

We know that the configuration of suitable components is complex. Together with you, we can therefore develop a complete solution proposal for the drive task. Starting with the selection of the most suitable gears and the matching motor and sensor components, we can configure the complete drive axis for your application.

In doing so, we draw on decades of experience. Since 1970, we have been building on a sizeable number of complex drive solutions, giving our customers a definite technological edge. All design elements can be customised and optimally matched to each other. Integration into the application always takes place in close partnership with our customers. The key factors here are, on the one hand, the high flexibility and, on the other hand, the individual scope of services and the level of integration. The result will be optimal overall solution for your application.

In our modern development centre, a team of more than 40 designers and engineers is available on a daily basis. Up-to-date design and calculation tools, self designed tools for fast analytical calculations and equally established FEM supported methods are in place. In the directly connected test field, the newly developed actuators and drive systems are verified for performance and functionality with the help of specific test benches. The knowledge gained from this is fed back into development and gives the basis for further optimisation.

We produce your transmission solution beginning with lot size 1

In addition to a few standard products with higher quantities, our production is dominated by many specialised and diverse assemblies in smaller quantities down to lot size 1. This is because almost all products that leave our premises are configured together with you specifically according to your wishes and requirements and then manufactured in house. In order to achieve this high flexibility in production, we have developed an intelligent setup concept with which we can even manufacture lot size 1 economically.

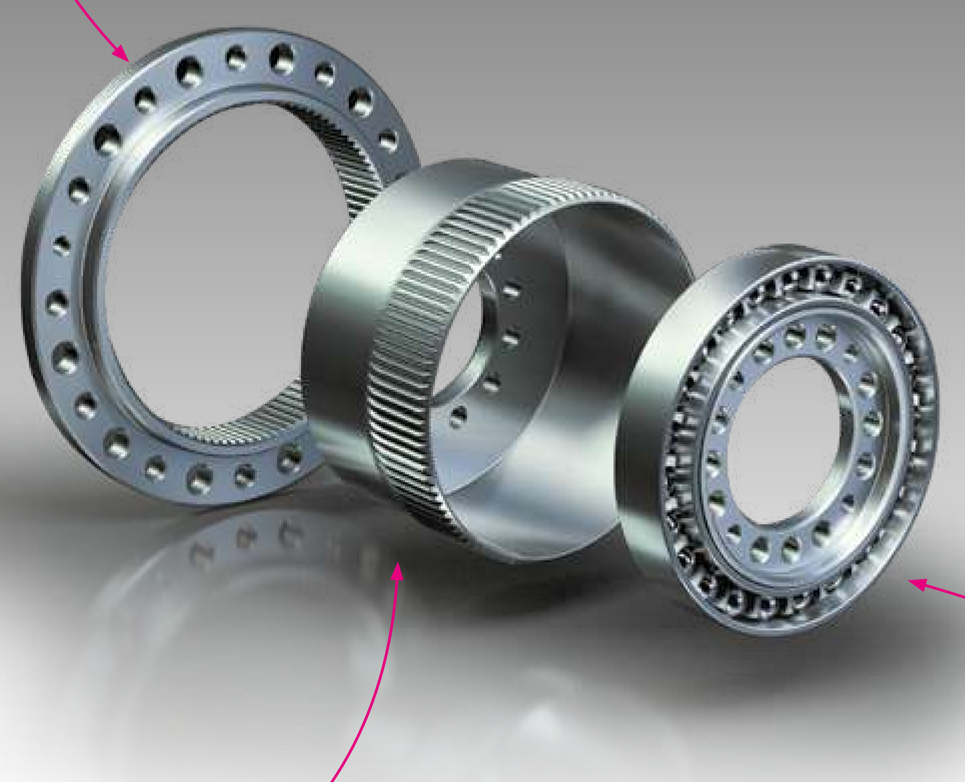
Production lines per size enable us to change setups smoothly and therefore ensure maximum flexibility - even for small lot sizes. In order to meet these requirements throughout the entire value chain, we rely on long term supplier relationships based on mutual partnership in the area of supply chain management, which we continuously develop into efficient supplier structures and therefore synchronise with our production system. In this way, we fulfil your wishes individually, no matter what the quantity.

In the chapter „Individual solutions“ you will find a selection of customised designs that we can realise according to your wishes and requirements.

Highly precise and backlash free gear component sets form the central element of Harmonic Drive® Gears and Servo Actuators. Harmonic Drive® Gear Component Sets consist of only three precision components:

Circular Spline

The Circular Spline is designed as a rigid ring with internal teeth. The Circular Spline has two teeth more than that of Flexspline.



Wave Generator

The Wave Generator is the driven element of the transmission. The elliptical shaped Wave Generator is fitted with a specially designed thin race ball bearing assembly.

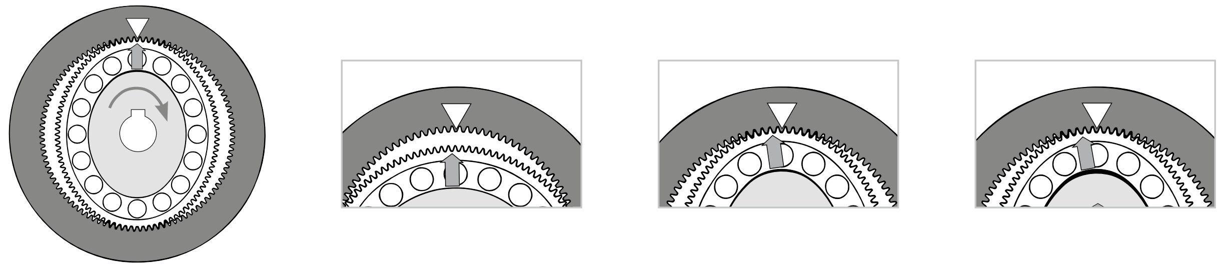
Flexspline

The Flexspline is a high strength, torsionally stiff yet flexible component with external teeth, which reliably transmits high loads.

By inserting the Wave Generator into the Flexspline, the Flexspline assumes the elliptical shape of the Wave Generator. The rotating Wave Generator causes the Flexspline to radially deform.

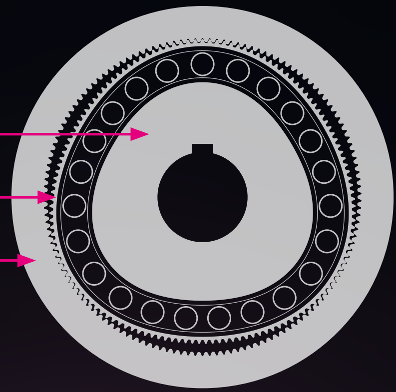
The assembled gear has two diametrically opposed tooth engagement areas around the major axis of the ellipse. The rotation of the Wave Generator causes the meshing of Flexspline with the Circular Spline to move around circumference. Since the Flexspline has two teeth less than the Circular Spline, rotating the Wave Generator leads to a relative movement between the Flexspline and the Circular Spline.

Harmonic Drive® Gears and Servo Actuators are used wherever zero backlash, extraordinary precision and high reliability are required – in all areas where drive technology is required.



1. Start
2. 1/4 Input rotation
3. 1/2 Input rotation
4. 1/1 Input rotation

FURTHER INFORMATION regarding the strain wave gear principle can be found at www.harmonicdrive.co.uk in section Technology - Harmonic Drive® Gears.



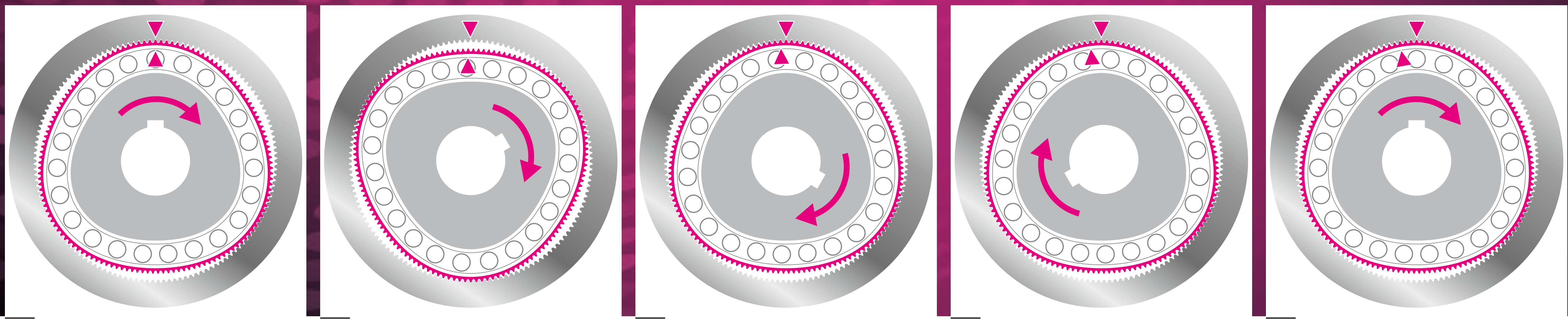
Triangle Technology is based on a revolutionary further development of the proven Harmonic Drive® operating principle

The rounded triangular shape of the Wave Generator creates three tooth engagement areas between the Flexspline, which has external teeth, and the Circular Spline, which has internal teeth.

The rotation of the Wave Generator causes a permanent circumferential tooth engagement between Flexspline and Circular Spline. Since the Flexspline has three teeth fewer than the Circular Spline, a rotation of the Wave Generator causes a relative movement of the Flexspline to the Circular Spline.

Compared to Harmonic Drive® Gears with an elliptical Wave Generator, the three tooth engagement areas of the Triangle technology result in higher torsional stiffness under load.

FURTHER INFORMATION regarding the Harmonic Drive® Triangle Technology can be found at www.harmonicdrive.co.uk in section Technology - Harmonic Drive® Gears.



1. Start **2.** 1/6 Input rotation **3.** 1/3 Input rotation **4.** 2/3 Input rotation **5.** 1 Input rotation

Harmonic Drive® Gears

Harmonic Drive® Gears consist of three individual components – Circular Spline, Flexspline and Wave Generator. Gear component sets with extremely compact design ensures installation in applications with the most demanding space requirements. Gears with output bearings ease integration by combining the precise component sets with high capacity tilt resistant output bearings.

Catalogue
Harmonic Drive® Gears

GEAR COMPONENT SETS


CSG-/HFUC-2A


CPL-2A


CSD-2A


SHG-/HFUS-2A

GEARS WITH OUTPUT BEARING


CSG-/HFUC-2UH


CSF-ULW


CPU-M/H/S


CSG-CPM/CPH/CPS


CSD-2UH/2UF


SHG-/HFUS-2UH/2SH/2SO


SHD-2SH


CSF Mini


PMG


CSF-2UP


FBS-2UH

Harmonic Drive® Servo Actuators

Harmonic Drive® Servo Actuators are the perfect combination of highly dynamic compact servo motors, precision Harmonic Drive® Gear Component Sets and integral high load capacity, tilt resistant output bearings. The frameless motors BHK are available for integration into customer applications.

Catalogue
Harmonic Drive® Mechatronics

SERVO ACTUATORS WITH HOLLOW SHAFT


IHD


BHA


CanisDrive®


AlopexDrive


FHA-C Mini

SERVO ACTUATORS WITH SOLID SHAFT


LynxDrive


FLA

FRAMELESS MOTORS


BHK

SERVO CONTROLLER


YukonDrive

Harmonic Planetary Gears

Harmonic Planetary Gears have lower gear ratios ususally operating higher speeds where there is often the need for very high precision. Our special design with a flexible ring gear in the output stage means that we guarantee constant high precision over the entire lifetime – we call this Permanent Precision®!

Catalogue
Harmonic Planetary Gears


HPN


HPGP


HPG-R


HPG

The proven gear components, output bearings, motors and encoder systems form the basis for different product groups of Harmonic Drive SE in the field of high precision drive technology. Harmonic Drive® Gears or Harmonic Planetary Gears are the starting point for all products. In combination with a servo motor and a motor feedback system, highly integrated, compact and powerful servo actuators are created.

Harmonic Drive® Gears

Gear Component Sets

Harmonic Drive® Gear Component Sets work according to the strain wave gear principle and are characterised by high single stage gear ratios, zero backlash and precise motion as well as maximum torques with low weight and compact dimensions. Consisting of only three components Circular Spline, Flexspline and Wave Generator, they enable maximum flexibility in design integration. Harmonic Drive® Gear Component Sets are ideal for applications with existing output bearings. By using the existing bearings and housing structure, they can be used to achieve both a low total weight and a compact design within the application.

Gears with output bearing

Harmonic Drive® Gears with output bearings combine precise gear component sets with a tilt resistant cross roller or four point contact bearing. Due to its compact design and its high concentricity and accuracy, the output bearing complements perfectly with the strain wave gear. Different gear types allow use in different gear configurations. Motor mounted gearboxes provide the prerequisites for providing direct and easy interfacing of servomotors to the gear with little engineering and assembly expense. The hollow shaft gear allows the central implementation of supply cables and shafts.

Harmonic Drive® Servo Actuators

The continuously increasing demands placed on servo actuators require, among other things, perfect interaction between the motor, gears, motor feedback system and controller. To guarantee characteristics such as precision and dynamics, servo actuators from Harmonic Drive SE have a high degree of compatibility.

The option to choose between a zero backlash strain wave gear and a low backlash planetary gear. The tilt resistant output bearing enables the direct attachment of high payloads without additional support and thus permits a simple and space saving design. In addition, there are numerous possible combinations for the motor winding and the motor feedback system as well as choices for brakes, connecting cables and connecting plugs. Due to the flexibility in the configuration of the motor winding and the motor feedback system, the compatibility with almost all servo controllers of the market is guaranteed. The latest IHD Series also has an integrated drive controller and a dual measuring system for direct control of the position at the gearbox output. This system can be easily implemented in the application by means of fieldbus interfaces.

Harmonic Planetary Gears

Requirements of the market for gears that support high speeds or low ratios often require the highest precision. Harmonic Planetary Gears meet this requirement. Due to their integrated motor connection with clamping element and motor flange, they allow easy mounting of servo motors. The special design with a flexible ring gear in the last stage ensures consistently high precision over the entire service life - we call this Permanent Precision®.

GEAR COMPONENT SETS

Series	CSG-/HFUC-2A	CPL-2A	CSD-2A	SHG-/HFUS-/TriSHG-2A
				
Type	CT	CT	CT	ST
Torque capacity and service life	●●●/●●	●●	●	●●●/●●
Transmission accuracy	●●●	●●●	●●●	●●●
Small outer diameter	●●●	●●●	●●●	●●
Short design	●●	●●	●●●	●●
Tilting moment output bearing	-	-	-	-
Low weight	●●	●●●	●●●	●●
Chapter / Page	1.1 / 28	1.2 / 50	1.3 / 64	1.4 / 76
Key data				
Maximum torque [Nm]	1,8 … 9180	9 … 372	12 … 823	9 … 3419
Tilting moment output bearing [Nm]	-	-	-	-
Hollow shaft diameter [mm]	-	13,5 … 36,0	11 … 50	-
Configurations				
Sizes	8 … 100	14 … 32	14 … 50	14 … 65
Ratio	30 … 160	30 … 160	50 … 160	30 … 160

Description: CT - Cup Type Gear
Type: Gear Component Set ST - Silk Hat Type Gear

GEARS WITH OUTPUT BEARING

Series	CSG-2UH/ HFUC-2UH	CSF-ULW	CPU-M	CPU-H	CPU-S	CSG-CPM	CSG-CPH	CSG-CPS
								
Type	M	M	M	CH	S	M	CH	S
Torque capacity and service life	●●●/●●	●●	●●	●●	●●	●●●	●●●	●●●
Transmission accuracy	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●
Small outer diameter	●●	●●	●	●	●	●	●	●
Short design	●●	●●●	●●	●	●	●●	●	●
Tilting moment output bearing	●●	●●	●●●	●●●	●●●	●●●	●●●	●●●
Low weight	●●	●●●	●	●	●	●	●	●
Chapter / Page	2.1 / 104	2.2 / 124	2.3 / 136	2.3 / 136	2.3 / 136	2.4 / 166	2.4 / 166	2.4 / 166
Key data								
Maximum torque [Nm]	9 … 6840	1,8 … 92	9 … 1840	9 … 1840	9 … 1840	34 … 586	34 … 586	34 … 586
Tilting moment output bearing [Nm]	41 … 4210	2,9 … 18,9	73 … 2222	73 … 2222	73 … 2222	114 … 886	114 … 886	114 … 886
Hollow shaft diameter [mm]	-	3 … 19	-	14 … 70	-	-	19 … 46	-
Configurations								
Sizes	14 … 90	8 … 20	14 … 58	14 … 58	14 … 58	17 … 40	17 … 40	17 … 40
Ratio	30 … 160	30 … 160	30 … 160	30 … 160	30 … 160	50 … 160	50 … 160	50 … 160

GEARS WITH OUTPUT BEARING

Series	CSD-2UH	CSD-2UF	SHG-2UH/ HFUS-2UH	SHG-2SO/ HFUS-2SO	SHG-2SH/ HFUS-2SH	SHD-2SH	CSF Mini (versch. Versionen)	PMG	CSF-2UP	FBS-2UH
										
Type	M	M	CH	M	OH	M	M/S	M/S	M	CH
Torque capacity and service life	●	●	●●●/●●	●●●/●●	●●●/●●	●	●●	●	●●	●
Transmission accuracy	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●	●●●	●●
Small outer diameter	●●	●	●	●	●	●●	●●●	●●●	●●	●●
Short design	●●●	●●●	●	●●	●●	●●●	●●●	●	●●●	●
Tilting moment output bearing	●●	●●●	●●●	●●●	●●●	●●	●	●	●●●	●●
Low weight	●●●	●●●	●	●●	●●	●●●	●●●	●●●	●●	●
Chapter / Page	2.5 / 198	2.5 / 198	2.6 / 216	2.6 / 216	2.6 / 216	2.7 / 246	2.8 / 260	2.9 / 282	2.10 / 292	2.11 / 304
Key data										
Maximum torque [Nm]	12 … 823	12 … 453	9 … 3419	9 … 3419	9 … 3419	12 … 453	0,09 … 28	0,3 … 14,7	1,8 … 28	25 … 106
Tilting moment output bearing [Nm]	41 … 759	91 … 849	74 … 2740	74 … 2740	74 … 2740	37 … 424	0,27 … 13,2	-	15 … 75	93 … 129
Hollow shaft diameter [mm]	-	9 … 37	14 … 80	-	14 … 80	11 … 40	-	-	-	41,0 … 55,1
Configurations										
Sizes	14 … 50	14 … 40	14 … 65	14 … 65	14 … 65	14 … 40	3 … 14	5 … 14	8 … 14	25, 32
Ratio	50 … 160	50 … 160	30 … 160	30 … 160	30 … 160	50 … 160	30 … 100	50 … 110	30 … 100	30 … 100

Description: M Motor mounting gear; CH Closed hollow shaft gear
Type: Gear with output bearing; OH Open hollow shaft gear; S Input shaft gear

●●● perfect ●● optimal ● good

It is always fascinating to find out the areas where our products are used. Here you will find a selection of the industries in which we are represented.

Challenge us with your application – together we can find the appropriate solution.

Robotics, handling & automation

For a long time, robots have been taking over tasks which are too monotonous for humans to produce to the highest quality. With modern programming and performance improvements from drive technology, these aides are now entering fields which were unthinkable a short time ago. This cooperation between man and robot has become an important trend in recent years – one meets each other in some sense.

Mechanical engineering

Is it possible to strike a Euro coin at a distance of a hundred metres? It is not only possible but must absolutely be achievable if high value machine tools are to be manufactured. Harmonic Drive® Products are used in particular at sites where space is limited. The layout in such cases is not defined by torque but rather by rigidity or by hollow shaft diameter.

Medical technology

It is not only world class athletes who want to be fit again quickly after an operation, and today in most cases, recovery is being supported by more technologies which permit targeted training of the body parts affected. The secret of success is programmable movement sequences which can be implemented via a precision actuator. Reliable and precise drive technology is also a fundamental design requirement in the field of surgery.

Special environments

The highest requirements for use in the harshest environmental conditions, such as extreme temperatures or other climatic peculiarities, can be achieved with Harmonic Drive® Products. System applications in defence, vacuum and safety technology or in the depths of our oceans are frequently confronted with such extreme conditions, where the integrated components have to prove themselves once again.

Aerospace

Our products have been working maintenance free in space for over 50 years, have been installed in aircraft for over 30 years and function under extreme low temperatures. Special materials, lightweight products and dry lubricants are specially developed for the aerospace industry.

Harmonic Drive®
Gear Component Sets

Series	CSG-/HFUC-2A	CPL-2A	CSD-2A	SHG-/HFUS-/TriSHG-2A
				
Type	CT	CT	CT	ST
Torque capacity and service life	●●●/●●	● ●	●	●●●/●●
Transmission accuracy	●●●	●●●	●●●	●●●
Small outer diameter	●●●	●●●	●●●	●●
Short design	●●	●●	●●●	●●
Tilting moment output bearing	-	-	-	-
Low weight	●●	●●●	●●●	●●
Chapter / Page	1.1 / 28	1.2 / 50	1.3 / 64	1.4 / 76
Key data				
Maximum torque [Nm]	1.8 … 9180	9 … 372	12 … 823	9 … 3419
Tilting moment output bearing [Nm]	-	-	-	-
Hollow shaft diameter [mm]	-	13.5 … 36.0	11 … 50	-
Configurations				
Sizes	8 … 100	14 … 32	14 … 50	14 … 65
Ratio	30 … 160	30 … 160	50 … 160	30 … 160

Description:
Type: Gear Component Set
CT - Cup Type Gear
ST - Silk Hat Type Gear

Content

Product description

Highest torque capacity and lifelong precision

The CSG-2A Series Gear Component Sets are characterised by maximum torque capacity and service life with a small outer diameter as well as lifelong precision and freedom from backlash.

The HFUC-2A Series Gear Component Sets complement the available CSG sizes and reduction ratios with a slightly lower service life in comparison.

In addition to the proven strain wave gear technology, CSG-2A Series is also available in Triangle Technology. Setting new standards in torsional stiffness, transmission accuracy and dynamics.

Features

- Highest torque capacity
- Outstanding lifelong precision with zero backlash
- Long lifetime
- Large torque range
- Ideal for applications using integrated output bearing arrangement

Ordering code

Table 1.1.1

Ordering code	CSG	- 20	- 100	- 2A-GR	- E	- SP
Series	CSG HFUC					
Size (corresponds to the pitch circle diameter of the Flexspline toothing in inches x 10)		8 11 14 17 20 25 32 40 45 50 58 65 80 90				
Ratio (in drive configuration: Circular Spline (CS) fixed, Wave Generator (WG) input, Flexspline (FS) output			30 50 80 100 120 160			
Version Gear component set sizes 8, 11, 14, 17 Gear component set sizes 20 ... 90				2A-R 2A-GR		
Option „Friction Shim“ CSG-2A Series: Friction Shim is optionally supplied together with the gear HFUC-2A Series: Not provided as standard (field remains empty)					E [ ]	
Customised design Standard design (field remains empty) Special design (on request)						[ ] SP

Please refer to the table of possible combinations.

Combinations

Table 1.1.2

CSG-2A

		Size													
		8	11	14	17	20	25	32	40	45	50	58	65	80	90
Ratio	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	50	-	-	●	●	●	●	●	●	●	-	-	-	-	-
	80	-	-	●	●	●	●	●	●	●	●	●	●	-	-
	100	-	-	●	●	●	●	●	●	●	●	●	●	-	-
	120	-	-	-	●	●	●	●	●	●	●	●	●	-	-
	160	-	-	-	-	●	●	●	●	●	●	●	●	-	-
Version	2A-R	-	-	●	●	-	-	-	-	-	-	-	-	-	-
	2A-GR	-	-	-	-	●	●	●	●	●	●	●	●	-	-

Table 1.1.3

HFUC-2A

		Size													
		8	11	14	17	20	25	32	40	45	50	58	65	80	90
Ratio	30	●	●	●	●	●	●	●	-	-	-	-	-	-	-
	50	●	●	-	-	-	-	-	-	-	●[1)]	●[1)]	●[1)]	●[1)]	●[1)]
	80	-	-	-	-	-	-	-	-	-	-	-	-	●	●
	100	●	●	-	-	-	-	-	-	-	-	-	-	●	●
	120	-	-	-	-	-	-	-	-	-	-	-	-	●	●
	160	-	-	-	-	-	-	-	-	-	-	-	-	●	●
Version	2A-R	●	●	●	●	-	-	-	-	-	-	-	-	-	-
	2A-GR	-	-	-	-	●	●	●	●	●	●	●	●	●	●

● available o on request - not available

1) Only with oil lubrication. Grease lubrication can be used if the average torque T_{av} is not greater than half the rated torque T_N according to Table 1.1.4 and Table 1.1.5.

Technical data

• Rating table

Table 1.1.4

Series	Size	Ratio	Limit for repeated peak torque	Limit for average torque	Rated torque at rated speed 2000 rpm	Limit for momentary peak torque	Max. input speed [rpm]		Limit for average input speed [rpm]		Moment of inertia	Weight
		i	T_R [Nm]	T_A [Nm]	T_N [Nm]	T_M [Nm]	Lubrication		Lubrication		[kgm²]	[kg]
							Oil	Grease	Oil	Grease		
HFUC	8	30	1.8	1.4	0.9	3.3	14000	8500	6500	3500	0.003×10^{-4}	0.026
	8	50	3.3	2.3	1.8	6.6						
	8	100	4.8	3.3	2.4	9.0						
HFUC	11	30	4.5	3.4	2.2	8.5	14000	8500	6500	3500	0.012×10^{-4}	0.05
	11	50	8.3	5.5	3.5	17.0						
	11	100	11.0	8.9	5.0	25.0						
HFUC	14	30	9.0	6.8	4.0	17.0	14000	8500	6500	3500	0.033×10^{-4}	0.09
CSG	14	50	23	9	7	46						
	14	80	30	14	10	61						
	14	100	36	14	10	70						
HFUC	17	30	16	12	8.8	30	10000	7300	6500	3500	0.079×10^{-4}	0.15
CSG	17	50	44	34	21	91						
	17	80	56	35	29	113						
	17	100	70	51	31	143						
	17	120	70	51	31	112						
HFUC	20	30	27	20	15	50	10000	6500	6500	3500	0.193×10^{-4}	0.28
CSG	20	50	73	44	33	127						
	20	80	96	61	44	165						
	20	100	107	64	52	191						
	20	120	113	64	52	191						
	20	160	120	64	52	191						
HFUC	25	30	50	38	27	95	7500	5600	5600	3500	0.413×10^{-4}	0.42
CSG	25	50	127	72	51	242						
	25	80	178	113	82	332						
	25	100	204	140	87	369						
	25	120	217	140	87	395						
	25	160	229	140	87	408						
HFUC	32	30	100	75	54	200	7000	4800	4600	3500	1.69×10^{-4}	0.89
CSG	32	50	281	140	99	497						
	32	80	395	217	153	738						
	32	100	433	281	178	841						
	32	120	459	281	178	892						
	32	160	484	281	178	892						
CSG	40	50	523	255	178	892	5600	4000	3600	3000	4.5×10^{-4}	1.7
	40	80	675	369	268	1270						
	40	100	738	484	345	1400						
	40	120	802	586	382	1530						
	40	160	841	586	382	1530						
CSG	45	50	650	345	229	1235	5000	3800	3300	3000	8.68×10^{-4}	2.3
	45	80	918	507	407	1651						
	45	100	982	650	459	2041						
	45	120	1070	806	523	2288						
	45	160	1147	819	523	2483						
HFUC	50	50[1)]	715	350	245	1430	4500	3500	3000	2500	12.5×10^{-4}	3.2
CSG	50	80	1223	675	484	2418						
	50	100	1274	866	611	2678						
	50	120	1404	1057	688	2678						
	50	160	1534	1096	688	3185						

1) Only with oil lubrication. Grease lubrication can be used if the average torque T_{av} is not greater than half the rated torque T_N according to Table 1.1.4.

ⓘ You will find more information on this in the Engineering data chapter.

Table 1.1.5

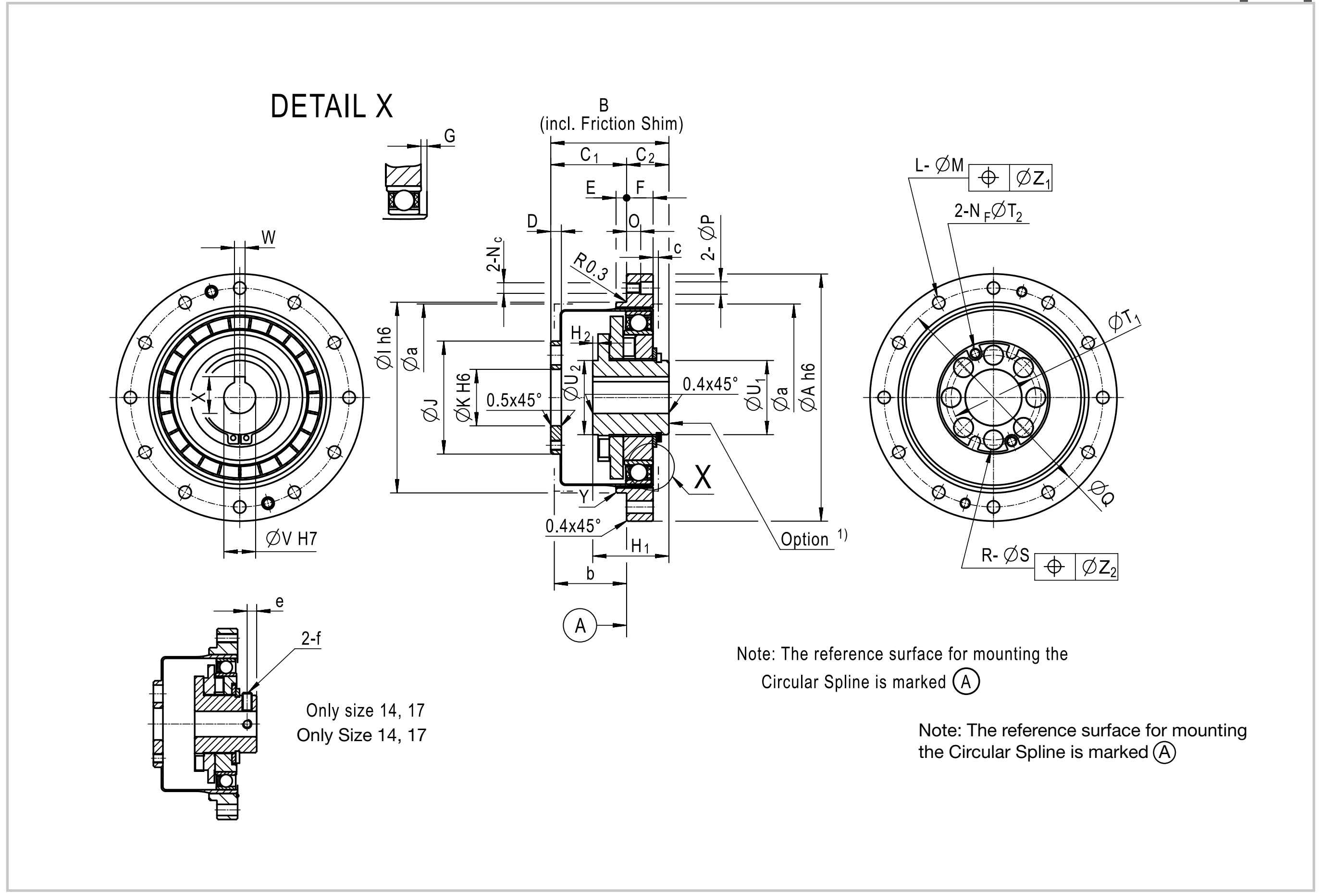
Series	Size	Ratio	Limit for repeated peak torque	Limit for average torque	Rated torque at rated speed 2000 rpm	Limit for momentary peak torque	Max. input speed [rpm]		Limit for average input speed [rpm]		Moment of inertia	Weight
							Lubrication		Lubrication			
		i	T_R [Nm]	T_A [Nm]	T_N [Nm]	T_M [Nm]	Oil	Grease	Oil	Grease	[kgm²]	[kg]
HFUC	58	50[1]	1020	520	353	1960	4000	3000	2700	2200	$27.3x10^{-4}$	4.7
CSG	58	80	1924	1001	714	3185						
	58	100	2067	1378	905	4134						
	58	120	2236	1547	969	4329						
	58	160	2392	1573	969	4459						
HFUC	65	50[1]	1420	720	490	2830	3500	2800	2400	1900	$46.8x10^{-4}$	6.7
CSG	65	80	2743	1352	969	4836						
	65	100	2990	1976	1236	6175						
	65	120	3263	2041	1236	6175						
	65	160	3419	2041	1236	6175						
HFUC	80	50[1]	2440	1260	872	4870	2900	2300	2200	1500	$122x10^{-4}$	12.4
	80	80	3430	1830	1320	6590						
	80	100	4220	2360	1700	7910						
	80	120	4590	3130	1990	7910						
	80	160	4910	3130	1990	7910						
HFUC	90	50[1]	3530	1720	1180	6660	2700	2000	2100	1300	$214x10^{-4}$	17.6
	90	80	3990	2510	1550	7250						
	90	100	5680	3360	2270	9020						
	90	120	6160	4300	2570	9800						
	90	160	6840	4300	2700	11300						

Only with oil lubrication. Grease lubrication can be used if the average torque T_{av} is not greater than half the rated torque T_N according to Table 1.1.5.

You will find more information on this in the Engineering data chapter.

• Dimensions

Illustration 1.1.1 **CSG-2A [mm]**



[1] Hub without keyway or with other diameter see chapter „Engineering data“.

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Wave Generator Details

Illustration 1.1.2 **HFUC-8 ... 90, CSG-14, 17, 65**

Illustration 1.1.3 **CSG-20 ... 58**

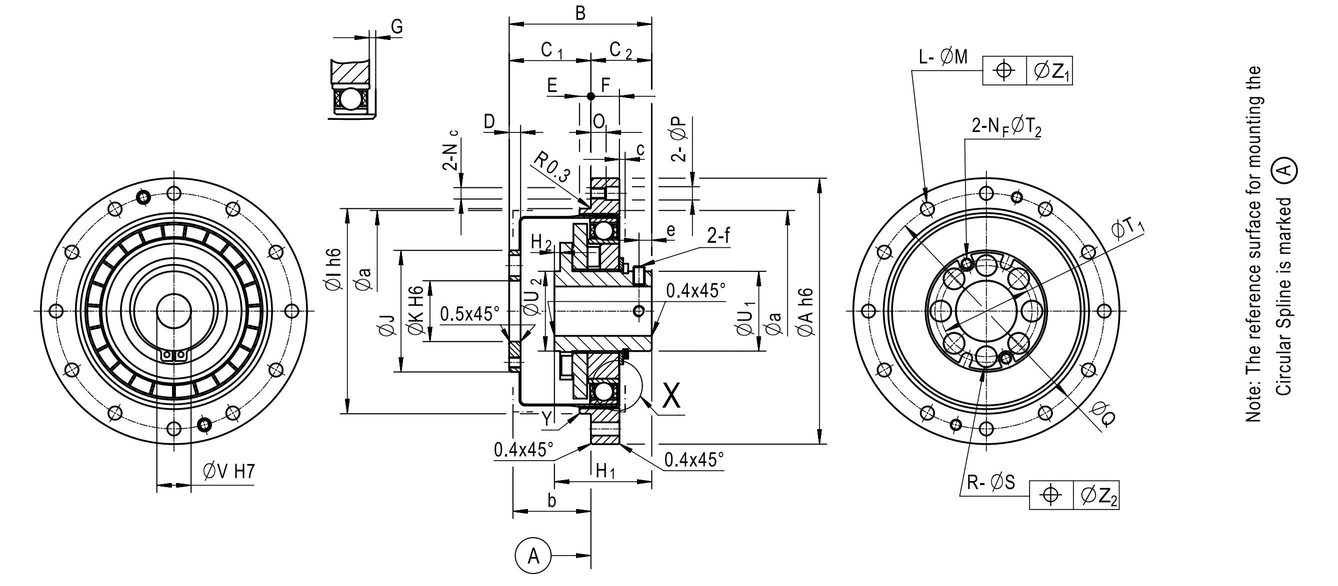
Table 1.1.6

CSG-2A [mm]

		Size									
		14	17	20	25	32	40	45	50	58	65
ø A h6		50	60	70	85	110	135	155	170	195	215
Relative axial position of CS, FS, WG	B	$28.6^{0}_{-0.4}$	$32.6^{0}_{-0.4}$	$33.6^{0}_{-0.4}$	$37.1^{0}_{-0.5}$	$44.1^{0}_{-0.6}$	$53.1^{0}_{-0.6}$	$58.6^{0}_{-1.2}$	$64.1^{0}_{-1.3}$	$75.6^{0}_{-1.3}$	$83.1^{0}_{-1.3}$
	C_1	$17.5^{+0.4}_{0}$	$20.0^{+0.5}_{0}$	$21.5^{+0.6}_{0}$	$24.0^{+0.6}_{0}$	$28.0^{+0.6}_{0}$	$34.0^{+0.6}_{0}$	$38.0^{+0.6}_{0}$	$41.0^{+0.6}_{0}$	$48.0^{+0.6}_{0}$	$52.5^{+0.6}_{0}$
	C_2	11.0	12.5	12.0	13.0	16.0	19.0	20.5	23.0	27.5	30.5
D		2.4	3.0	3.0	3.0	3.2	4.0	4.5	5.0	5.8	6.5
E		2.0	2.5	3.0	3.0	3.0	4.0	4.0	4.0	5.0	5.0
F		6.0	6.5	7.5	10.0	14.0	17.0	19.0	22.0	25.0	29.0
G		1.4	1.6	1.5	3.5	4.2	5.6	6.3	7.0	8.2	9.5
$H_1{}^{0}_{-0.1}$		18.5	20.7	21.5	21.6	23.6	29.7	30.5	34.8	38.3	44.6
H_2		0	0	0	0	0	0.4	0	0.8	0	2.2
ø I h6		38	48	54	67	90	110	124	135	156	177
ø J		23.0	27.2	32.0	40.0	52.0	64.0	72.0	80.0	92.8	104.0
ø K H6		11	10	16	20	26	32	36	40	46	52
L		8	16	16	16	16	16	16	16	16	16
ø M		3.5	3.5	3.5	4.5	5.5	6.6	9.0	9.0	11.0	11.0
N_C		M3	M3	M3	M4	M5	M6	M8	M8	M10	M10
N_F		M3	M3	M3	M4	M5	M6	M6	M8	M8	M8
O		6.0	6.5	4.0	6.0	7.0	9.0	12.0	13.0	15.0	15.0
ø P		–	–	3.5	4.5	5.5	6.6	9.0	9.0	11.0	11.0
Q (Pitch circle)		44	54	62	75	100	120	140	150	175	195
R		6	6	8	8	8	8	8	8	8	8
ø S		4.5	5.5	5.5	6.6	9.0	11.0	13.5	15.5	15.5	18.0
T_1 (Pitch circle)		17	19	24	30	40	50	54	60	70	80
T_2 (Pitch circle)		18.5	21.5	27.0	34.0	45.0	56.0	61.0	68.0	79.0	90.0
ø U_1		14	18	21	26	26	32	32	32	40	48
ø U_2		–	–	–	–	–	32	–	32	–	48
ø V	Standard ø H7	6	8	9	11	14	14	19	19	22	24
	Max. ø	8	10	13	15	15	20	20	20	25	30
W JS 9		–	–	3	4	5	5	6	6	6	8
X		–	–	$10.4^{+0.1}$	$12.8^{+0.1}$	$16.3^{+0.1}$	$16.3^{+0.1}$	$21.8^{+0.1}$	$21.8^{+0.1}$	$24.8^{+0.1}$	$27.3^{+0.2}$
Y chamfer		0.30	0.40	0.40	0.40	0.40	0.40	0.40	0.80	0.80	0.80
ø Z_1		0.25	0.20	0.25	0.25	0.25	0.30	0.50	0.50	0.50	0.50
ø Z_2		0.25	0.25	0.25	0.30	0.50	0.50	0.75	0.75	0.75	1.00
Minimum housing clearance	ø a	38	45	53	66	86	106	119	133	154	172
	b	17.1	19.0	20.5	23.0	26.8	33.0	36.5	39.0	46.2	50.0
	c	1.0	1.0	1.5	1.5	1.5	2.0	2.0	2.0	2.5	2.5
e		2.5	3.0	–	–	–	–	–	–	–	–
f ISO 4026		M3x4	M3x6	–	–	–	–	–	–	–	–

Illustration 1.1.4

HFUC-8-2A ... HFUC-17-2A [mm]



Only size 8

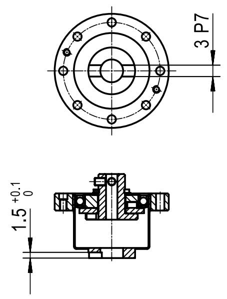


Table 1.1.7

HFUC-2A [mm]

		Size			
		8	11	14	17
ø A h6		30	40	50	60
Relative axial position of CS, FS, WG	B	$22.1^{0}_{-0.3}$	$25.8^{0}_{-0.7}$	$28.5^{0}_{-0.8}$	$32.5^{0}_{-0.9}$
	C_1	$12.5^{+0.2}_{0}$	$14.5^{+0.4}_{0}$	$17.5^{+0.4}_{0}$	$20.0^{+0.5}_{0}$
	C_2	9.6	11.3	11.0	12.5
D		2.7	2.0	2.4	3.0
E		–	2	2	2.5
F		4.5	5.0	6.0	6.5
G		–	–	0.4	0.3
$H_1{}^{0}_{-0,1}$		12.0	16.0	17.6	19.5
H_2		–	0	0	0
ø I h6	i ≥ 50	–	31	38	48
	i = 30	–	31	38	48
ø J		12.3	17.8	23.0	27.2
ø K H6		6	6	11	10
L		8	8	6	12
ø M		2.2	2.9	3.5	3.4
N_C		M2	M2.5	M3	M3
N_F		–	–	M3	M3
O		3.0	3.0	6.0	6.5
ø P		2.2	2.9	–	–
Q (Pitch circle)		25.5	35.0	44.0	54.0
R		–	6	6	6
ø S		–	3.4	4.5	5.5
T_1 (Pitch circle)		–	12	17	19
T_2 (Pitch circle)		–	15.2	18.5	21.5
ø U_1		7	11	14	18
ø U_2		–	–	–	–
ø V	Standard ø H7	3	5	6	8
	Max. ø	–	–	8	10
W JS 9		–	–	–	–
X		–	–	–	–
Y Fase		–	C0.2	C0.3	C0.4
ø Z_1		0.10	0.20	0.25	0.20
ø Z_2		–	0.20	0.25	0.25
ø Z_3		–	0.02	0.02	0.02
e		2	3	2.5	3
f ISO 4026		M2x3	M3x4	M3x4	M3x6
Minimum housing clearance	ø a	21.5	30.0	38.0	45.0
	b	11.34	14.0	17.1	19.0
	c	–	–	1	1

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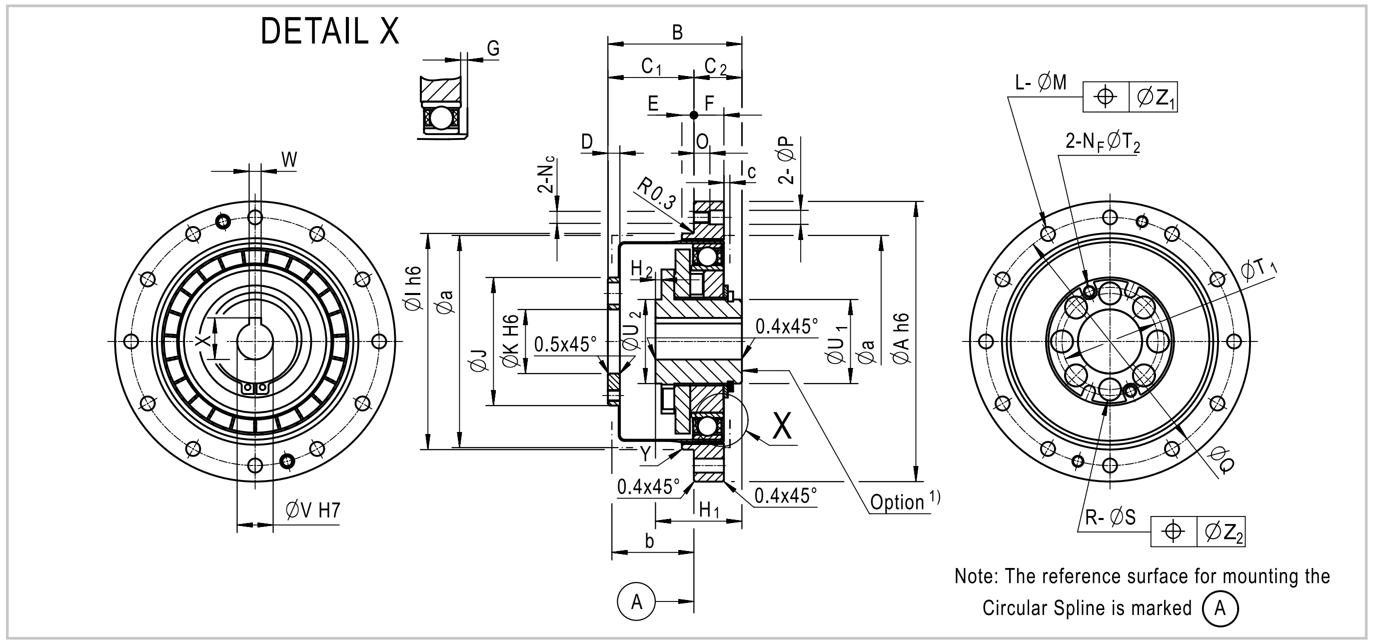
Illustration 1.1.5

HFUC-20-2A ... HFUC-90-2A [mm]



1) Hub without keyway or with other diameter see chapter „Engineering data".

Table 1.1.8

HFUC-2A [mm]

		Size							
		20	25	32	50	58	65	80	90
ø A h6		70	85	110	170	195	215	265	300
Relative axial position of CS, FS, WG	B	$33.5^{0}_{-1.0}$	$37.0^{0}_{-1.0}$	$44.0^{0}_{-1.1}$	$64.0^{0}_{-1.3}$	$75.5^{0}_{-1.3}$	$83.0^{0}_{-1.3}$	$101.0^{0}_{-1.3}$	$112.5^{0}_{-1.4}$
	C_1	$21.5^{+0.6}_{0}$	$24.0^{+0.6}_{0}$	$28.0^{+0.6}_{0}$	$41.0^{+0.6}_{0}$	$48.0^{+0.6}_{0}$	$52.5^{+0.6}_{0}$	$64.0^{+0.6}_{0}$	$71.5^{+0.8}_{0}$
	C_2	12.0	13.0	16.0	23.0	27.5	30.5	37.0	41.0
D		3.0	3.0	3.2	5.0	5.8	6.5	8.0	9.0
E		3	3	3	4	5	5	6	6
F		7.5	10.0	14.0	22.0	25.0	29.0	36.0	41.0
G		0.1	2.1	2.5	4.2	4.8	5.8	6.6	7.5
$H_1{}^{0}_{-0.1}$		20.1	20.2	22.0	32.0	34.9	40.9	49.1	48.2
H_2		0	0	0	0.8	0	2.2	3.1	0
ø I h6	i ≥ 50	54	67	90	135	156	177	218	245
	i = 30	55	68	90	–	–	–	–	–
ø J		32.0	40.0	52.0	80.0	92.8	104.0	128.0	144.0
ø K H6		16	20	26	40	46	52	65	72
L		12	12	12	12	12	12	16	16
Ø M		3.5	4.5	5.5	9.0	11.0	11.0	11.0	14.0
N_C		M3	M4	M5	M8	M10	M10	M10	M12
N_F		M3	M4	M5	M8	M8	M8	M8	M12
O		4	6	7	13	15	15	15	18
ø P		3.5	4.5	5.5	9.0	11.0	11.0	11.0	14.0
Q (Pitch circle)		62	75	100	150	175	195	240	270
R		8	8	8	8	8	8	10	8
ø S		5.5	6.6	9.0	15.5	15.5	18.0	18.0	22.0
T_1 (Pitch circle)		24	30	40	60	70	80	100	110
T_2 (Pitch circle)		27	34	45	68	79	90	114	120
ø U_1		21	26	26	32	40	48	55	60
ø U_2		–	–	–	32	–	48	55	–
ø V	Standard ø H7	9	11	14	19	22	24	28	28
	Max. ø	13	15	15	20	25	30	35	37
W JS 9		3	4	5	6	6	8	8	8
X		$10.4^{+0.1}_{0}$	$12.8^{+0.1}_{0}$	$16.3^{+0.1}_{0}$	$21.8^{+0.1}_{0}$	$24.8^{+0.1}_{0}$	$27.3^{+0.1}_{0}$	$31.3^{+0.1}_{0}$	$31.3^{+0.1}_{0}$
Y chamfer		C0.4	C0.4	C0.4	C0.8	C0.8	C0.8	C0.8	C0.8
ø Z_1		0.25	0.25	0.25	0.50	0.50	0.50	0.50	1.00
ø Z_2		0.25	0.30	0.50	0.75	0.75	1.00	1.00	1.00
ø Z_3		0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Minimum housing clearance	ø a	53	66	86	133	154	172	212	239
	b	20.5	23.0	26.8	39.0	46.2	50.0	61.0	68.5
	c	1.5	1.5	1.5	2.0	2.5	2.5	3.0	3.0

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• Accuracy

Table 1.1.9

[arcmin]

	Size										
	8			11		14		17		≥20	
Ratio	30	50	≥80	30	≥50	30	≥50	30	≥50	30	≥50
Transmission accuracy 1)	<2.0	<2.0	<2.0	<2.0	<1.5	<2.0	<1.5	<1.5	<1.5	<1.5	<1.0
Hysteresis loss	<3.0	<3.0	<2.0	<3.0	<2.0	<3.0	<1.0	<3.0	<1.0	<3.0	<1.0
Lost motion	< 1										
Repeatability	< ± 0.1										

1) Higher accuracy on request

• Accuracy of the Oldham coupling

Harmonic Drive® Gears are zero backlash. If an Oldham coupling is used, a small backlash in the range of a few seconds of arc occurs outside the tooth engagement, see Table 1.1.10. This small amount of backlash does not occur with a Solid Wave Generator.

Table 1.1.10

[arcsec]

Ratio	Series	Size													
		8	11	14	17	20	25	32	40	45	50	58	65	80	90
30	HFUC	59	49	60	33	28	28	23	-	-	-	-	-	-	-
50	CSG	-	-	36	20	17	17	14	14	12	-	-	-	-	-
	HFUC	35	24	-	-	-	-	-	-	-	12	10	10	10	8
80	CSG	-	-	23	13	11	11	9	9	8	8	6	6	-	-
	HFUC	-	-	-	-	-	-	-	-	-	-	-	-	5	5
100	CSG	-	-	18	10	9	9	7	7	6	6	5	5	-	-
	HFUC	18	15	-	-	-	-	-	-	-	-	-	-	5	4
120	CSG	-	-	-	8	8	8	6	6	5	5	4	4	-	-
	HFUC	-	-	-	-	-	-	-	-	-	-	-	-	4	3
160	CSG	-	-	-	-	6	6	5	5	4	4	3	3	-	-
	HFUC	-	-	-	-	-	-	-	-	-	-	-	-	3	2

You will find more information on this in the Engineering data chapter.

• Torsional stiffness

Table 1.1.11

	Symbol [Unit]	Size													
		8	11	14	17	20	25	32	40	45	50	58	65	80	90
Limit torques	T_1 [Nm]	0.29	0.8	2	3.9	7	14	29	54	76	108	168	235	430	618
	T_2 [Nm]	0.75	2.0	6.9	12	25	48	108	196	275	382	598	843	1570	2260
i = 30	K_3 [x 10^3 Nm/rad]	0.54	1.60	3.40	6.70	11	21	49	–	–	–	–	–	–	–
	K_2 [x 10^3 Nm/rad]	0.44	1.30	2.40	4.40	7.1	13	30	–	–	–	–	–	–	–
	K_1 [x 10^3 Nm/rad]	0.34	0.84	1.90	3.40	5.7	10	24	–	–	–	–	–	–	–
i = 50	K_3 [x 10^3 Nm/rad]	0.84	3.20	5.7	13	23	44	98	180	260	340	540	780	1450	2060
	K_2 [x 10^3 Nm/rad]	0.67	3.00	4.7	11	18	34	78	140	200	280	440	610	1150	1620
	K_1 [x 10^3 Nm/rad]	0.44	2.20	3.4	8.1	13	25	54	100	150	200	310	440	810	1180
i ≥ 80	K_3 [x 10^3 Nm/rad]	1.20	4.40	7.1	16	29	57	120	230	330	440	710	980	1850	2630
	K_2 [x 10^3 Nm/rad]	1.00	3.40	6.1	14	25	50	110	200	290	400	610	880	1620	2300
	K_1 [x 10^3 Nm/rad]	0.91	2.70	4.7	10	16	31	67	130	180	250	400	540	1000	1450

• No load starting torque

Table 1.1.12 **[Ncm]**

Ratio	Series	Size													
		8	11	14	17	20	25	32	40	45	50	58	65	80	90
30	HFUC	1.3	2.7	4.3	6.5	11.0	19.0	45.0	-	-	-	-	-	-	-
50	CSG	-	-	3.6	5.6	7.3	13.0	29.0	51.0	69.0	-	-	-	-	-
	HFUC	0.8	1.6	-	-	-	-	-	-	-	86.0	130.0	180.0	320.0	450.0
80	CSG	-	-	2.6	3.6	4.5	8.5	18.0	32.0	45.0	59.0	90.0	121.0	-	-
	HFUC	-	-	-	-	-	-	-	-	-	-	-	-	200	280
100	CSG	-	-	2.3	3.2	4.1	7.6	17.0	29.0	40.0	53.0	80.0	108.0	-	-
	HFUC	0.59	1.1	-	-	-	-	-	-	-	-	-	-	180	250
120	CSG	-	-	-	3.0	3.6	6.9	14.0	26.0	36.0	50.0	74.0	101.0	-	-
	HFUC	-	-	-	-	-	-	-	-	-	-	-	-	170	230
160	CSG	-	-	-	-	3.2	6.1	13.0	23.0	32.0	43.0	64.0	88.0	-	-
	HFUC	-	-	-	-	-	-	-	-	-	-	-	-	140	200

• No load back driving torque

Table 1.1.13 **[Nm]**

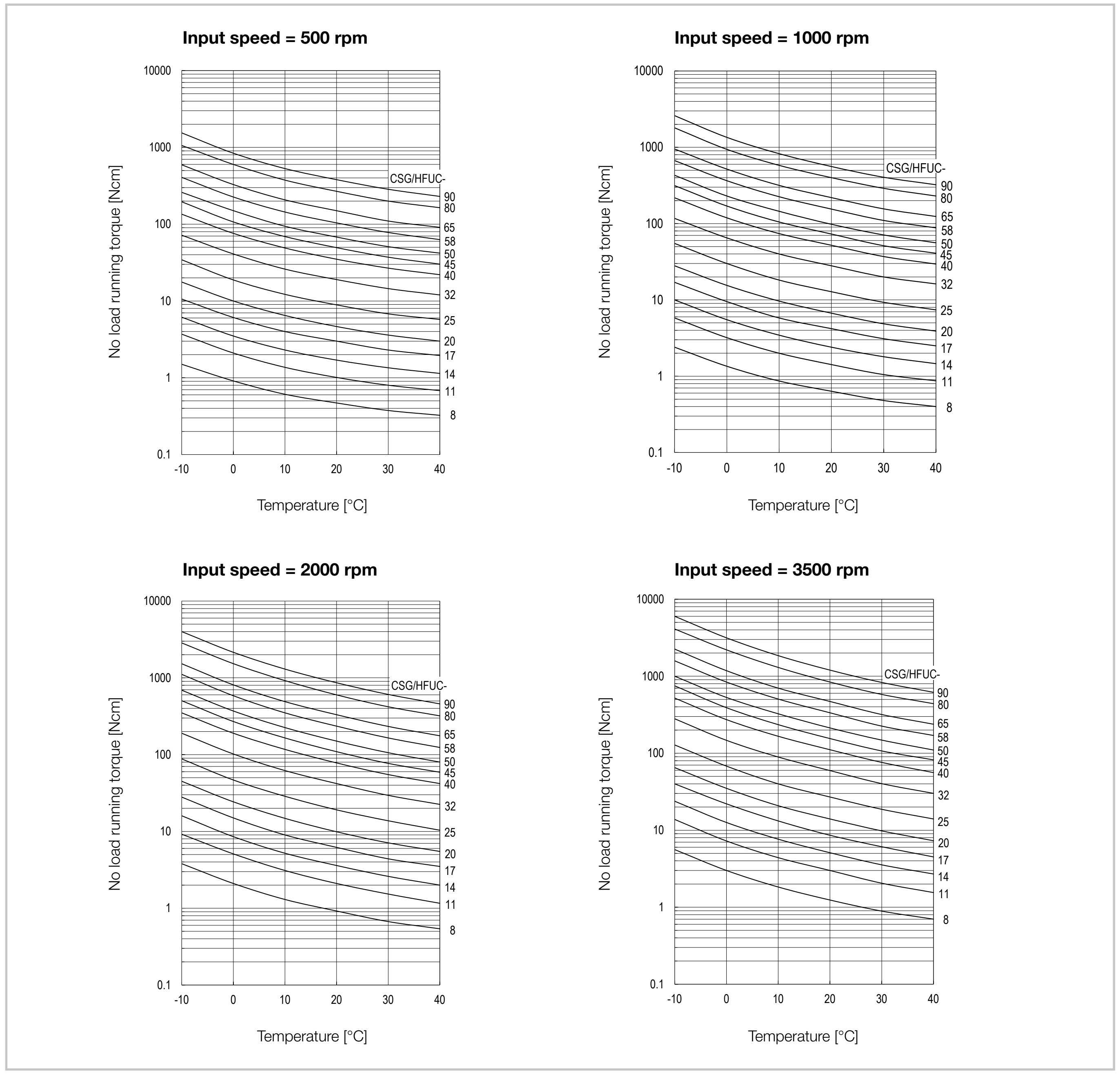
Ratio	Series	Size													
		8	11	14	17	20	25	32	40	45	50	58	65	80	90
30	HFUC	0.65	1.30	2.00	3.20	5.50	10.00	21.00	-	-	-	-	-	-	-
50	CSG	-	-	1.5	2.8	4.4	8.3	18.0	31.0	41.0	-	-	-	-	-
	HFUC	0.5	1.0	-	-	-	-	-	-	-	52	80	110	200	270
80	CSG	-	-	1.5	2.8	4.6	8.5	18.0	31.0	43.0	58.0	89.0	132.0	-	-
	HFUC	-	-	-	-	-	-	-	-	-	-	-	-	200	270
100	CSG	-	-	1.9	3.1	5.0	9.2	20.0	34.0	46.0	63.0	97.0	143.0	-	-
	HFUC	0.7	1.4	-	-	-	-	-	-	-	-	-	-	220	300
120	CSG	-	-	-	3.4	5.4	10.0	21.0	37.0	52.0	69.0	107.0	154.0	-	-
	HFUC	-	-	-	-	-	-	-	-	-	-	-	-	240	330
160	CSG	-	-	-	-	6.4	12.0	25.0	44.0	63.0	85.0	132.0	187.0	-	-
	HFUC	-	-	-	-	-	-	-	-	-	-	-	-	290	390

You will find more information on this in the Engineering data chapter.

• No load running torque

The diagrams apply to Harmonic Drive® Grease SK-2 (size 8 ... 17) or SK-1A (size ≥ 20).

Illustration 1.1.6



Compensation values for no load running torque

When using gears with ratios other than i=100 please apply the compensation values from the table to the values taken from the curves.

Table 1.1.14 **[Ncm]**

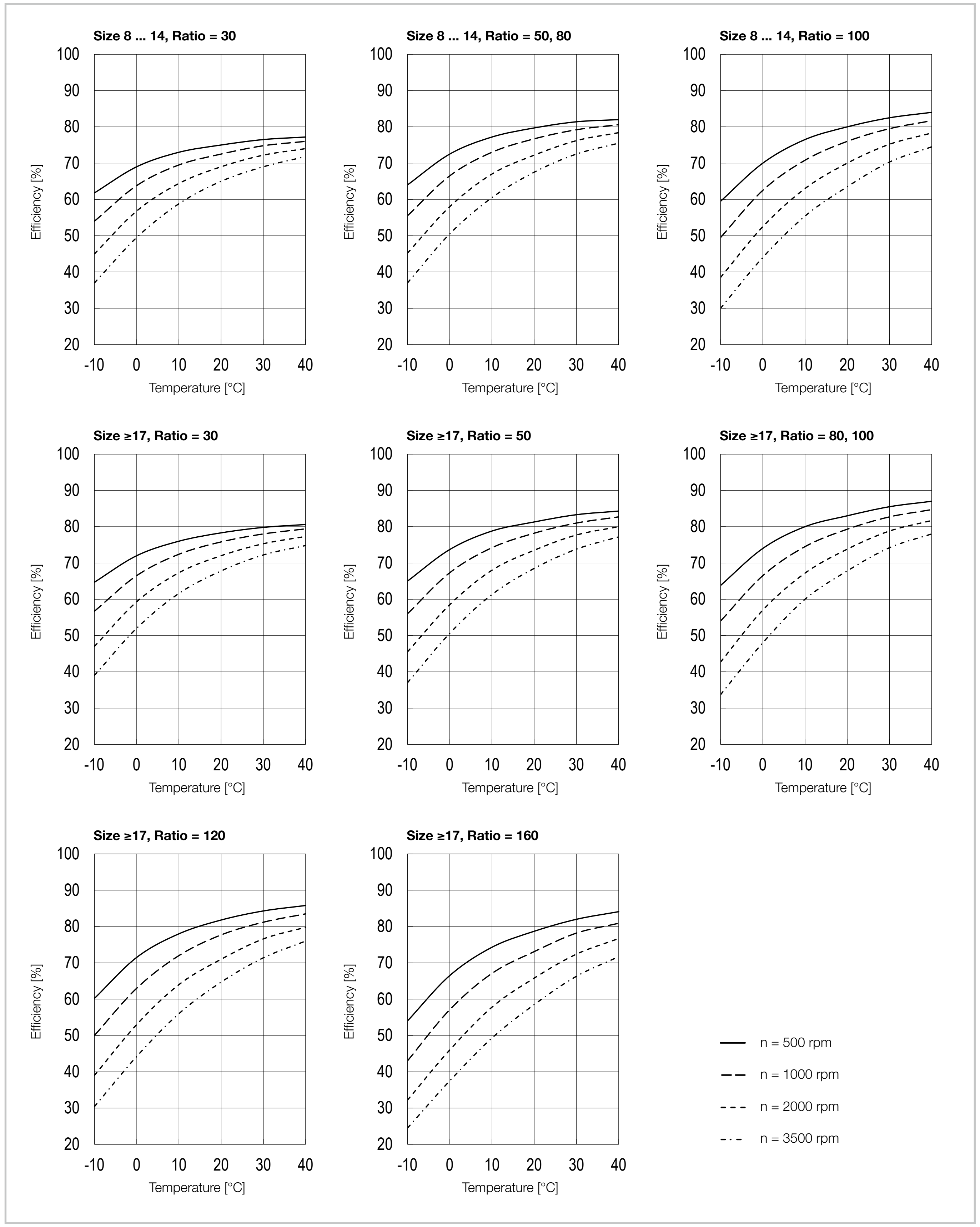
Ratio	Size													
	8	11	14	17	20	25	32	40	45	50	58	65	80	90
30	0.4	0.7	1.1	1.8	2.7	5.0	10.0	–	–	–	–	–	–	–
50	0.2	0.3	0.5	0.8	1.2	2.2	4.5	8.0	11.0	15.0	22.0	31.0	55.0	77.0
80	–	–	0.1	0.1	0.2	0.3	0.7	1.2	1.7	2.3	3.4	4.7	8.5	12.0
120	–	–	–	-0.1	-0.1	-0.2	-0.5	-0.9	-1.3	-1.7	-2.5	-3.5	-6.2	-8.7
160	–	–	–	–	-0.3	-0.6	-1.2	-2.2	-3.0	-4.0	-6.1	-8.4	-15	-21

• Efficiency

Efficiency for grease lubrication at rated torque

The diagrams apply to Harmonic Drive® Grease SK-2 (size 8 ... 17) or SK-1A (size ≥ 20).

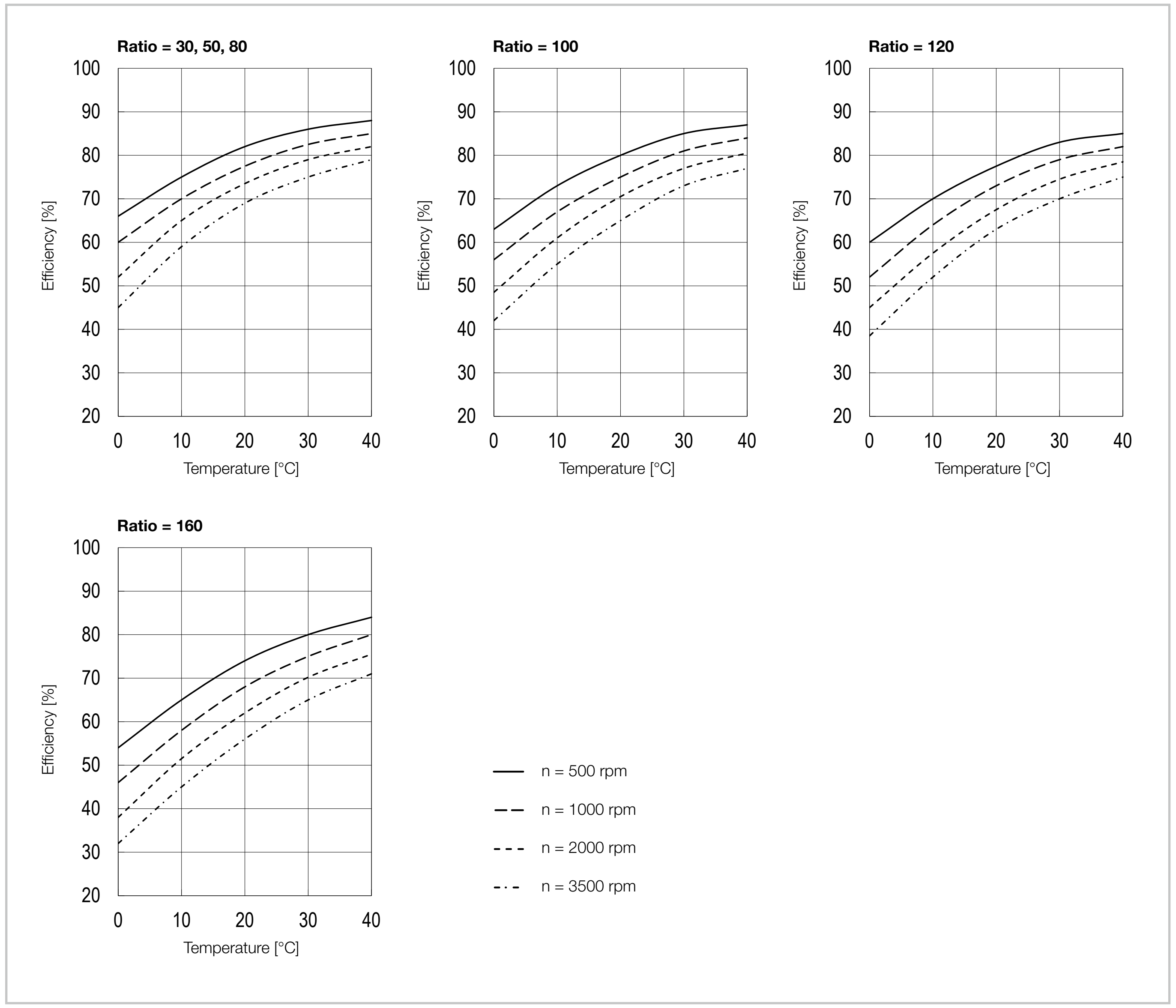
Illustration 1.1.7



Efficiency for oil lubrication at rated torque

The diagrams apply to mineral oil CLP 68.

Illustration 1.1.8



You will find more information on this in the Engineering data chapter.

Efficiency calculation

The efficiency depends on the following parameters: Gear ratio, input speed, load torque, temperature, lubricant and lubricant quantity. If the load torque is lower than the rated torque, the efficiency will be lower than the efficiency indicated in the efficiency curves. The torque specific efficiency is determined by means of the calculation factor K.

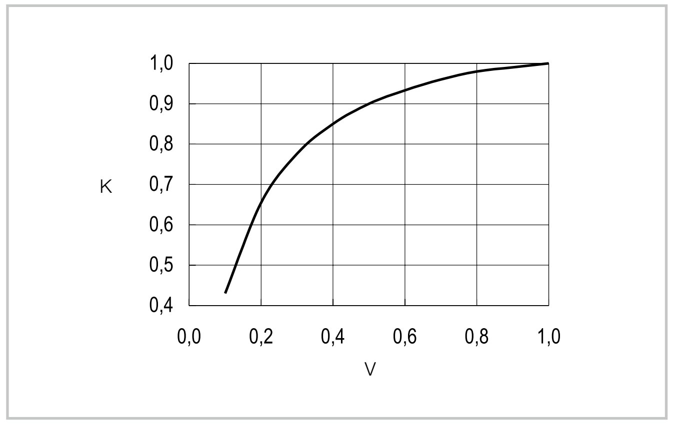
Calculation example

Product: CSG-20-80-2A-GR

- Input speed: 1000 rpm
- (Average) load torque T_{av}: 20 Nm
- Rated torque T_N (catalogue reference): 44 Nm
- Grease lubrication with Harmonic Drive® Grease SK-1A, lubricant temperature: 20 °C.

1. Calculation of the torque factor
   $V = T_{av}/T_N = 20/44 = 0.45$ (For V > 1 is K = 1)
2. Reading the calculation factor K from diagram Illustration 1.1.9: K = 0.87
3. Reading the efficiency from the efficiency curve Illustration 1.1.7: η = 80 %
4. Calculation of the load dependant efficiency
   $\eta_L = 80\ \% \cdot 0.87 = 70\ \%$

Illustration 1.1.9 **Calculation factor K**



Design guidelines

- Grease lubrication

To ensure optimum lubrication, the gear housing should be kept compact, for example see Illustration 1.1.10 and Table 1.1.15.

If the gear housing is filled with more than 50 % of grease, the risk of leakage increases. Therefore the grease volume/gear housing ratio should be less than 0.5. When installing with a predominantly top or bottom mounted Wave Generator, the gap c should be filled with an additional amount of grease according to Table 1.1.15.

Materials used:

- Circular Spline: Grey cast iron, bright
- Wave Generator, Flexspline: Steel, bright

Illustration 1.1.10

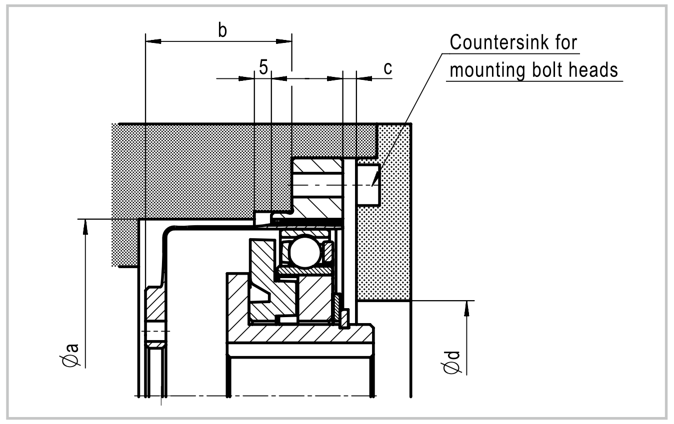


Table 1.1.15 **[mm]**

Symbol	Size													
	8	11	14	17	20	25	32	40	45	50	58	65	80	90
øa	21.5	30.0	38.0	45.0	53.0	66.0	86.0	106.0	119.0	133.0	154.0	172.0	212.0	239.0
b	11.34	14.00	17.10	19.00	20.50	23.00	26.80	33.00	36.50	39.00	46.20	50.00	61.00	68.50
c[1]	0.5	0.5	1.0	1.0	1.5	1.5	1.5	2.0	2.0	2.0	2.5	2.5	3.0	3.0
c[2]	1.5	1.5	3.0	3.0	4.5	4.5	4.5	6.0	6.0	6.0	7.5	7.5	9.0	9.0
ød	13	16	16	26	30	37	37	45	45	45	56	62	67	73

1) Axis horizontal or vertical, Wave Generator below
2) Axis vertical, Wave Generator on top

You will find more information on this in the Engineering data chapter.

Lubrication

Harmonic Drive® Gear Component Sets are supplied without lubricant as standard. Before commissioning they must be lubricated according to the following diagrams.

- Grease lubrication

We recommend the use of the greases listed in Table 1.1.16.

Table 1.1.16

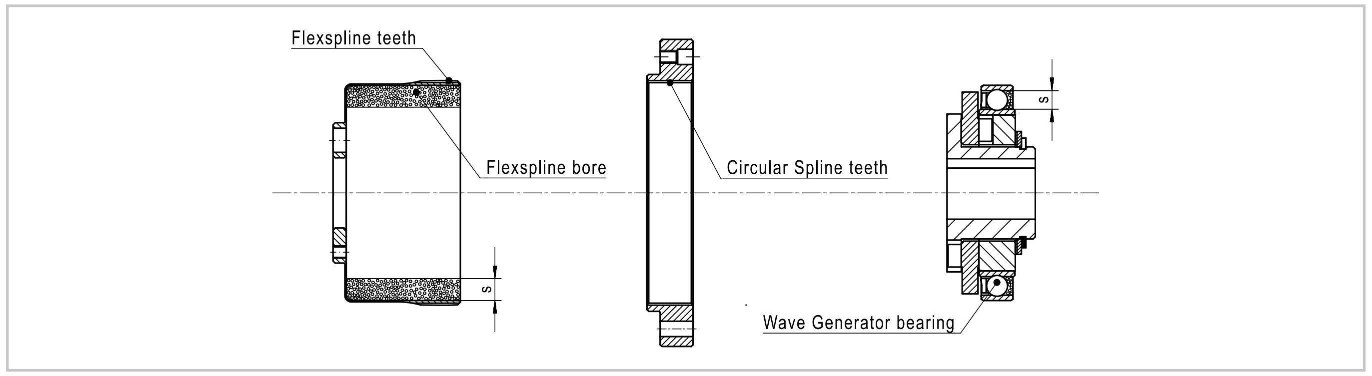
Ratio	Harmonic Drive® Grease	Size									
		8	11	14	17	20	25	32	40	45 ... 58	65 ... 90
30	Flexolub®-A1	-	-	O	O	O	O	O	-	-	-
	SK-1A	-	-	-	-	Δ	Δ	Δ	-	-	-
	SK-2	O	O	Δ	Δ	-	-	-	-	-	-
	4BNo.2	Δ	Δ	Δ	Δ	□	□	□	-	-	-
≥50	SK-1A	-	-	-	-	O	O	O	O	O	O
	SK-2	O	O	O	O	Δ	Δ	Δ	Δ	-	-
	4BNo.2	-	-	□	□	□	□	□	□	□	□
	Flexolub®-A1[1]	-	-	Δ	Δ	Δ	Δ	Δ	Δ	Δ	-

1) Only for HFUC-2A Series
O Standard grease
□ Recommended for very high loads or very high demands on the service life of the grease
Δ Optional grease, please consult us

The gear component sets must be lubricated in four areas before commissioning, see Illustration 1.1.11.

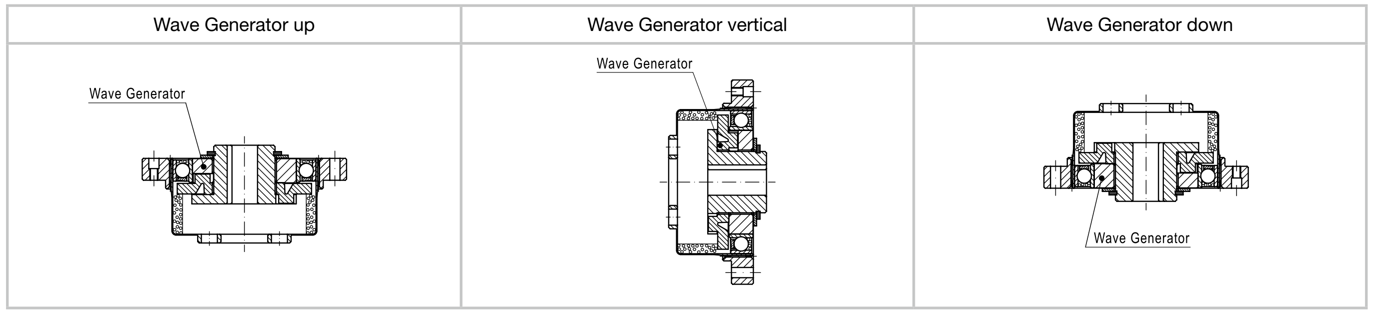
- Flexspline: Place a grease reservoir all around the inner wall of the flexspline. The dimension “s” should be approximately the height of the Wave Generator ball bearing.
- Toothing: Fill the gaps between the teeth with grease.
- Wave Generator ball bearing: Apply a generous amount of grease to the area of the bearing balls and bearing cage.

Illustration 1.1.11



The required grease quantity depends not only on the size but also on the operating position of the gear. The operating positions “Wave Generator up” and “Wave Generator down” defined in the text below refer to the relative position of the Wave Generator to the Flexspline flange, see Illustration 1.1.12.

Illustration 1.1.12 **Operating position**



You will find more information on this in the Engineering data chapter.

In case of predominant use with top or bottom mounted Wave Generator, additional grease is required, see Illustration 1.1.13 and Table 1.1.17.

Illustration 1.1.13

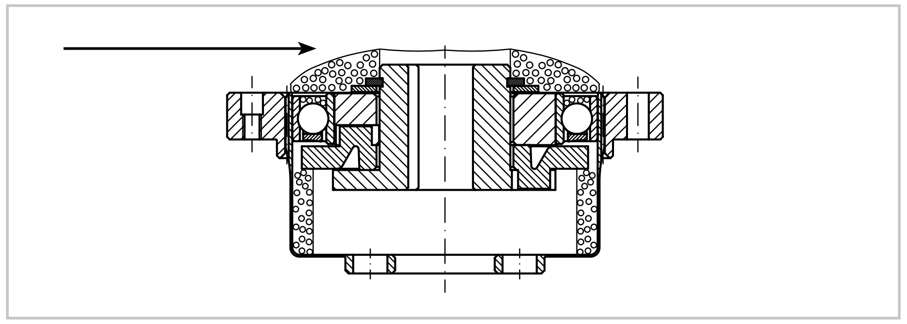


Table 1.1.17

Grease quantity [g]

		Size													
		8	11	14	17	20	25	32	40	45	50	58	65	80	90
Mounting position	Wave Generator vertical	1.2	2.9	5.5	10.0	16.0	30.0	60.0	110.0	170.0	220.0	360.0	460.0	850.0	1150.0
	Wave Generator down	1.4	3.5	7.0	12.0	18.0	35.0	70.0	125.0	190.0	240.0	380.0	500.0	900.0	1300.0
	Wave Generator up	1.8	4.4	8.5	14.0	21.0	40.0	80.0	145.0	220.0	275.0	460.0	600.0	1000.0	1500.0

- ## Oil lubrication

Oil lubrication is possible for Harmonic Drive® CSG-2A/HFUC-2A Gear Component Sets. A separate lubrication space must be must be provided. In Illustration 1.1.14 and Table 1.1.18 recommended oil levels for horizontal and vertical installation positions are given.

Illustration 1.1.14

Operating position

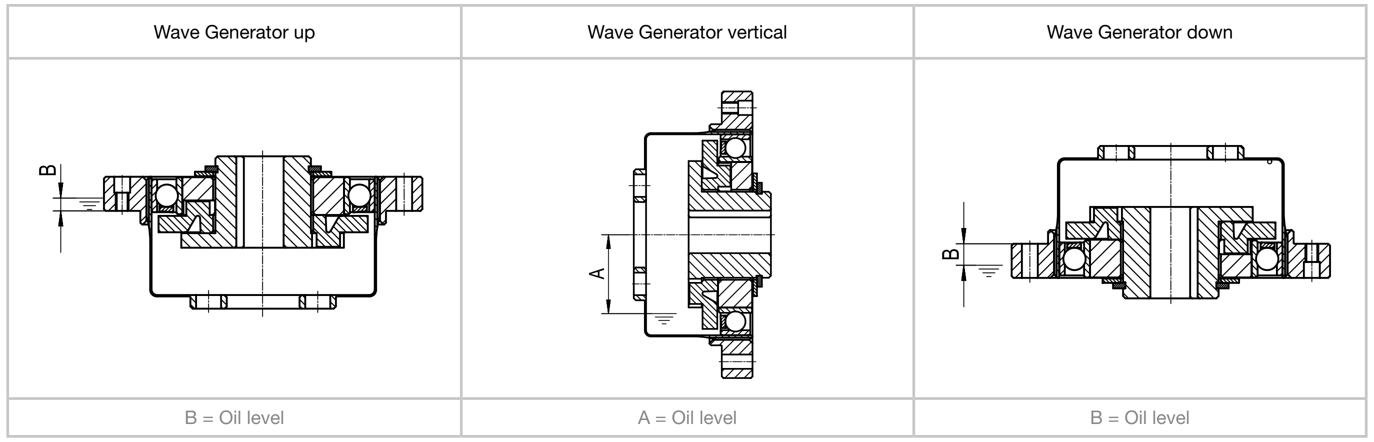


Table 1.1.18

Oil levels [mm]

	Size													
	8	11	14	17	20	25	32	40	45	50	58	65	80	90
A	6	8	10	12	14	17	24	31	35	38	44	50	59	66
B	2.0	2.3	2.5	3.0	3.0	5.0	7.0	9.0	10.0	12.0	13.0	15.0	19.0	22.0

Lube holes

In the case of a vertical axis with an overhead Wave Generator, design measures must be taken to ensure that the oil thrown out of the Flexspline by the Wave Generator can flow back again. This can be achieved by connecting the two oil areas by means of lube holes in the Flexspline flange. Please consult Harmonic Drive SE.

Illustration 1.1.15

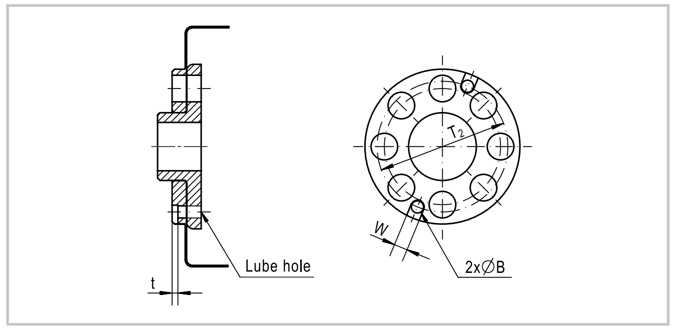


Table 1.1.19

Dimensions of lube holes [mm]

	Size													
	8 [1]	11 [1]	14 [1]	17 [1]	20	25	32	40	45	50	58	65	80	90
T_2	–	–	–	–	27	34	45	56	61	68	79	90	114	120
B	–	–	–	–	2.5	2.5	3.5	3.5	3.5	5.5	5.5	5.5	6.5	6.5
W	–	–	–	–	2.8	3.5	4.0	4.0	4.0	6.0	6.0	6.0	7.0	7.0
t	–	–	–	–	1.2	1.2	1.4	1.4	1.4	2.0	2.0	2.0	3.0	3.0

1) No lube holes possible

You will find more information on this in the Engineering data chapter.

Assembly tolerances

We recommend observing the following tolerances during assembly:

Illustration 1.1.16

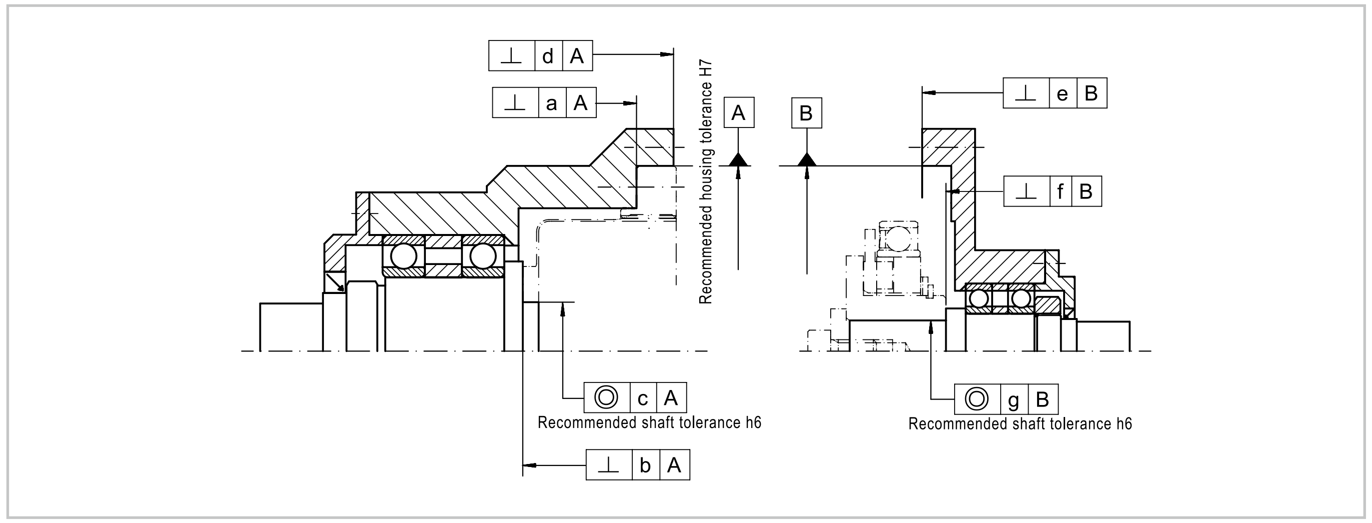


Table 1.1.20

[mm]

	Size													
	8	11	14	17	20	25	32	40	45	50	58	65	80	90
a	0.008	0.011	0.011	0.012	0.013	0.014	0.016	0.016	0.017	0.018	0.020	0.023	0.027	0.029
b	0.006	0.006	0.008	0.011	0.014	0.018	0.022	0.025	0.028	0.030	0.032	0.035	0.040	0.043
c	0.005	0.008	0.015	0.018	0.019	0.022	0.022	0.024	0.027	0.030	0.032	0.035	0.043	0.046
d	0.010	0.010	0.011	0.015	0.017	0.024	0.026	0.026	0.027	0.028	0.031	0.034	0.043	0.050
e	0.010	0.010	0.011	0.015	0.017	0.024	0.026	0.026	0.027	0.028	0.031	0.034	0.043	0.050
f	0.012	0.012	0.017 (0.008)	0.020 (0.010)	0.020 (0.010)	0.024 (0.012)	0.024 (0.012)	0.032 (0.012)	0.032 (0.013)	0.032 (0.015)	0.032 (0.015)	0.032 (0.015)	0.036 (0.015)	0.036 (0.015)
g	0.015	0.015	0.030 (0.016)	0.034 (0.018)	0.044 (0.019)	0.047 (0.022)	0.050 (0.022)	0.063 (0.024)	0.065 (0.027)	0.066 (0.030)	0.068 (0.033)	0.070 (0.035)	0.090 (0.043)	0.091 (0.046)

The values in brackets are recommended tolerances for a Wave Generator without Oldham coupling. This coupling is used to compensate for eccentricity errors of the motor shaft and is installed in the standard gear. In case of a direct coupling of the Wave Generator on the motor shaft without Oldham coupling (option), the motor shaft tolerances should correspond to DIN 42955 R.

Assembly

- Assembly of the Flexspline

Clamping ring

Clamping ring for size 8
A clamping ring and a special shaft as shown in Illustration 1.1.17 to Illustration 1.1.19 are required for mounting the size 8 Flexspline. Screws of quality 12.9 should be used and secured with Loctite 243.

Illustration 1.1.17

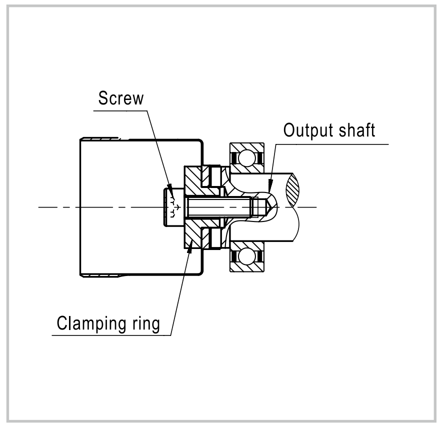


Illustration 1.1.18

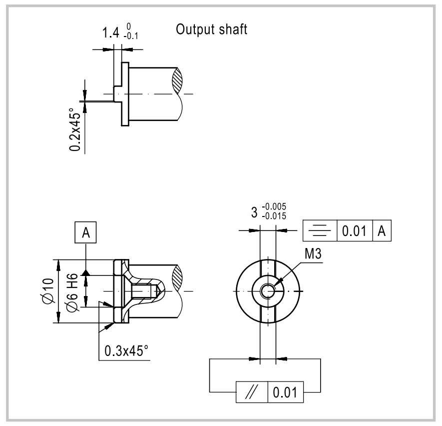
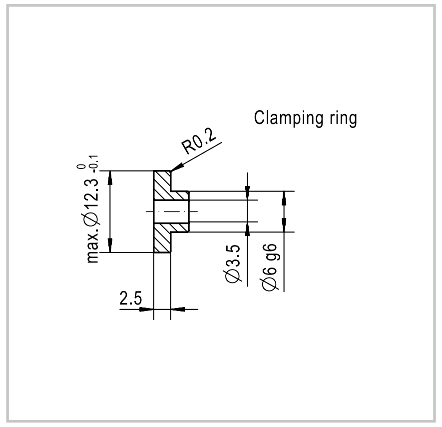


Illustration 1.1.19



Clamping ring for sizes 11 to 90
To avoid damage to the gear, care must be taken that the screw heads, pins or nuts do not hinder the deformation of the Flexspline. We recommend the use of a clamping ring with the specified dimensions. Material S45C (DINHC45), quenched and tempered, HB200 to 270 or comparable. The clamping ring is not included in the scope of delivery.

Illustration 1.1.20

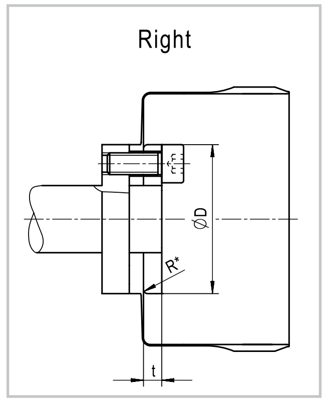
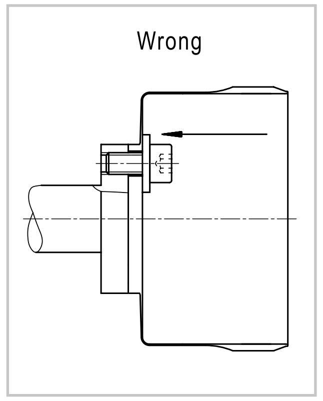


Illustration 1.1.21



The outer edge of the clamping ring must be rounded to allow deformation of the Flexspline.

Dimensions of the clamping ring

Table 1.1.21 **[mm]**

	Size													
	8	11	14	17	20	25	32	40	45	50	58	65	80	90
D $^{0}_{-0.1}$	–	17.8	24.5	29.0	34.0	42.0	55.0	68.0	74.0	83.0	95.8	106.0	130.0	145.0
R $^{+0.1}_{0}$	–	0.5	1.2	1.2	1.4	1.5	2.0	2.5	2.0	2.5	2.5	2.5	2.5	2.5
t	–	2.0	3.0	3.0	3.0	5.0	7.0	7.0	8.0	8.0	12.0	12.0	15.0	20.0

Screw connection Flexspline (CSG-2A, HFUC-2A Series)

Table 1.1.22 shows the torque of the gear component sets of the CSG-2A and HFUC-2A Series that can be transmitted to the Flexspline by means of a screw connection. Please check whether the torque transmittable at the Flexspline according to the table is sufficient for your application.

Table 1.1.22

	[Unit]	Size													
		8	11	14	17	20	25	32	40	45	50	58	65	80	90
Number of screws		1	6	6	6	8	8	8	8	8	8	8	8	10	8
Size of screws		M3	M3	M4	M5	M5	M6	M8	M10	M12	M14	M14	M16	M16	M20
Pitch circle diameter	[mm]	–	12	17	19	24	30	40	50	54	60	70	80	100	110
Screw tightening torque	[Nm]	2.15	2.00	4.50	9.00	9.00	15.30	37.00	74.00	128.00	205.00	205.00	319.00	319.00	622.00
Torque transmitting capacity	[Nm]	4.7	15.0	35.0	64.0	108.0	186.0	460.0	910.0	1440.0	2160.0	2550.0	3980.0	6220.0	8560.0

12.9 quality screws, friction coefficient μ= 0,15.

Screw connection and pinning Flexspline (HFUC-2A Series)

Table 1.1.23 shows the torque that can be transmitted to the Flexspline by means of a bolted connection and additional pinning of the Flexspline of HFUC-2A Series Gear Component Sets. Please check if the transmittable torque according to the table is sufficient for your application.
We recommend the additional pin connection if the load torque is higher than the repeatable peak torque. Pin holes must be made for this purpose. Please specify this when ordering.

Table 1.1.23

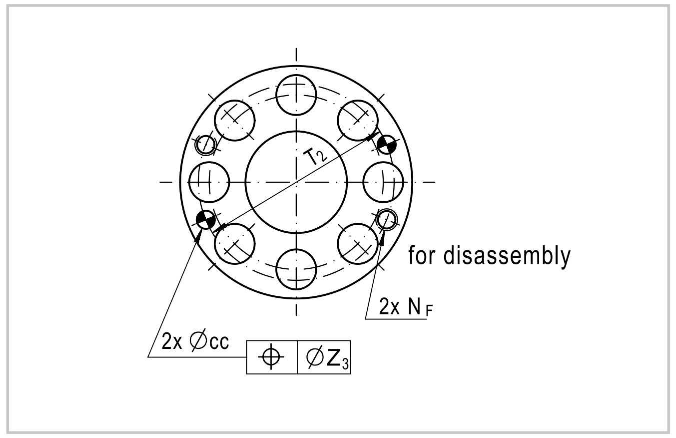
	[Unit]	Size													
		8	11	14	17	20	25	32	40	45	50	58	65	80	90
Number of pins		–	2	2	2	2	2	2	2	2	2	2	2	2	2
ø cc H7	[mm]	–	2	3	3	3	4	5	8	8	8	8	12		
Pitch circle diameter T_2	[mm]	–	15.2	18.5	21.5	27.0	34.0	45.0	68.0	79.0	90.0	114.0	120.0		
Torque transmitting capacity	[Nm]	–	29	74	108	167	314	725	3160	3710	5310	7910	12540		

12.9 quality screws, friction coefficient μ= 0,15.

Flexspline pin holes and forcing-off thread

Illustration 1.1.22 shows the variable drawing of the optional Flexspline pin holes (only for HFUC-2A) and the forcing-off threads provided for Flexspline disassembly (HFUC-2A and CSG-2A). For related dimensions see Table 1.1.23.

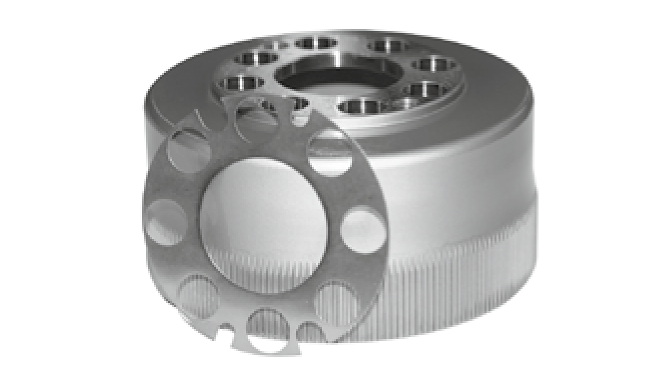
Illustration 1.1.22



Screw connection Flexspline (CSG-2A Series)

To fully utilise the high maximum torques of the CSG-2A Gear Component Sets, we recommend the use a Friction Shim, see Illustration 1.1.23. This metal disc, diamond coated on both sides, serves to increase the coefficient of friction between the Flexspline and the customer's output element.

Illustration 1.1.23



Screw connection Flexspline with Friction Shim (CSG-2A series)

Table 1.1.24 shows the torque of the CSG-2A series gear component sets that can be transmitted to the Flexspline by means of a bolted connection and friction shim.
The Friction Shim can be ordered as an option. If the maximum torque of the application allows it, the CSG-2A Gear Component Set can also be used without the friction shim. In this case, the transmittable torques on the Flexspline are as per Table 1.1.22.

Table 1.1.24

	[Unit]	Size									
		14	17	20	25	32	40	45	50	58	65
Number of screws		6	6	8	8	8	8	8	8	8	8
Size of screws		M4	M5	M5	M6	M8	M10	M12	M14	M14	M16
Pitch circle diameter	[mm]	17	19	24	30	40	50	54	60	70	80
Screw tightening torque	[Nm]	4.5	9.0	9.0	15.3	37.0	74.0	128.0	205.0	205.0	319.0
Torque transmitting capacity	[Nm]	96	176	291	529	1263	2476	3954	5930	7000	10928

12.9 quality screws, friction coefficient μ= 0,4 (by Friction Shim).

- Assembly of the Circular Spline

Screw connection Circular Spline (HFUC-2A Series)

Table 1.1.25

	[Unit]	Size											
		8	11	14	17	20	25	32	50	58	65	80	90
Number of screws		8	8	6	12	12	12	12	12	12	12	16	16
Size of screws		M2	M2.5	M3	M3	M3	M4	M5	M8	M10	M10	M10	M12
Pitch circle diameter	[mm]	25.5	35.0	44.0	54.0	62.0	75.0	100.0	150.0	175.0	195.0	240.0	270.0
Screw tightening torque	[Nm]	0.17	0.35	2.00	2.00	2.00	4.50	9.00	37.00	74.00	74.00	74.00	128.00
Torque transmitting capacity	[Nm]	5	12	54	131	147	314	676	2620	4820	5370	8820	14450

12.9 quality screws, friction coefficient μ= 0,15.

Screw connection Circular Spline (CSG-2A Series)

Table 1.1.26

	[Unit]	Size									
		14	17	20	25	32	40	45	50	58	65
Number of screws		8	16	16	16	16	16	16	16	16	16
Size of screws		M3	M3	M3	M4	M5	M6	M8	M8	M10	M10
Pitch circle diameter	[mm]	44	54	62	75	100	120	140	150	175	195
Screw tightening torque	[Nm]	2.0	2.0	2.0	4.5	9.0	15.3	37.0	37.0	74.0	74.0
Torque transmitting capacity	[Nm]	72	175	196	419	901	1530	3238	3469	6475	7215

12.9 quality screws, friction coefficient μ= 0,15

- Assembly of the Wave Generator

During assembly, the axial assembly dimension specified in the catalogue/confirmation drawing (relative axial position to Flexspline flange "B" according to Table 1.1.6, Table 1.1.7, Table 1.1.8) must be considered.

You will find more information on this in the Engineering data chapter.

Product description

The lightweight gear with large hollow shaft

The CPL-2A Series Gear Component Sets are characterised by their very low weight, low moment of inertia and are perfectly suited for moving axes with the highest dynamics.

In addition to the proven strain wave gear technology, CPL-2A Series is also available in Triangle Technology. Setting new standards in torsional stiffness, transmission accuracy and dynamics.

Features

- High torques at the lowest weight
- High dynamics due to reduced moment of inertia
- Large hollow shaft for the passage of supply cables and shafts
- Small outer diameter
- Ideal for applications with own output bearing arrangement

Ordering code

Table 1.2.1

Ordering code	CPL	-	25	-	100	-	2A	-	SP
Series	CPL								
Size (corresponds to the pitch circle diameter of the Flexspline toothing in inches x 10)			14 17 20 25 32						
Ratio (in drive configuration: Circular Spline (CS) fixed, Wave Generator (WG) input, Flexspline (FS) output					30 50 80 100 120 160				
Version Gear component set							2A		
Customised design Standard design (field remains empty) Special design (on request)									[ ] SP

Please refer to the table of possible combinations.

Combinations

Table 1.2.2

		Size 14	Size 17	Size 20	Size 25	Size 32
Ratio	30	•	•	•	•	•
	50	•	•	•	•	•
	80	•	•	•	•	•
	100	•	•	•	•	•
	120	-	•	•	•	•
	160	-	-	•	•	•

• available o on request - not available

Technical data

• Rating table

All specifications in this catalogue apply when the gear components are mounted in sufficiently rigid assemblies. Please consult us if you want to use these products in lightweight constructions with reduced radial stiffness of the Circular Spline and Wave Generator components compared to the industry standard.

Table 1.2.3

Size	Ratio	Limit for repeated peak torque	Limit for average torque	Rated torque at rated speed 2000 rpm	Limit for momentary peak torque	Max. input speed [rpm]		Limit for average input speed [rpm]		Moment of inertia	Weight
	i	T_R [Nm]	T_A [Nm]	T_N [Nm]	T_M [Nm]	Lubrication Oil	Grease	Lubrication Oil	Grease	[kgm²]	[kg]
14	30	9.0	6.8	4.0	17.0	14000	8500	6500	3500	0.02×10^{-4}	0.055
	50	18.0	6.9	5.4	35.0						
	80	23.0	11.0	7.8	47.0						
	100	28.0	11.0	7.8	54.0						
17	30	16.0	12.0	8.8	30.0	10000	7300	6500	3500	0.049×10^{-4}	0.1
	50	34	26	16	70						
	80	43	27	22	87						
	100	54	39	24	110						
	120	54	39	24	86						
20	30	27	20	15	50	10000	6500	6500	3500	0.112×10^{-4}	0.14
	50	56	34	25	98						
	80	74	47	34	127						
	100	82	49	40	147						
	120	87	49	40	147						
	160	92	49	40	147						
25	30	50	38	27	95	7500	5600	5600	3500	0.265×10^{-4}	0.24
	50	98	55	39	186						
	80	137	87	63	255						
	100	157	108	67	284						
	120	167	108	67	304						
	160	176	108	67	314						
32	30	100	75	54	200	7000	4800	4600	3500	0.958×10^{-4}	0.54
	50	216	108	76	382						
	80	304	167	118	568						
	100	333	216	137	647						
	120	353	216	137	686						
	160	372	216	137	686						

If torques up to the "Limit for momentary peak torque" are to be transmitted, the maximum transmittable torques at the Flexspline in the chapter "Flexspline screw connections" must also be taken into account.

You will find more information on this in the Engineering data chapter.

CAD drawings for download: www.harmonicdrive.co.uk

• Dimensions

Illustration 1.2.1 **[mm]**

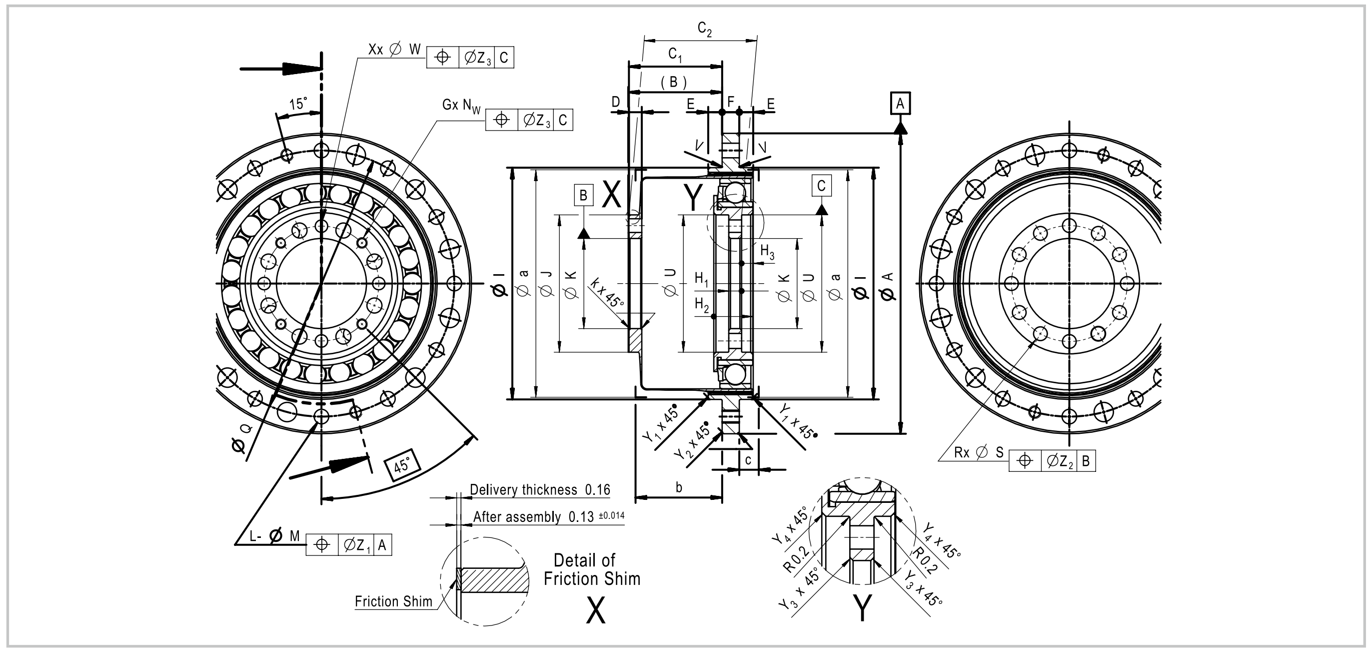


Table 1.2.4 **[mm]**

		Size 14	17	20	25	32
øA h6		50	60	70	85	110
B[1)]		18.1	20.4	21.9	25.1	30.6
C_1		$18.0^{+0.4}_{0}$	$20.3^{+0.50}_{0}$	$21.8^{+0.6}_{0}$	$25.0^{+0.6}_{0}$	$30.5^{+0.6}_{0}$
C_2		$20.9^{0}_{-0.8}$	$24^{0}_{-0.9}$	26.3^{0}_{-1}	30.4^{0}_{-1}	$37^{0}_{-1.1}$
D		2.4	3.0	3.0	3.0	3.2
E[1)]		2.5	2.8	3.3	4.0	5.5
F		3.0	3.5	4.0	5.0	6.0
G		4	4	4	4	4
H_1		1.9	2.3	3.0	3.3	3.5
H_2		7.4	7.6	9.1	8.9	11.5
H_3		2.2	2.2	2.6	1.5	2.5
øI h6		38	48	i=30: 55. i≥50: 54	i=30: 68. i≥50: 67	90
øJ		23.0	27.2	32.0	40.0	52.0
øK H6		13.5	18.0	21.0	26.0	36.0
k		0.25	0.25	0.25	0.25	0.50
L[2)]		12	12	12	12	12
øM		3.4	3.4	3.4	4.5	5.5
N_C		M3	M3	M3	M4	M5
N_W		M2	M2	M2.5	M3	M4
øP		18.00	22.50	26.75	34.00	44.50
øQ		44	54	62	75	100
R		12	14	12	12	12
øS		2.7	2.7	3.2	4.3	5.3
T		18.9	23.1	27.0	33.6	44.9
U H6		22.6	27.0	32.0	41.0	53.0
V		R 0.2	R 0.3	R 0.3	R 0.3	R 0.3
øW		2.4	2.4	2.9	3.4	4.5
X[2)]		4	4	4	4	4
Y_1		0.3	0.4	0.4	0.4	0.4
Y_2		0.4	0.4	0.4	0.4	0.4
Y_3		0.3	0.3	0.4	0.4	0.4
Y_4		0.4	0.4	0.5	0.3	0.5
$øZ_1$		0.25	0.25	0.25	0.25	0.25
$øZ_2$		0.25	0.25	0.25	0.25	0.25
$øZ_3$		0.2	0.2	0.2	0.2	0.2
Minimum housing dimensions	Ø a	38	45	53	66	86
	b[1)]	17.6	19.3	20.3	24.0	29.3
	c[1)]	3.5	3.8	4.5	5.5	7.0

[1)] Partly rounded values, [2)] Bores not specified are for weight reduction only and must not be used for fastening.

• Accuracy

Table 1.2.5 **[arcmin]**

	Size					
	14		17		≥20	
Ratio	30	≥50	30	≥50	30	≥50
Transmission accuracy [1]	<2.0	<1.5	<1.5	<1.5	<1.5	<1.0
Hysteresis loss	<3.0	<1.0	<3.0	<1.0	<3.0	<1.0
Lost motion	<1.0					
Repeatability	< ± 0.1					

[1] Higher accuracy on request

• Torsional stiffness

Table 1.2.6

	Symbol [Unit]	Size				
		14	17	20	25	32
Limit torques	T_1 [Nm]	2	3.9	7	14	29
	T_2 [Nm]	6.9	12	25	48	108
i = 30	K_3 [x 10^3 Nm/rad]	3.4	6.7	11	21	49
	K_2 [x 10^3 Nm/rad]	2.4	4.4	7.1	13	30
	K_1 [x 10^3 Nm/rad]	1.9	3.4	5.7	10	24
i = 50	K_3 [x 10^3 Nm/rad]	5.7	13	23	44	98
	K_2 [x 10^3 Nm/rad]	4.7	11	18	34	78
	K_1 [x 10^3 Nm/rad]	3.4	8.1	13	25	54
i > 50	K_3 [x 10^3 Nm/rad]	7.1	16	29	57	120
	K_2 [x 10^3 Nm/rad]	6.1	14	25	50	110
	K_1 [x 10^3 Nm/rad]	4.7	10	16	31	67

• No load starting torque

Table 1.2.7 **[Ncm]**

Ratio	Size				
	14	17	20	25	32
30	4.3	6.5	11.0	19.0	45.0
50	3.3	5.1	6.6	12.0	26.0
80	2.4	3.3	4.1	7.7	16.0
100	2.1	2.9	3.7	6.9	15.0
120	–	2.7	3.3	6.3	13.0
160	–	–	2.9	5.5	12.0

• No load back driving torque

Table 1.2.8 **[Nm]**

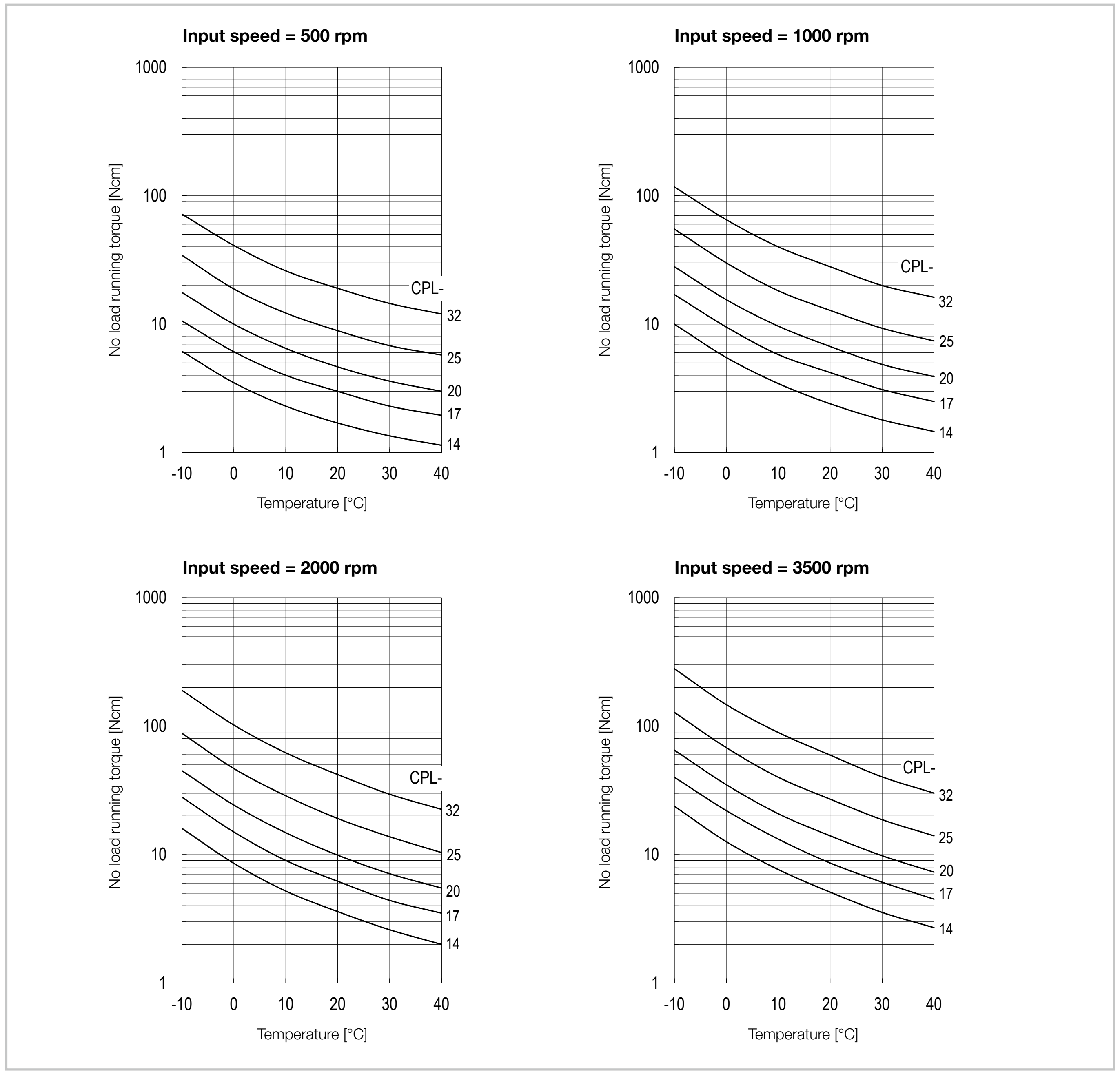
Ratio	Size				
	14	17	20	25	32
30	2.0	3.2	5.5	10.0	21.0
50	1.4	2.5	4.0	7.5	16.0
80	1.4	2.5	4.2	7.7	16.0
100	1.7	2.8	4.5	8.4	18.0
120	–	3.1	4.9	9.2	19.0
160	–	–	5.8	11.0	23.0

You will find more information on this in the Engineering data chapter.

• No load running torque

The diagrams apply to Harmonic Drive® Grease SK-2 (size 14, 17) or SK-1A (size ≥ 20).

Illustration 1.2.2



Compensation values for no load running torque

When using gears with ratios other than i=100 please apply the compensation values from the table to the values taken from the curves.

Table 1.2.9 **[Ncm]**

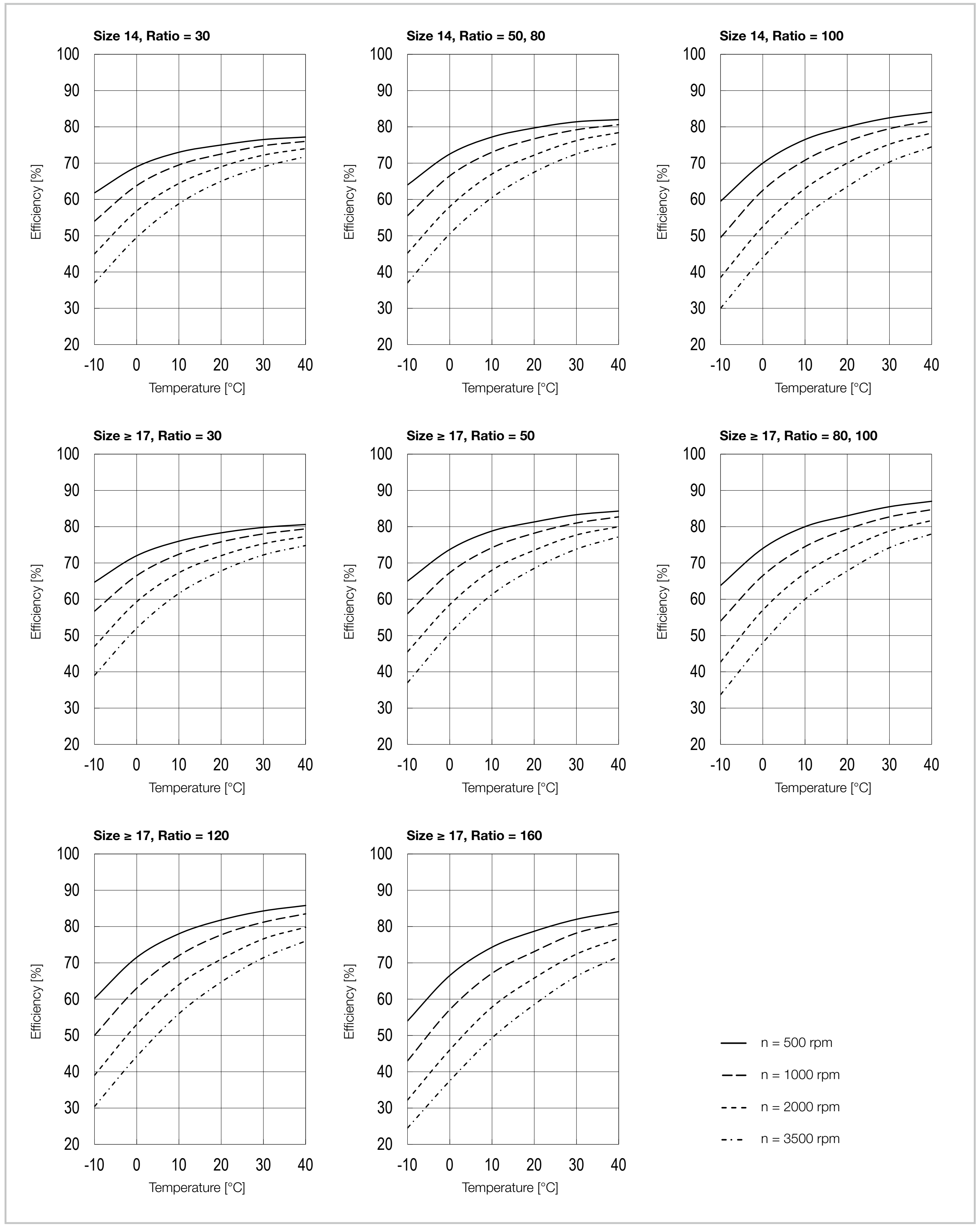
Ratio	Size				
	14	17	20	25	32
30	1.1	1.8	2.7	5.0	10.0
50	0.5	0.8	1.2	2.2	4.5
80	0.1	0.1	0.2	0.3	0.7
120	-	-0.1	-0.1	-0.2	-0.5
160	-	-	-0.3	-0.6	-1.2

- Efficiency

Efficiency for grease lubrication at rated torque

The diagrams apply to Harmonic Drive® Grease SK-2 (size 14, 17) or SK-1A (size ≥ 20).

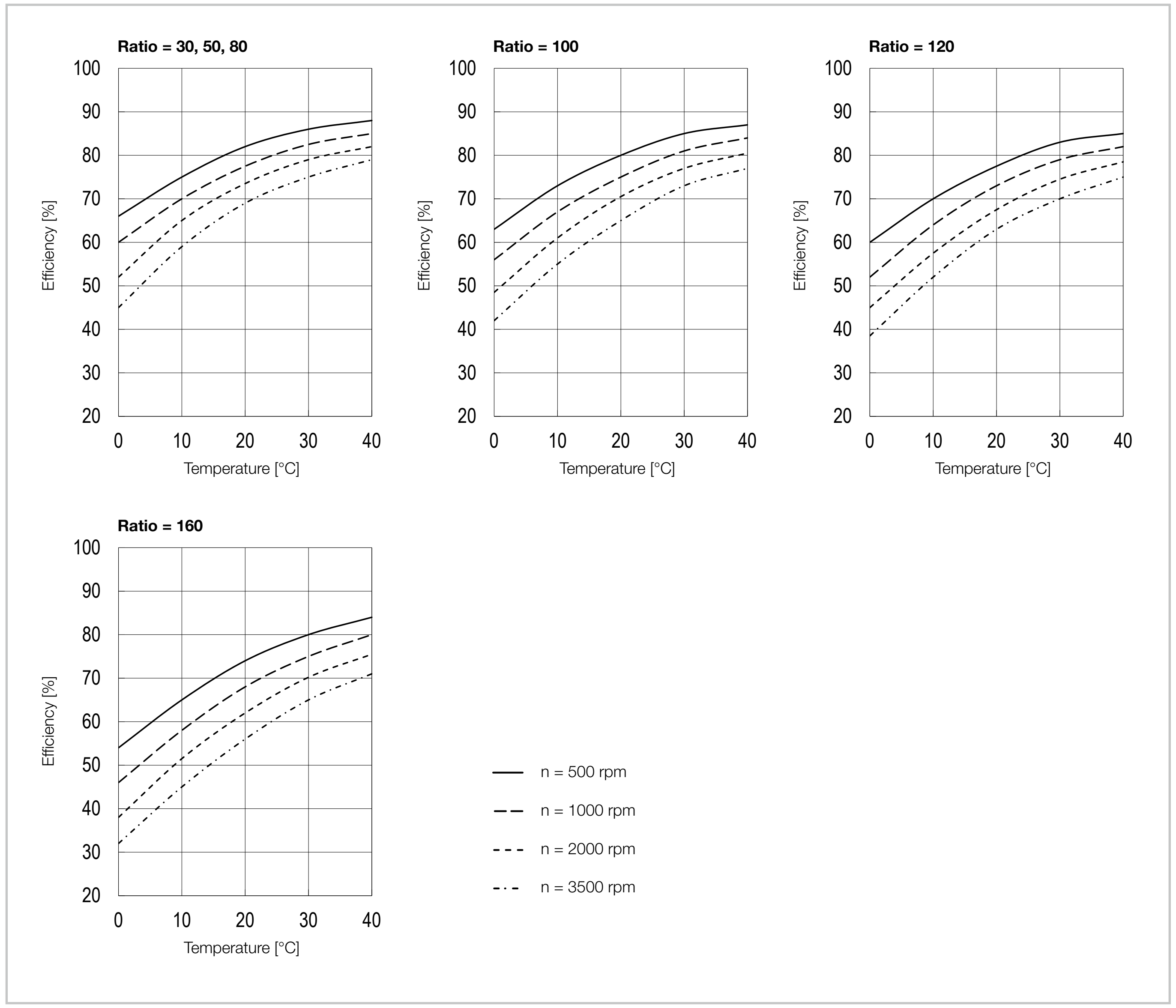
Illustration 1.2.3



Efficiency for oil lubrication at rated torque

The diagrams apply to mineral oil DEA CLP 68.

Illustration 1.2.4



You will find more information on this in the Engineering data chapter.

Efficiency calculation

The efficiency depends on the following parameters: Gear ratio, input speed, load torque, temperature, lubricant and lubricant quantity. If the load torque is lower than the rated torque, the efficiency will be lower than the efficiency indicated in the efficiency curves. The torque specific efficiency is determined by means of the calculation factor K.

Calculation example

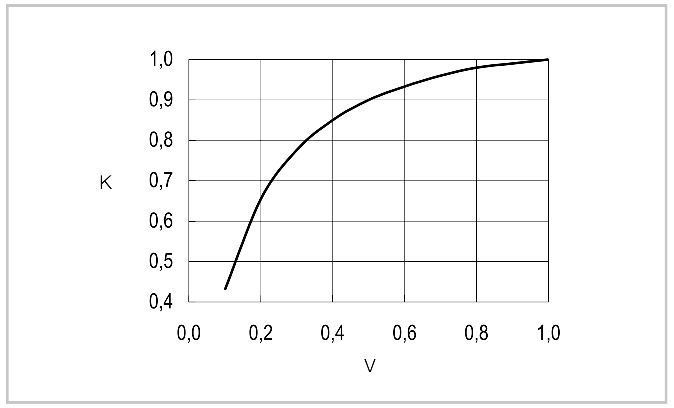
Product: CPL-20-80-2A-GR

- Input speed: 1000 rpm
- (Average) load torque T_{av}: 20 Nm
- Rated torque T_N (catalogue reference): 34 Nm
- Grease lubrication with Harmonic Drive® Grease SK-1A, lubricant temperature: 20 °C.

1. Calculation of the torque factor
   $V = T_{av}/T_N = 20/34 = 0.59$ (For V > 1 is K = 1)
2. Reading the calculation factor K from diagram figure Illustration 1.2.5: K = 0.93
3. Reading the efficiency from the efficiency curve figure Illustration 1.2.3: η = 80 %
4. Calculation of the load dependant efficiency
   $\eta_L = 80\ \% \cdot 0.93 = 74\ \%$

Illustration 1.2.5

Calculation factor K



Design guidelines

• Grease lubrication

To ensure optimum lubrication, the gear housing should be kept compact, for example see Illustration 1.2.6 and Table 1.2.10.

If the gear housing is filled with more than 50 % grease, the risk of leakage increases. Therefore the grease volume/gear housing ratio should be less than 0.5. When installing with a predominantly top or bottom mounted Wave Generator, the gap c should be filled with an additional amount of grease according to Table 1.2.10.

Materials used:
- Circular Spline: Grey cast iron, bright
- Wave Generator, Flexspline: Steel, bright

Illustration 1.2.6

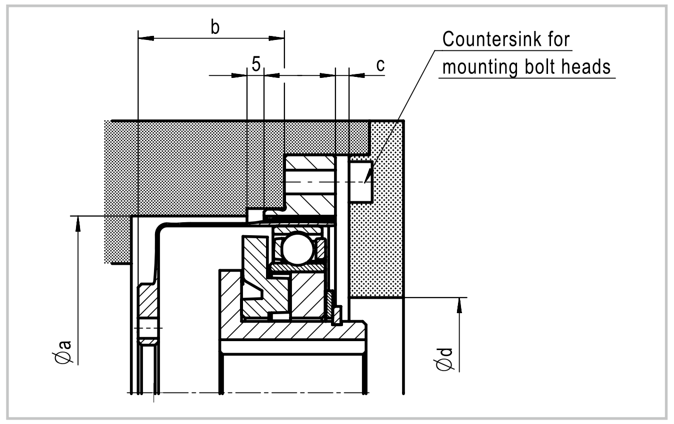


Table 1.2.10

[mm]

	Size				
	14	17	20	25	32
ø a	38	45	53	66	86
b	17.1	19.0	20.5	23.0	26.8
c[1]	1.0	1.0	1.5	1.5	1.5
c[2]	3.0	3.0	4.5	4.5	4.5
ø d	16	26	30	37	37

[1] Axis horizontal or vertical, Wave Generator below
[2] Axis vertical, Wave Generator on top

You will find more information on this in the Engineering data chapter.

Lubrication

Harmonic Drive® Gear Component Sets are supplied without lubricant as standard. Before commissioning they must be lubricated according to the following diagrams.

• Grease lubrication

We recommend the use of the greases listed in Table 1.2.11.

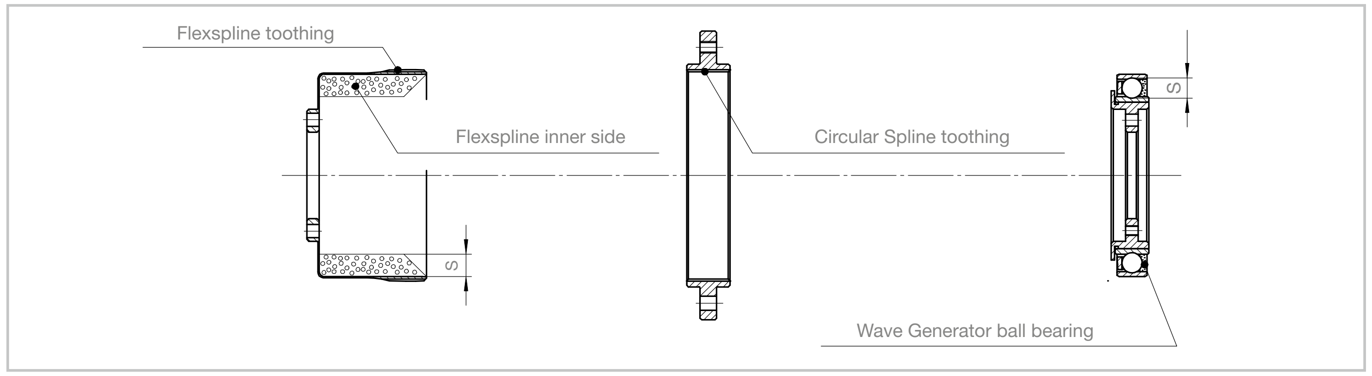
Table 1.2.11

Ratio	Harmonic Drive® Grease	Size				
		14	17	20	25	32
30	Flexolub®-A1	O	O	O	O	O
	SK-1A	-	-	Δ	Δ	Δ
	SK-2	Δ	Δ	-	-	-
	4BNo.2	Δ	Δ	□	□	□
≥50	SK-1A	-	-	O	O	O
	SK-2	O	O	Δ	Δ	Δ
	4BNo.2	□	□	□	□	□
	Flexolub®-A1	Δ	Δ	Δ	Δ	Δ

O Standard grease
□ Recommended for very high loads or very high demands on the service life of the grease
Δ Optional grease, please consult Harmonic Drive SE

The gear component sets must be lubricated in four areas before commissioning, see Illustration 1.2.7.
- Flexspline: Place a grease reservoir all around the inner wall of the Flexspline. The dimension „s“ should be approximately the height of the Wave Generator ball bearing.
- Toothing: Fill the gaps between the teeth with grease.
- Wave Generator ball bearings: Apply a generous amount of grease to the area of the bearing balls and bearing cage.

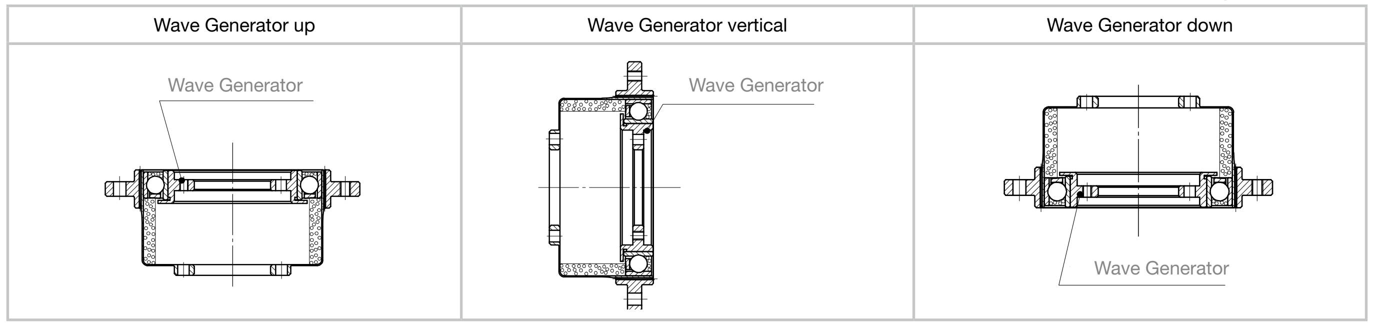
Illustration 1.2.7



The required grease quantity depends not only on the size but also on the operating position of the gear. The operating positions „Wave Generator up“ and „Wave Generator down“ defined in the text below refer to the relative position of the Wave Generator to the Flexspline flange, see Illustration 1.2.8.

Illustration 1.2.8

Operating position



You will find more information on this in the Engineering data chapter.

In case of predominant use with the Wave Generator on top or on the bottom, additional grease is required, see Illustration 1.2.9 and Table 1.2.12.

Illustration 1.2.9

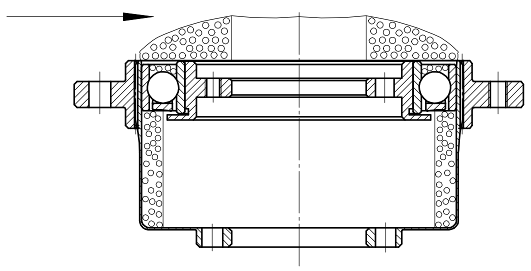


Table 1.2.12

Grease quantity [g]

		Size				
		14	17	20	25	32
Mounting position	Wave Generator vertical	5.5	10.0	16.0	30.0	60.0
	Wave Generator down	7.0	12.0	18.0	35.0	70.0
	Wave Generator up	8.5	14.0	21.0	40.0	80.0

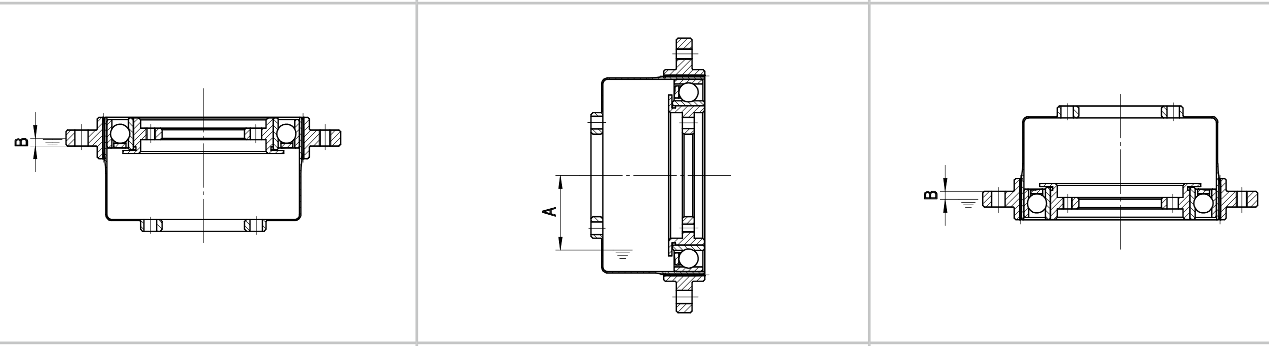
• Oil lubrication

Oil lubrication is possible for Harmonic Drive® CPL-2A Gear Component Sets. A separate lubrication space must be provided. Illustration 1.2.10 and Table 1.2.13 show recommended oil levels for horizontal and vertical mounting positions.

Illustration 1.2.10

Operating position

Wave Generator up	Wave Generator vertical	Wave Generator down



B = Oil level	A = Oil level	B = Oil level

Table 1.2.13

Oil levels [mm]

	Size				
	14	17	20	25	32
A	10	12	14	17	24
B	1	1	1	2	3

Lube holes

In the case of a vertical axis with an overhead Wave Generator, design measures must be taken to ensure that the oil thrown out of the Flexspline by the Wave Generator can flow back again. This can be achieved by connecting the two oil areas by means of lube holes in the Flexspline flange. Please consult Harmonic Drive SE.

You will find more information on this in the Engineering data chapter.

Assembly tolerances

We recommend observing the following tolerances during assembly:

Illustration 1.2.11

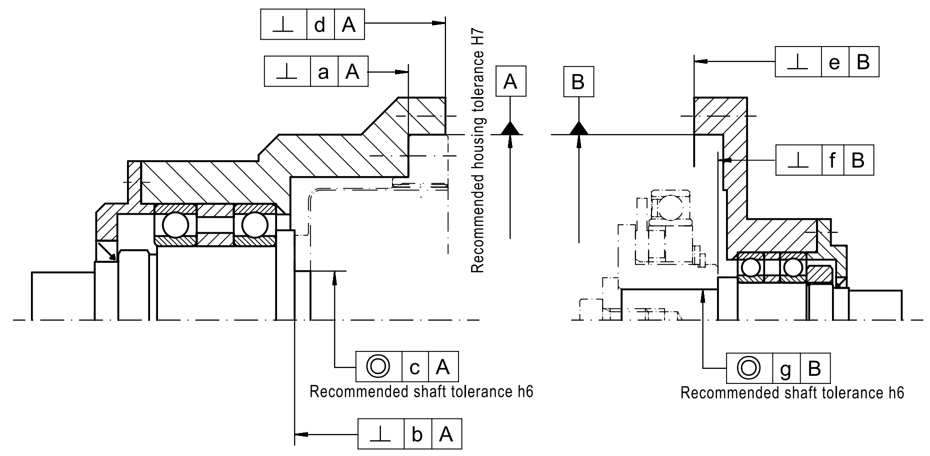


Table 1.2.14

[mm]

	Size				
	14	17	20	25	32
a	0.011	0.012	0.013	0.014	0.016
b	0.008	0.011	0.014	0.018	0.022
c	0.015	0.018	0.019	0.022	0.022
d	0.011	0.015	0.017	0.024	0.026
e	0.011	0.015	0.017	0.024	0.026
f	0.008	0.010	0.010	0.012	0.012
g	0.016	0.018	0.019	0.022	0.022

Motor shaft tolerances should comply with DIN 42955 R.

Assembly

• Assembly of the Flexspline

Clamping ring

To avoid damage to the gear, care must be taken ensuring that the screw heads, pins or nuts do not hinder the deformation of the Flexspline. We recommend the use of a clamping ring with the specified dimensions. Material S45C (DINHC45), quenched and tempered, HB200 to 270 or comparable. The clamping ring is not included in the scope of delivery.

Illustration 1.2.12

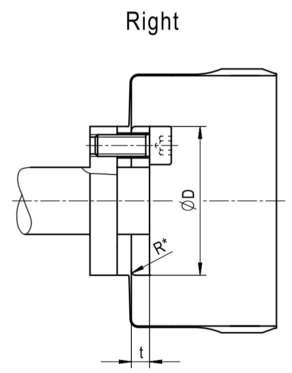
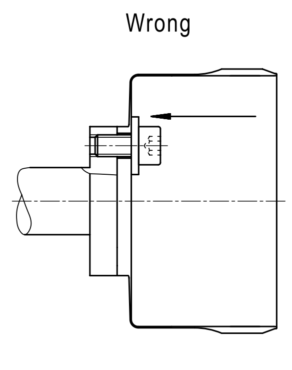


Illustration 1.2.13



The outer edge of the clamping ring must be rounded to allow deformation of the Flexspline.

You will find more information on this in the Engineering data chapter.

Dimensions of the clamping ring

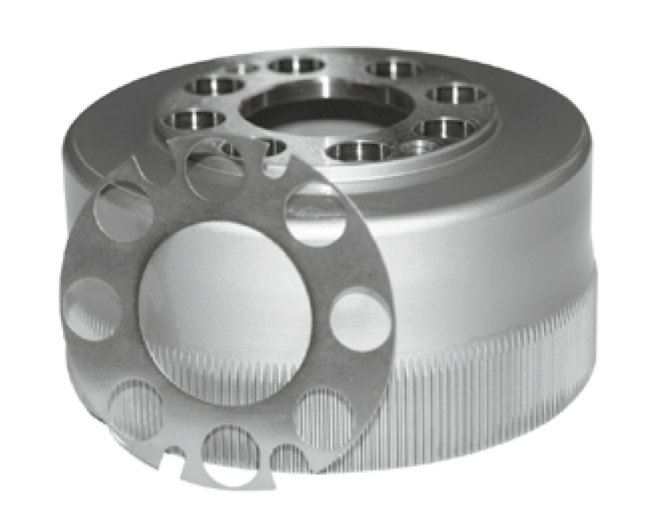
Table 1.2.15 [mm]

	Size				
	14	17	20	25	32
$D^{0}_{-0.1}$	24.5	29.0	34.0	42.0	55.0
$R^{+0.1}_{0}$	1.2	1.2	1.4	1.5	2.0
t	3.0	3.0	3.0	5.0	7.0

Friction Shim

To increase the friction coefficient between the Flexspline and the customer's output element, a metal disc with diamond coating on both sides (Friction Shim) is used. This element is included in the scope of delivery.

Illustration 1.2.14



Screws Flexspline

Table 1.2.16

	[Unit]	Size				
		14	17	20	25	32
Number of screws		12	14	12	12	12
Size of screws		M2.5	M2.5	M3	M4	M5
Pitch circle diameter	[mm]	18.9	23.1	27.0	33.6	44.9
Screw tightening torque	[Nm]	1.2	1.2	2.2	5.1	10.0
Torque transmitting capacity	[Nm]	57	87	134	328	778

12.9 quality screws, friction coefficient μ=0,4 (with Friction Shim).
The transmittable torque of the Flexspline fitting is lower than the Limit for momentary peak torque for some products, compare with Table 1.2.3.
We recommend not to exceed the torque that can be transmitted by the Flexspline fitting during operation.

- Assembly of the Circular Spline

Screws Circular Spline

Table 1.2.17

	[Unit]	Size				
		14	17	20	25	32
Number of screws		12	12	12	12	12
Size of screws		M3	M3	M3	M4	M5
Pitch circle diameter	[mm]	44	54	62	75	100
Screw tightening torque	[Nm]	2.1	2.1	2.1	5.1	10.0
Torque transmitting capacity	[Nm]	110	130	150	315	690

12.9 quality screws, friction coefficient μ = 0,15

- Assembly of the Wave Generator

During assembly, the axial assembly dimension specified in the catalogue/confirmation drawing must be observed.

Screws Wave Generator

Table 1.2.18

	[Unit]	Size				
		14	17	20	25	32
Number of screws		4	4	4	4	4
Size of screws		M2	M2	M2.5	M3	M4
Screw tightening torque	[Nm]	0.60	0.60	1.23	2.15	5.10

12.9 quality screws

You will find more information on this in the Engineering data chapter.

Product description

Compact, lightweight and precise

The CSD-2A Series Gear Component Sets are characterised by the shortest design, low weight, large hollow shaft and are suitable for applications with a small installation space.

Features

- Short design
- Low weight
- Large hollow shaft for the passage of supply cables and shafts
- High dynamics due to reduced moment of inertia
- Ideal for applications using integrated output bearing arrangement

Ordering code

Table 1.3.1

Ordering code	CSD	-	20	-	100	- 2A-GR -	BB	-	SP
Series									
Size (corresponds to the pitch circle diameter of the Flexspline toothing in inches x 10)			14 17 20 25 32 40 50						
Ratio (in drive configuration: Circular Spline (CS) fixed, Wave Generator (WG) input, Flexspline (FS) output					50 80 100 120 160				
Version									
Gear component set sizes 14, 17						2A-R			
Gear component set sizes 20 to 50						2A-GR			
Option „Flexspline hollow diameter“									
Standard design (Field remains empty)							[ ]		
Flexspline with enlarged central bore (BB = big bore)							BB		
Customised design									
Standard design (Field remains empty)									[ ]
Special design (on request)									SP

Please refer to the table of possible combinations.

Combinations

Table 1.3.2

		Size 14	17	20	25	32	40	50
Ratio	50	●	●	●	●	●	●	●
	80	●	●	●	●	●	●	●
	100	●	●	●	●	●	●	●
	120	-	●	●	●	●	●	●
	160	-	-	●	●	●	●	●
Option Flexspline	[ ]	●	●	●	●	●	●	●
Hollow diameter	BB	-	-	●	●	●	●	●

● available o on request - not available

Technical data

• Rating table

Table 1.3.3

Size	Ratio	Limit for repeated peak torque	Limit for average torque	Rated torque at rated speed 2000 rpm	Limit for momentary peak torque		Max. input speed [rpm]		Limit for average input speed [rpm]		Moment of inertia	Weight
	i	T_R [Nm]	T_A [Nm]	T_N [Nm]	T_M [Nm]		Lubrication Oil	Grease	Lubrication Oil	Grease	[kgm²]	[kg]
14	50	12.0	4.8	3.7	24.0		14000	8500	6500	3500	0.021*10⁻⁴	0.06
	80	16.0	7.7	5.4	31.0							
	100	19.0	7.7	5.4	31.0							
17	50	23	18	11	48		10000	7300	6500	3500	0.054*10⁻⁴	0.1
	80	29	19	15	55[3)]							
	100	37	27	16	55[3)]							
	120	37	27	16	55[3)]							
20	50	39	24	17	69		10000	6500	6500	3500	0.090*10⁻⁴	0.13
	80	51	33	24	76[1)3)]	65[2)3)]						
	100	57	34	28	76[1)3)]	65[2)3)]						
	120	60	34	28	76[1)3)]	65[2)3)]						
	160	64	34	28	76[1)3)]	65[2)3)]						
25	50	69	38	27	127		7500	5600	5600	3500	0.282*10⁻⁴	0.24
	80	96	60	44	152[1)3)]	135[2)3)]						
	100	110	75	47	152[1)3)]	135[2)3)]						
	120	117	75	47	152[1)3)]	135[2)3)]						
	160	123	75	47	152[1)3)]	135[2)3)]						
32	50	151	75	53	268		7000	4800	4600	3500	1.09*10⁻⁴	0.51
	80	213	117	83	359[1)3)]	331[2)3)]						
	100	233	151	96	359[1)3)]	331[2)3)]						
	120	247	151	96	359[1)3)]	331[2)3)]						
	160	261	151	96	359[1)3)]	331[2)3)]						
40	50	281	137	96	480		5600	4000	3600	3000	2.85*10⁻⁴	0.92
	80	364	198	144	685[1)]	580[2)3)]						
	100	398	260	185	694[1)3)]	580[2)3)]						
	120	432	315	205	694[1)3)]	580[2)3)]						
	160	453	316	206	694[1)3)]	580[2)3)]						
50	50	500	247	172	1000		4500	3500	3000	2500	8.61*10⁻⁴	1.9
	80	659	363	260	1300							
	100	686	466	329	1440[1)]	1315[2)3)]						
	120	756	569	370	1440[1)]	1315[2)3)]						
	160	823	590	370	1577[1)3)]	1315[2)3)]						

1) Standard design
2) Version with enlarged hollow diameter (BB)
3) The limit for momentary peak torque is limited by the max. transmittable torque of the Flexspline screw connection.

You will find more information on this in the Engineering data chapter.

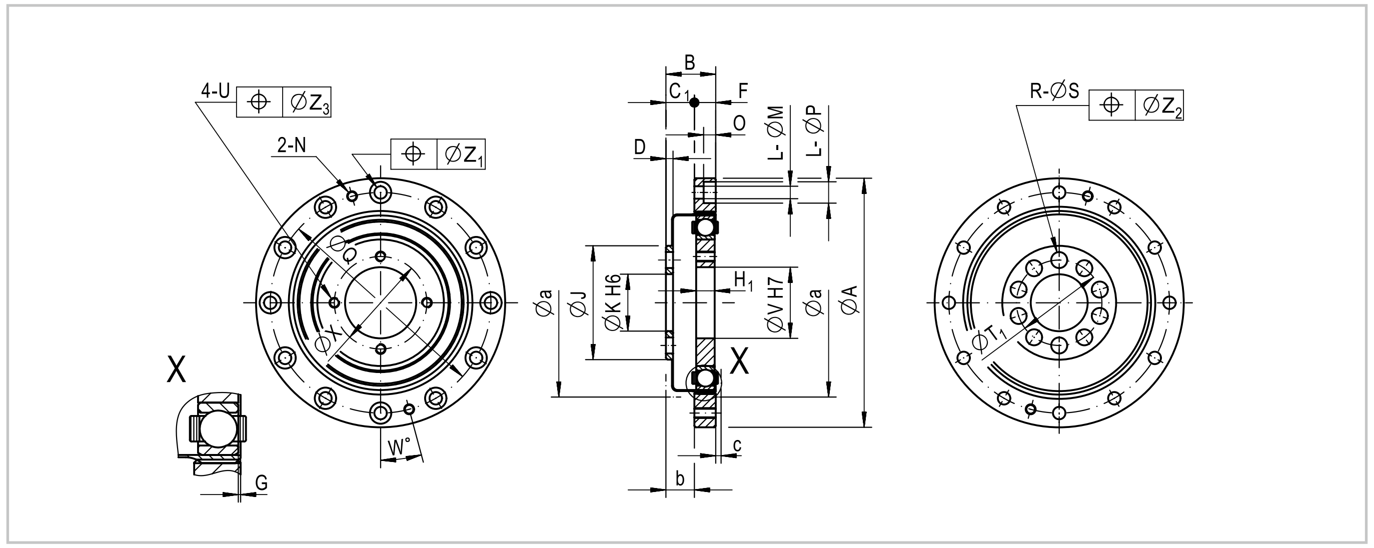
Wave Generator Details

Illustration 1.3.1 **CSD-14, 17**

Illustration 1.3.2 **CSD-20 ... 50**

• Dimensions

Illustration 1.3.3 **[mm]**



CAD drawings for download: www.harmonicdrive.co.uk

Table 1.3.4

Size	14	17	20		25		32		40		50	
	Standard	Standard	Standard	BB	Standard	BB	Standard	BB	Standard	BB	Standard	BB
Ø A h7	50	60	70		85		110		135		170	
B	11.0	12.5	14.0		17.0		22.0		27.0		33.0	
C_1	$6.5^{+0.2}_{0}$	$7.5^{+0.2}_{0}$	$8^{+0.3}_{0}$		$10^{+0.3}_{0}$		$13^{+0.3}_{0}$		$16^{+0.3}_{0}$		$19.5^{+0.3}_{0}$	
D	1.4	1.7	2.0		2.0		2.5		3.0		3.5	
F	4.5	5.0	6.0		7.0		9.0		11.0		13.5	
G	$0.3^{+0.2}_{0}$	$0.3^{+0.2}_{0}$	$0.3^{+0.2}_{0}$		$0.4^{+0.2}_{0}$		$0.5^{+0.2}_{0}$		$0.6^{+0.2}_{0}$		$0.8^{+0.2}_{0}$	
H_1	$4^{0}_{-0.1}$	$5^{0}_{-0.1}$	$5.2^{0}_{-0.1}$		$6.35^{0}_{-0.1}$		$8.6^{0}_{-0.1}$		$10.3^{0}_{-0.1}$		$12.7^{0}_{-0.1}$	
Ø J	23.0	27.2	32.0		40.0		52.0		64.0		80.0	
Ø K H6	11	11	16	20	20	24	30	32	32	40	44	50
L - Ø M / Ø P	6 - Ø 3.4 / –	8 - Ø 3.4 / –	12 - Ø 3.4 / Ø 6.5		12 - Ø 3.4 / Ø 6.5		12 - Ø 4.5 / Ø 8		12 - Ø 5.5 / Ø 9.5		12 - Ø 6.6 / Ø 11	
N	M3	M3	M3		M3		M4		M5		M6	
O	–	–	3.3		3.3		4.4		5.4		6.5	
Ø Q	44	54	62		75		100		120		150	
R - Ø S	9 - Ø 3.4	8 - Ø 4.5	9 - Ø 4.5	12 - Ø 3.4	9 - Ø 5.5	12 - Ø 4.5	11 - Ø 6.6	14 - Ø 5.5	10 - Ø 9	14 - Ø 6.6	11 - Ø 11	14 - Ø 9
Ø T_1	17	19.5	24	26	30	32	41	42	48	52	62	65
U	M3	M3	M3		M3		M4		M5		M6	
Ø V H7	11	15	20		24		32		40		50	
W°	30.0	22.5	15.0		15.0		15.0		15.0		15.0	
Ø X	17	21	26		30		40		50		60	
Ø Z_1	0.20	0.20	0.20		0.20		0.25		0.25		0.30	
Ø Z_2	0.20	0.25	0.25	0.20	0.25		0.30	0.25	0.50	0.30	0.50	
Ø Z_3	0.25	0.25	0.20		0.20		0.25		0.25		0.30	
Ø a *	38	45	53		66		86		106		133	
b *	6.5	7.5	8.0		10.0		13.0		16.0		19.5	
c *	1.0	1.0	1.5		1.5		2.0		2.5		3.5	

* Minimum housing distance

• Accuracy

Table 1.3.5 **[arcmin]**

	Size	
	14, 17	≥ 20
Transmission accuracy	< 1.5	< 1.0
Hysteresis loss	< 2	< 2
Lost motion	< 1	
Repeatability	< ±0.1	

• Torsional stiffness

Table 1.3.6

	Symbol [Unit]	Size						
		14	17	20	25	32	40	50
Limit torques	T_1 [Nm]	2.0	3.9	7	14	29	54	108
	T_2 [Nm]	6.9	12.0	25	48	108	196	382
i = 50	K_3 [x 10^4 Nm/rad]	0.47	1.20	2.0	3.7	8.4	15.0	30
	K_2 [x 10^4 Nm/rad]	0.37	0.88	1.3	2.7	6.1	11.0	21
	K_1 [x 10^4 Nm/rad]	0.29	0.67	1.1	2.0	4.7	8.8	17
≥ 80	K_3 [x 10^4 Nm/rad]	0.61	1.30	2.5	4.7	11.0	20.0	37
	K_2 [x 10^4 Nm/rad]	0.44	0.94	1.7	3.7	7.8	14.0	29
	K_1 [x 10^4 Nm/rad]	0.40	0.84	1.3	2.7	6.1	11.0	21

• No load starting torque

Table 1.3.7 **[Ncm]**

Ratio	Size						
	14	17	20	25	32	40	50
50	3.7	5.7	7.3	14.0	28	50	94
80	2.7	3.8	4.8	8.8	19	32	63
100	2.4	3.3	4.3	7.9	18	29	56
120	-	3.1	3.8	7.2	16	27	53
160	-	-	3.4	6.4	14	24	44

• No load back driving torque

Table 1.3.8 **[Nm]**

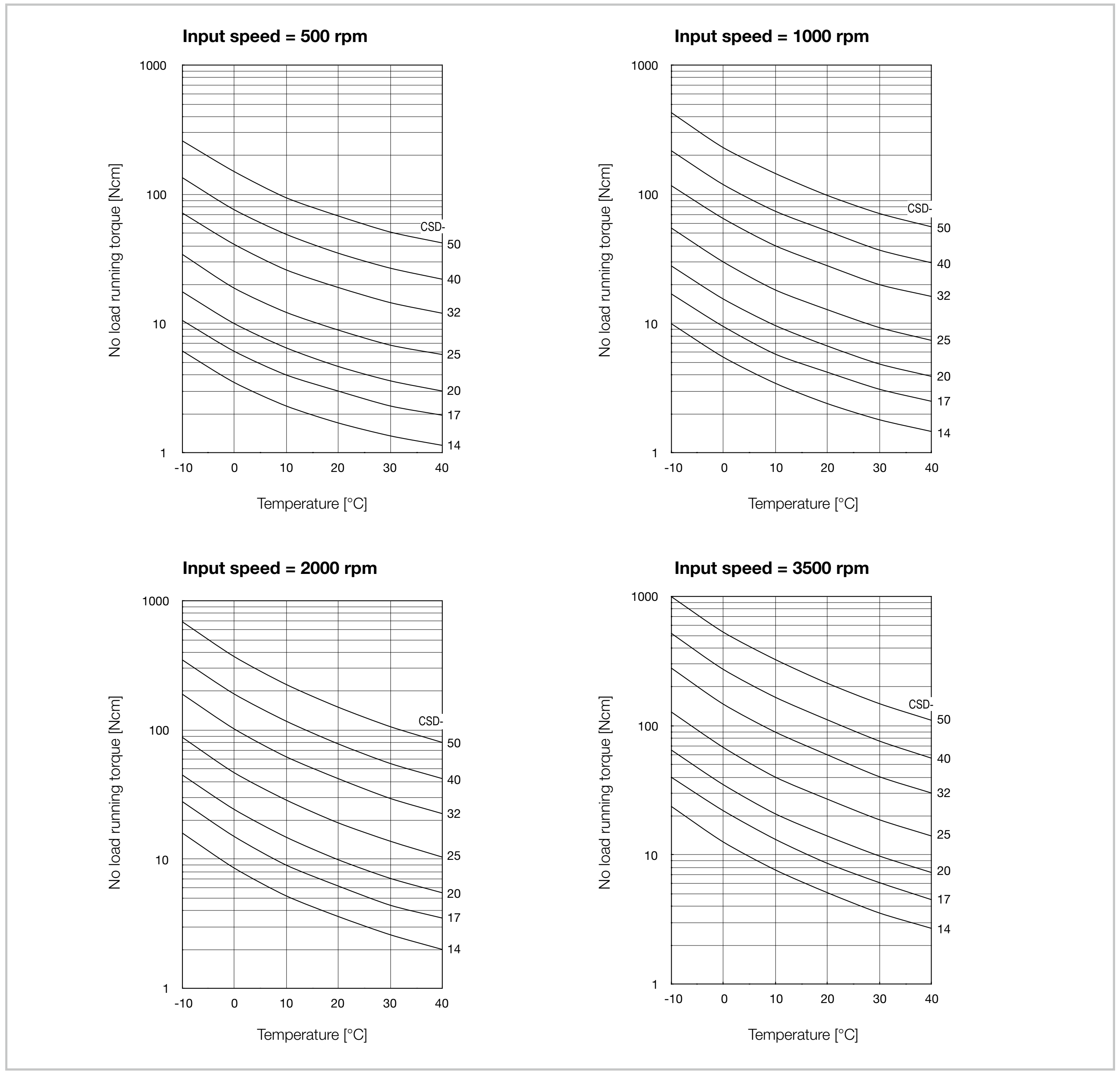
Ratio	Size						
	14	17	20	25	32	40	50
50	2.5	3.8	4.4	8.3	17	30	57
80	2.6	3.7	4.9	8.8	19	32	62
100	3.1	4.1	5.2	9.6	21	35	67
120	-	4.5	5.7	11.0	22	38	74
160	-	-	6.6	12.0	28	45	85

You will find more information on this in the Engineering data chapter.

• No load running torque

The diagrams apply to Harmonic Drive® Grease SK-2 (size 14, 17) or SK-1A (size ≥ 20).

Illustration 1.3.4



Compensation values for no load running torque

When using gears with ratios other than i=100 please apply the compensation values from the table to the values taken from the curves.

Table 1.3.9 **[Ncm]**

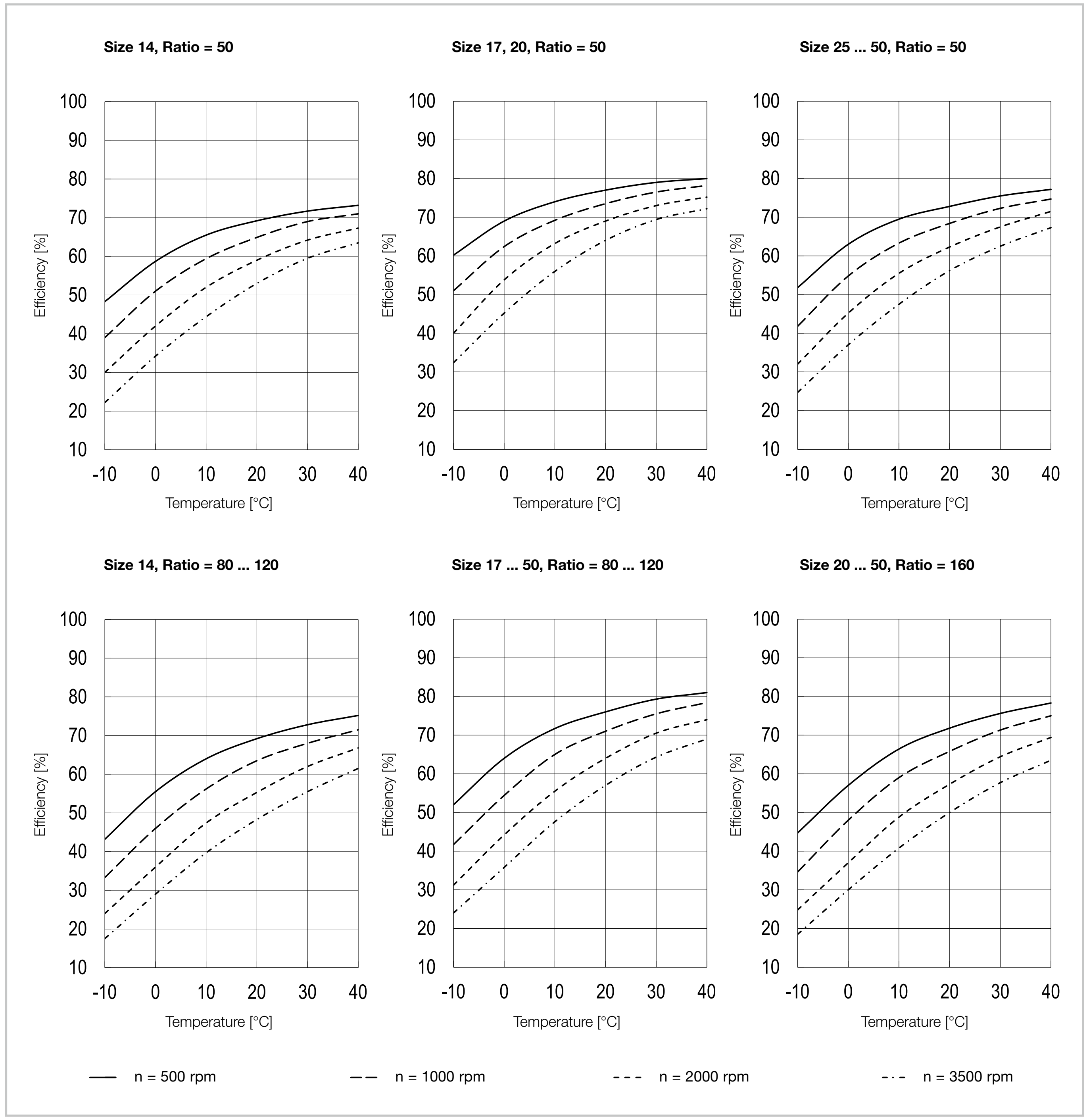
Ratio	Size						
	14	17	20	25	32	40	50
50	0.56	0.95	1.40	2.60	5.40	9.60	18.00
80	0.1	0.1	0.2	0.4	0.8	1.5	2.7
120	-	-0.1	-0.2	-0.3	-0.6	-1.1	-2.0
160	-	-	-0.39	-0.72	-1.50	-2.60	-4.80

• Efficiency

Efficiency for grease lubrication at rated torque

The diagrams apply to Harmonic Drive® Grease SK-2 (size 14, 17) or SK-1A (size ≥ 20).

Illustration 1.3.5



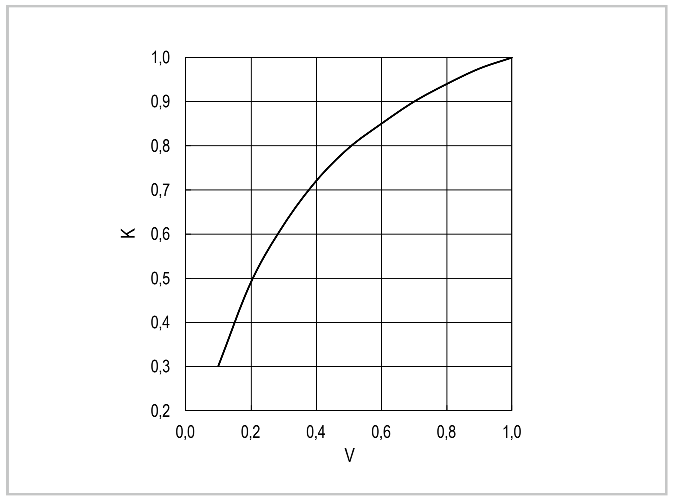
Efficiency calculation

The efficiency depends on the following parameters: Gear ratio, input speed, load torque, temperature, lubricant and lubricant quantity. If the load torque is lower than the rated torque, the efficiency will be lower than the efficiency indicated in the efficiency curves. The torque specific efficiency is determined by means of the calculation factor K.

Calculation example

Product: CSD-20-80-2A-GR

Illustration 1.3.6



- Input speed: 1000 rpm
- (Average) load torque T_{av}: 20 Nm
- Rated torque T_N (catalogue reference): 24 Nm
- Grease lubrication with Harmonic Drive® Grease
- SK-1A, lubricant temperature: 20 °C.

1. Calculation of the torque factor
   $V = T_{av}/T_N = 20/24 = 0{,}83$ (For V > 1 is K = 1)
2. Reading the calculation factor K from diagram figure Illustration 1.3.6: K = 0.95
3. Reading the efficiency from the efficiency curve figure Illustration 1.3.5: η = 71 %
4. Calculation of the load dependant efficiency
   $\eta_L = 71\ \% \cdot 0.95 = 67\ \%$

Design guidelines

• Grease lubrication

To ensure optimum lubrication, the gear housing should be kept compact, for example see Illustration 1.3.7 and Table 1.3.10.

If the gear housing is filled with more than 50 % grease, the risk of leakage increases. Therefore the grease volume/gear housing ratio should be less than 0.5. When installing with a predominantly top or bottom mounted Wave Generator, the gap c should be filled with an additional amount of grease according to Table 1.3.10.

Materials used:
- Circular Spline: Grey cast iron, bright
- Wave Generator, Flexspline: Steel, bright

Illustration 1.3.7

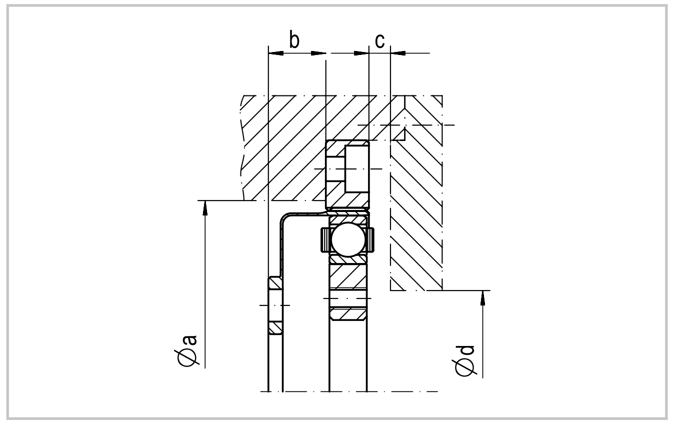


Table 1.3.10

Symbol	Size 14	17	20	25	32	40	50
ø a	38	45	53	66	86	106	133
b	6.5	7.5	8.0	10.0	13.0	16.0	19.5
c[1]	1.0	1.0	1.5	1.5	2.0	2.5	3.5
c[2]	3.0	3.0	4.5	4.5	6.0	7.5	10.5
ø d	16	26	30	37	37	45	45

[1] Axis horizontal or vertical, Wave Generator down
[2] Axis vertical, Wave Generator up

You will find more information on this in the Engineering data chapter.

Lubrication

Harmonic Drive® Gear Component Sets are supplied without lubricant as standard. Before commissioning they must be lubricated according to the following diagrams.

• Grease lubrication

We recommend the use of the greases listed in Table 1.3.11.

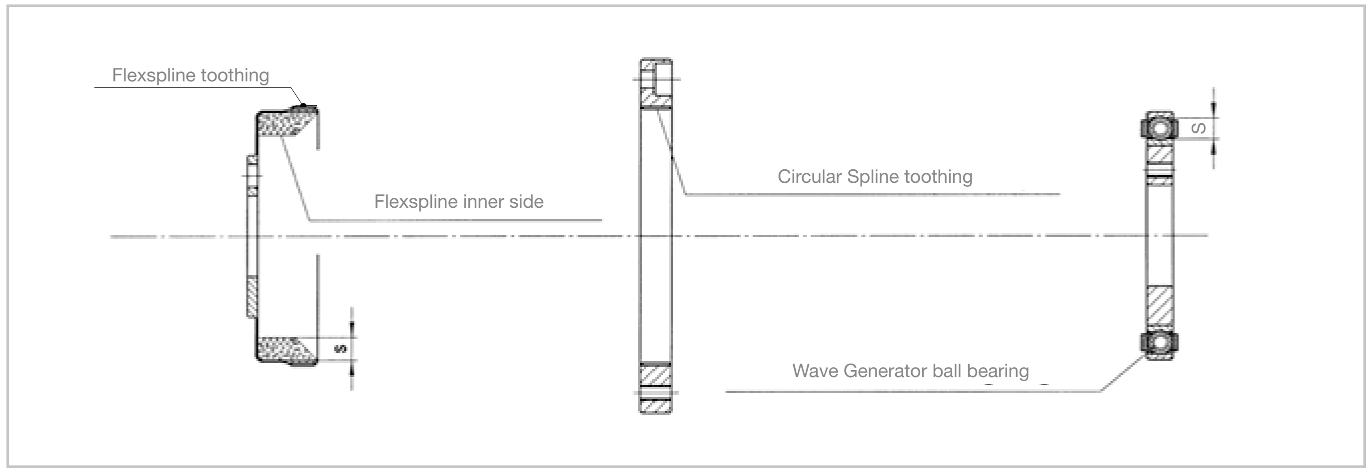
Table 1.3.11

Harmonic Drive® Grease	Size						
	14	17	20	25	32	40	50
SK-1A	-	-	O	O	O	O	O
SK-2	O	O	Δ	Δ	Δ	Δ	-
4BNo.2	□	□	□	□	□	□	□

O Standard grease
□ Recommended for very high loads or very high demands on the service life of the grease
Δ Optional grease, please consult Harmonic Drive SE

The gear component sets must be lubricated in four areas before commissioning, see Illustration 1.3.8.
- Flexspline: Place a grease reservoir all around the inner wall of the Flexspline. The dimension „s“ should be approximately the height of the Wave Generator ball bearing.
- Toothing: Fill the gaps between the teeth with grease.
- Wave Generator ball bearings: Apply a generous amount of grease to the area of the bearing balls and bearing cage.

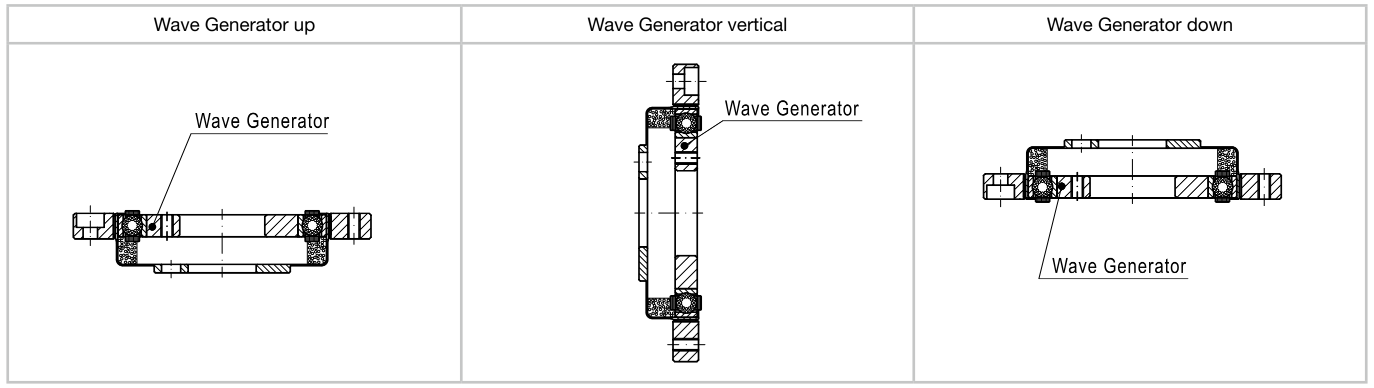
Illustration 1.3.8



The required grease quantity depends not only on the size but also on the operating position of the gear. The operating positions „Wave Generator up“ and „Wave Generator down“ defined in the text below refer to the relative position of the Wave Generator to the Flexspline flange, see Illustration 1.3.9.

Illustration 1.3.9

Operating position



In case of predominant use with the Wave Generator on top or on the bottom, additional grease is required, see Illustration 1.3.10 und Table 1.3.12.

Illustration 1.3.10

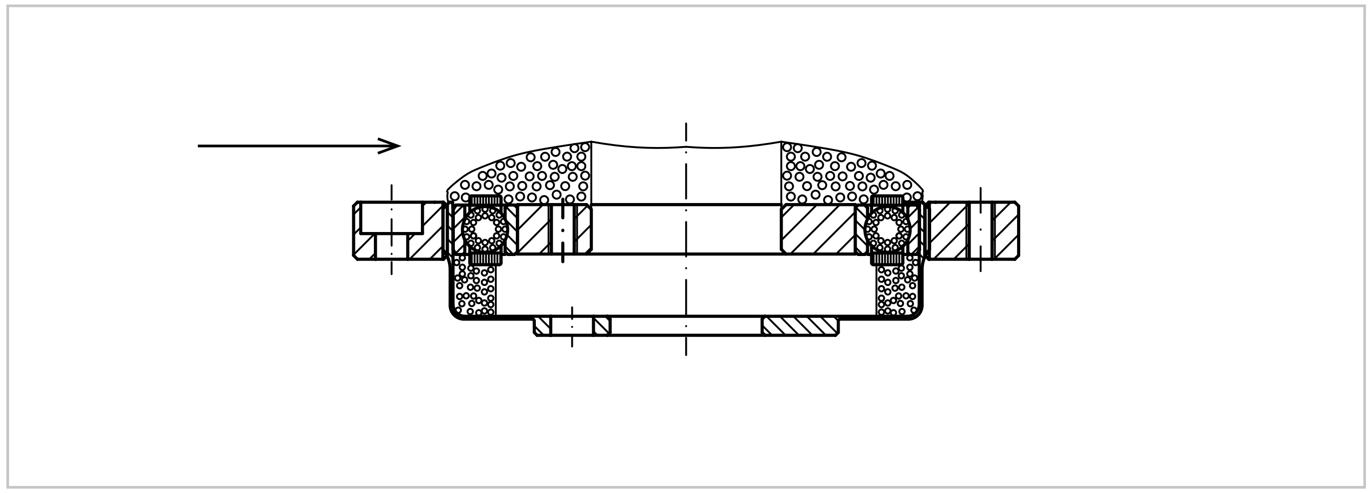


Table 1.3.12

Grease quantity [g]

		Size						
		14	17	20	25	32	40	50
Mounting position	Wave Generator vertical	3.5	5.2	9.0	17.0	37.0	68.0	131.0
	Wave Generator down	3.9	6.0	10.0	19.0	42.0	78.0	149.0
	Wave Generator up	4.6	7.1	12.0	22.0	48.0	88.0	175.0

• Oil lubrication

Oil lubrication is possible for Harmonic Drive® CSD-2A Gear Component Sets. A separate lubrication space must be provided. Please contact Harmonic Drive SE.

ⓘ You will find more information on this in the Engineering data chapter.

Assembly tolerances

We recommend observing the following tolerances during assembly:

Illustration 1.3.11

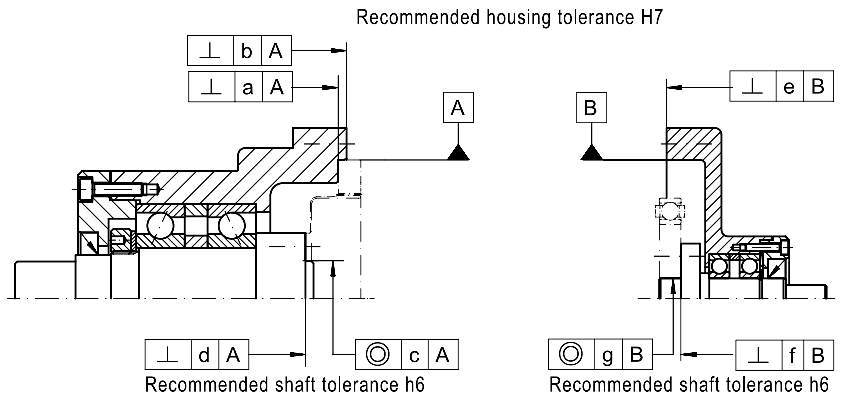


Table 1.3.13 **[mm]**

Symbol	Size						
	14	17	20	25	32	40	50
a	0.011	0.012	0.013	0.014	0.016	0.016	0.018
b	0.008	0.011	0.014	0.018	0.022	0.025	0.030
c	0.015	0.018	0.019	0.022	0.022	0.024	0.030
d	0.011	0.015	0.017	0.024	0.026	0.026	0.028
e	0.011	0.015	0.017	0.024	0.026	0.026	0.028
f	0.008	0.010	0.010	0.012	0.012	0.012	0.015
g	0.016	0.018	0.019	0.022	0.022	0.024	0.030

Assembly

• Assembly of the Flexspline

To avoid damage to the gear, care must be taken that bolt heads, pins or nuts do not interfere with Flexspline deformation.

The bolt heads must not protrude beyond the øJ on the Flexspline, as shown in Illustration 1.3.12 and Table 1.3.14. Otherwise the Flexspline may be damaged. A clamping ring is not required. If a clamping ring is used, ensure that there is sufficient axial clearance between the bolt heads and the Wave Generator. Washers are not required. If washers are nevertheless used, they must not exceed the øJ.

Illustration 1.3.12

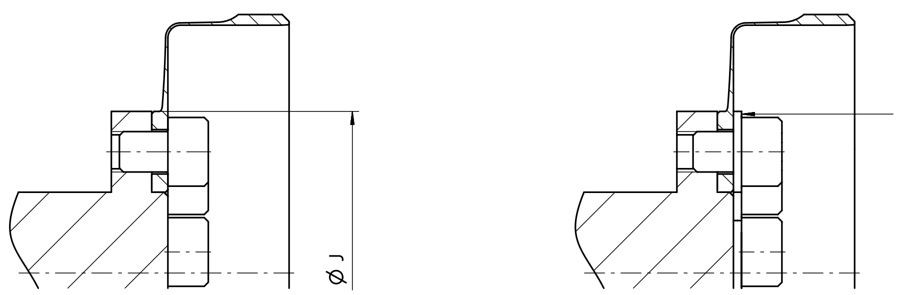


Table 1.3.14

Symbol	Size						
	14	17	20	25	32	40	50
øJ	23.0	27.2	32.0	40.0	52.0	64.0	80.0

Screws Flexspline

Table 1.3.15

	[Unit]	CSD-2A							CSD-2A-BB				
		14	17	20	25	32	40	50	20	25	32	40	50
Number of screws		9	8	9	9	11	10	11	12	12	14	14	14
Size of screws		M3	M4	M4	M5	M6	M8	M10	M3	M4	M5	M6	M8
Pitch circle diameter	[mm]	17	19.5	24	30	41	48	62	26	32	42	52	65
Screw tightening torque	[Nm]	2.0	4.5	4.5	9.0	15.3	37.0	74.0	2.0	4.5	9.0	15.3	37.0
Torque transmitting capacity	[Nm]	32	55	76	152	359	694	1577	65	135	331	580	1315

12.9 quality screws, friction coefficient μ=0,15.

• Assembly of the Circular Spline

During assembly of the Circular Spline, the instructions in the chapter “Engineering data” must be considered.

Screws Circular Spline

Table 1.3.16

	[Unit]	Size						
		14	17	20	25	32	40	50
Number of screws		6	8	12	12	12	12	12
Size of screws		M3	M3	M3	M3	M4	M5	M6
Pitch circle diameter	[mm]	44	54	62	75	100	120	150
Screw tightening torque	[Nm]	2.0	2.0	2.0	2.0	4.5	9.0	15.3
Torque transmitting capacity	[Nm]	55	90	155	188	422	810	1434

12.9 quality screws, friction coefficient μ = 0,15.

• Assembly of the Wave Generator

During assembly of the Wave Generator, the assembly dimension “G” specified in the catalogue/confirmation drawing must be observed in accordance with Table 1.3.4.

Screw connection on the Wave Generator

Table 1.3.17

	[Unit]	Size						
		14	17	20	25	32	40	50
Number of screws		4	4	4	4	4	4	4
Size of screws		M3	M3	M3	M3	M4	M5	M6
Pitch circle diameter	[mm]	17,0	21,0	26,0	30,0	40,0	50,0	60,0
Screw tightening torque	[Nm]	2,30	2,30	2,30	2,30	5,29	10,54	17,81
Torque transmitting capacity	[Nm]	10	12	15	18	47	104	187

You will find more information on this in the Engineering data chapter.

Product description

High overload capacity and service life

The SHG-2A Series Gear Component Sets are characterised by maximum torque capacity, service life and overload capacity and are available with a large hollow shaft as an option.

The HFUS-2A Series Gear Component Sets complement the SHG Series with lower ratios and slightly lower service life.

In addition to the proven strain wave gear technology, SHG-2A Series is also available in Triangle Technology. Setting new standards in torsional stiffness, transmission accuracy and dynamics.

Features

- Highest torque capacity
- Long service life
- High torque range
- Large hollow shaft for the passage of supply cables and shafts available as an option
- Ideal for applications with own output bearing arrangement

Ordering code

Table 1.4.1

Ordering code	Tri	SHG	-	20	-	100	-	2UH	-	SP
Technology Standard Strain Wave Gear Technology (Field remains empty)) Triangle Technology	[ ] Tri									
Series		SHG HFUS								
Ratio (in drive configuration: Circular Spline (CS) fixed, Wave Generator (WG) input, Flexspline (FS) output)				14 17 20 25 32 40 45 50 58 65						
Ratio (in drive configuration: Circular Spline (CS) fixed, Wave Generator (WG) input, Flexspline (FS) output)						30 50 80 100 120 160				
Version Sizes 14, 17 Sizes 20 … 65								2A-R 2A-GR		
Customised design Standard design (Field remains empty) Special design (on request)										[ ] SP

Please refer to the table of possible combinations.

Combinations SHG-/HFUS-2A

Table 1.4.2 **SHG-2A**

		Size									
		14	17	20	25	32	40	45	50	58	65
Ratio	30	-	-	-	-	-	-	-	-	-	-
	50	●	●	●	●	●	●	●	-	-	-
	80	●	●	●	●	●	●	●	●	●	●
	100	●	●	●	●	●	●	●	●	●	●
	120	-	●	●	●	●	●	●	●	●	●
	160	-	-	●	●	●	●	●	●	●	●
Version	2A-R	●	●	-	-	-	-	-	-	-	-
	2A-GR	-	-	●	●	●	●	●	●	●	●

Table 1.4.3 **HFUS-2A**

		Size									
		14	17	20	25	32	40	45	50	58	65
Ratio	30	●	●	●	●	●	-	-	-	-	-
	50	-	-	-	-	-	-	-	●1)	●1)	-
	80	-	-	-	-	-	-	-	-	-	-
	100	-	-	-	-	-	-	-	-	-	-
	120	-	-	-	-	-	-	-	-	-	-
	160	-	-	-	-	-	-	-	-	-	-
Version	2A-R	●	●	-	-	-	-	-	-	-	-
	2A-GR	-	-	●	●	●	-	-	●	●	-

● available o on request - not available

1) Only with oil lubrication. Grease lubrication can be used if the average torque T_{av} is not greater than half the rated torque T_N according to Table 1.4.5.

Table 1.4.4 **TriSHG-2A**

		Size								
		14	17	20	25	32	40	45	50	58
Ratio	50	-	-	-	-	-	-	-	-	-
	80	-	o	o	o	o	o	o	o	o
	100	-	-	o	●	o	o	o	o	o
	120	-	-	-	o	o	o	o	o	o
	160	-	-	-	o	●	o	o	o	o
Version	2A-R	-	o	-	-	-	-	-	-	-
	2A-GR	-	-	o	●	●	o	o	o	o

● available o on request - not available

Technical data

- Rating table

Table 1.4.5 **SHG-/HFUS-2A**

Series	Size	Ratio	Limit for repeated peak torque	Limit for average torque	Rated torque at rated speed 2000 rpm	Limit for momentary peak torque	Max. input speed [rpm]		Limit for average input speed [rpm]		Moment of inertia	Weight
		i	T_R [Nm]	T_A [Nm]	T_N [Nm]	T_M [Nm]	Lubrication		Lubrication		[kgm²]	[kg]
							Oil	Grease	Oil	Grease		
HFUS	14	30	9.0	6.8	4.0	17.0	14000	8500	6500	3500	0.033×10^{-4}	0.11
SHG	14	50	23	9	7	46						
	14	80	30	14	10	61						
	14	100	36	14	10	70						
HFUS	17	30	16.0	12.0	8.8	30.0	10000	7300	6500	3500	0.079×10^{-4}	0.18
SHG	17	50	44	34	21	91						
	17	80	56	35	29	113						
	17	100	70	51	31	143						
	17	120	70	51	31	112						
HFUS	20	30	27	20	15	50	10000	6500	6500	3500	0.193×10^{-4}	0.31
SHG	20	50	73	44	33	127						
	20	80	96	61	44	165						
	20	100	107	64	52	191						
	20	120	113	64	52	191						
	20	160	120	64	52	191						
HFUS	25	30	50	38	27	95	7500	5600	5600	3500	0.413×10^{-4}	0.48
SHG	25	50	127	72	51	242						
	25	80	178	113	82	332						
	25	100	204	140	87	369						
	25	120	217	140	87	395						
	25	160	229	140	87	408						
HFUS	32	30	100	75	54	200	7000	4800	4600	3500	1.69×10^{-4}	0.97
SHG	32	50	281	140	99	497						
	32	80	395	217	153	738						
	32	100	433	281	178	841						
	32	120	459	281	178	892						
	32	160	484	281	178	892						
SHG	40	50	523	255	178	892	5600	4000	3600	3000	4.5×10^{-4}	1.87
	40	80	675	369	268	1270						
	40	100	738	484	345	1400						
	40	120	802	586	382	1530						
	40	160	841	586	382	1530						
SHG	45	50	650	345	229	1235	5000	3800	3300	3000	8.68×10^{-4}	2.64
	45	80	918	507	407	1651						
	45	100	982	650	459	2041						
	45	120	1070	806	523	2288						
	45	160	1147	819	523	2483						
HFUS	50	50 1)	715	175	122	1430	4500	3500	3000	2500	12.5×10^{-4}	3.53
SHG	50	80	1223	675	484	2418						
	50	100	1274	866	611	2678						
	50	120	1404	1057	688	2678						
	50	160	1534	1096	688	3185						
HFUS	58	50 1)	1020	260	176	1960	4000	3000	2700	2200	27.3×10^{-4}	5.17
SHG	58	80	1924	1001	714	3185						
	58	100	2067	1378	905	4134						
	58	120	2236	1547	969	4329						
	58	160	2392	1573	969	4459						
SHG	65	80	2743	1352	969	4836	3500	2800	2400	1900	46.5×10^{-4}	7.04
	65	100	2990	1976	1236	6175						
	65	120	3263	2041	1236	6175						
	65	160	3419	2041	1236	6175						

1) Valid for grease lubrication. Higher torque values are permissible with oil lubrication. In this case, please contact Harmonic Drive SE.

Table 1.4.6 **TriSHG-2A**

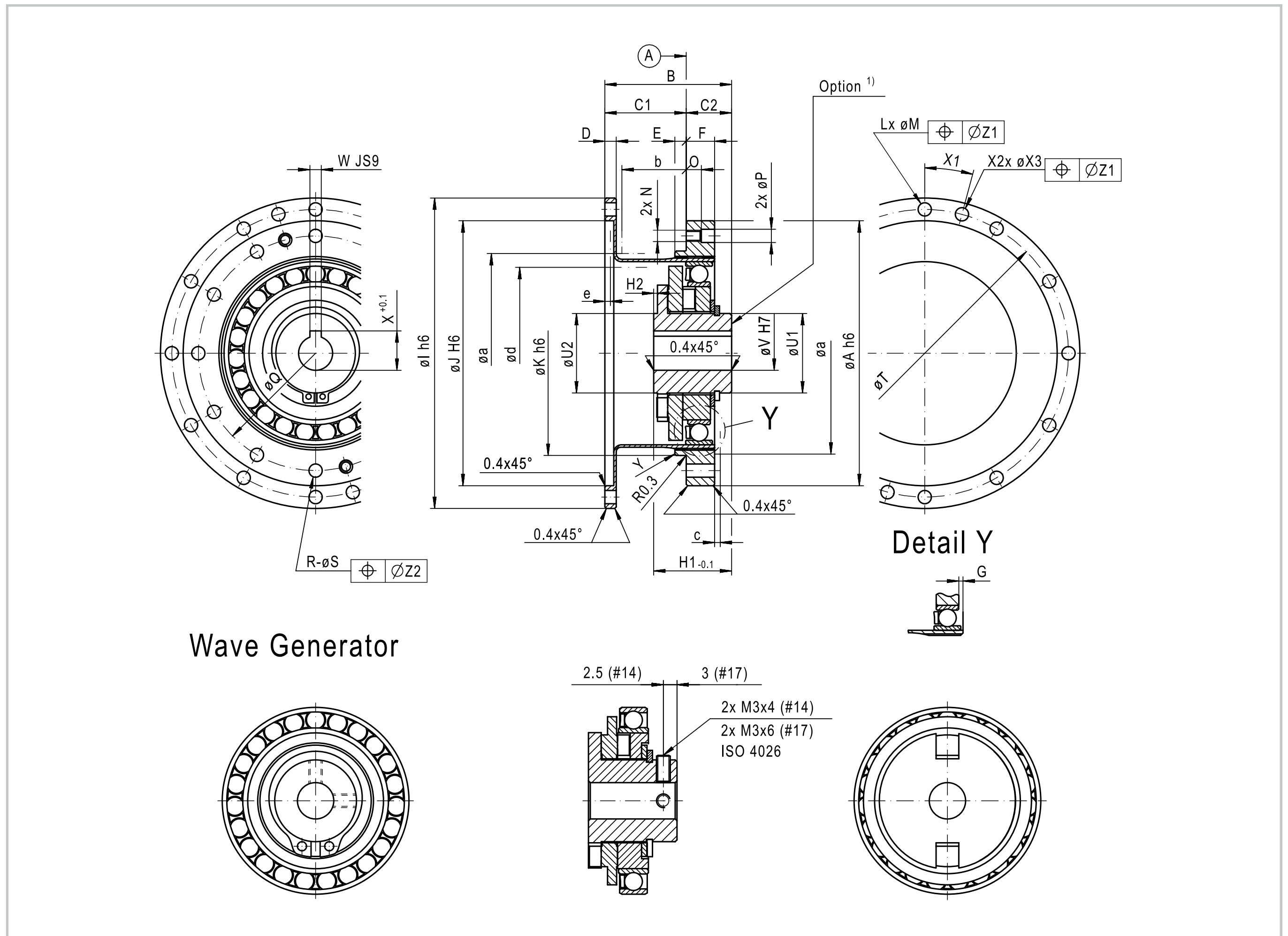
Series	Size	Ratio	Limit for repeated peak torque	Limit for average torque	Rated torque at rated speed 2000 rpm	Limit for momentary peak torque	Max. input speed [rpm]		Limit for average input speed [rpm]		Moment of inertia	Weight
		i	T_R [Nm]	T_A [Nm]	T_N [Nm]	T_M [Nm]	Lubrication		Lubrication		[kgm²]	[kg]
							Oil	Grease	Oil	Grease		
TriSHG	25	100	204	140	87	369	7500	5600	5600	3500	0.413	0.48
	32	160	484	281	178	892	7000	4800	4600	3500	1.69	0.97

1) Valid for grease lubrication. Higher torque values are permissible with oil lubrication. In this case, please contact Harmonic Drive SE.

You will find more information on this in the Engineering data chapter.

• Dimensions

Illustration 1.4.1 **[mm]**



Please note: The reference surface for the mounting of the Circular Spline is marked with (A)

1) Hub without keyway or with other diameter see chapter „Engineering data/modifications of the Wave Generator".

Wave Generator Details

The design of the bearing retainer varies depending on the series and size.

Illustration 1.4.2 **HFUS-14 ... 58, SHG-14,17,65**

Illustration 1.4.3 **SHG-20 ... 58**

Table 1.4.7 **[mm]**

		Size									
		14	17	20	25	32	40	45	50	58	65
øA h6		50	60	70	85	110	135	155	170	195	215
B	SHG-2A	$28.5^{0}_{-0.4}$	$32.5^{0}_{-0.4}$	$33.5^{0}_{-0.4}$	$37^{0}_{-0.5}$	$44^{0}_{-0.6}$	$53^{0}_{-0.6}$	$58.5^{0}_{-0.6}$	$64^{0}_{-0.7}$	$75.5^{0}_{-0.7}$	$83^{0}_{-0.7}$
	HFUS-2A	$28.5^{0}_{-0.8}$	$32.5^{0}_{-0.9}$	$33.5^{0}_{-1.0}$	$37^{0}_{-1.0}$	$44^{0}_{-1.1}$	-	-	$64^{0}_{-1.3}$	$75.5^{0}_{-1.3}$	-
C1		$17.5^{+0.4}_{0}$	$20^{+0.5}_{0}$	$21.5^{+0.8}_{0}$	$24^{+0.8}_{0}$	$28^{+0.8}_{0}$	$34^{+0.6}_{0}$	$38^{+0.6}_{0}$	$41^{+0.6}_{0}$	$48^{+0.6}_{0}$	$52.5^{+0.6}_{0}$
C2		11.0	12.5	12.0	13.0	16.0	19.0	20.5	23.0	27.5	30.5
D		2.4	3.0	3.0	3.3	3.6	4.0	4.5	5.0	5.8	6.5
E		2.0	2.5	3.0	3.0	3.0	4.0	4.0	4.0	5.0	5.0
F		6.0	6.5	7.5	10.0	14.0	17.0	19.0	22.0	25.0	29.0
G	SHG-2A	1.4	1.6	1.5	3.5	4.2	5.6	6.3	7.0	8.2	9.5
	HFUS-2A	0.4	0.3	0.1	2.1	2.5	-	-	4.2	4.8	-
H1	SHG-2A	$18.5^{0}_{-0.1}$	$20.7^{0}_{-0.1}$	$21.5^{0}_{-0.1}$	$21.6^{0}_{-0.1}$	$23.6^{0}_{-0.1}$	$29.7^{0}_{-0.1}$	$30.5^{0}_{-0.1}$	$34.8^{0}_{-0.1}$	$38.3^{0}_{-0.1}$	$44.6^{0}_{-0.1}$
	HFUS-2A	$17.6^{0}_{-0.1}$	$19.5^{0}_{-0.1}$	$20.1^{0}_{-0.1}$	$20.2^{0}_{-0.1}$	$22.0^{0}_{-0.1}$	-	-	$32.0^{0}_{-0.1}$	$34.9^{0}_{-0.1}$	-
H2		-	-	-	-	-	0.4	-	0.8	-	2.2
øI h6	SHG-2A	60	72	82	104	134	164	190	214	240	276
	HFUS-2A	60	72	82	104	134	-	-	205	233	-
øJ H6		48	60	70	88	114	140	158	175	203	232
øK h6	Ratio ≥50	38	48	54	67	90	110	124	135	156	177
	HFUS-2A Ratio =30	38	48	55	68	90	-	-	-	-	-
L		8	12	12	12	12	12	18	12	16	16
øM		3.5	3.4	3.5	4.5	5.5	6.6	6.6	9.0	9.0	11.0
N		M3	M3	M3	M4	M5	M6	M8	M8	M10	M10
O		6.0	6.5	4.0	6.0	7.0	9.0	12.0	13.0	15.0	15.0
øP		-	-	3.5	4.5	5.5	6.6	9.0	9.0	11.0	11.0
øQ		44	54	62	75	100	120	140	150	175	195
R	SHG-2A	8	16	16	16	16	16	16	16	16	16
	HFUS-2A	6	12	12	12	12	-	-	12	12	-
øS		3.5	3.5	3.5	4.5	5.5	6.6	9.0	9.0	11.0	11.0
øT	SHG-2A	54	66	76	96	124	152	180	200	226	258
	HFUS-2A	54	66	76	96	124	-	-	190	218	-
øU1		14	18	21	26	26	32	32	32	40	48
øU2		-	-	-	-	-	32	-	32	-	48
øV	Standard (H7)	6	8	9	11	14	14	19	19	22	24
	Max.	8	10	13	15	16	20	20	20	25	30
WJs9		-	-	3	4	5	5	6	6	6	8
X		-	-	$10.4^{+0.1}_{0}$	$12.8^{+0.1}_{0}$	$16.3^{+0.1}_{0}$	$16.3^{+0.1}_{0}$	$21.8^{+0.1}_{0}$	$21.8^{+0.1}_{0}$	$24.8^{+0.1}_{0}$	$27.3^{+0.2}_{0}$
Y chamfer		0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.8	0.8	0.8
øZ1		0.25	0.20	0.25	0.25	0.25	0.30	0.30	0.50	0.50	0.50
øZ2		0.25	0.25	0.25	0.25	0.25	0.30	0.50	0.50	0.50	0.50
øa	Minimum housing clearance	38	45	53	66	86	106	119	133	154	172
b		14.6	16.4	17.8	19.8	23.2	28.6	31.9	34.2	40.1	43.0
c		1.0	1.0	1.5	1.5	1.5	2.0	2.0	2.0	2.5	2.5
ød		31	38	45	56	73	90	101	113	131	150
e		1.7	2.1	2.0	2.0	2.0	2.0	2.3	2.5	2.9	3.5

Accuracy

Table 1.4.8 **SHG-/HFUS-2A [arcmin]**

	Size					
	14		17		≥20	
Ratio	30	≥50	30	≥50	30	≥50
Transmission accuracy	<2.0	<1.5	<1.5	<1.5	<1.5	<1.0
Hysteresis loss	<3.0	<1.0	<3.0	<1.0	<3.0	<1.0
Lost motion	<1.0					
Repeatability	< ± 0.1					

Table 1.4.9 **TriSHG-2A [arcmin]**

	Size
	25 … 32
Ratio	≥100
Transmission accuracy	<0.5
Hysteresis loss	<1.0
Lost motion	<1.0
Repeatability	< ±0.1

Accuracy of the Oldham coupling

Harmonic Drive® Gears are zero backlash. If an Oldham coupling is used, there is a small backlash outside the tooth engagement in the range of a few seconds of arc, see Table 1.4.10. This small backlash does not occur with a Solid Wave Generator.

Table 1.4.10 **[arcsec]**

Ratio	Series	Size									
		14	17	20	25	32	40	45	50	58	65
30	HFUS	60	33	28	28	23	-	-	-	-	-
50	SHG	36	20	17	17	14	14	12	-	-	-
	HFUS	-	-	-	-	-	-	-	12	10	-
80	SHG	23	13	11	11	9	9	8	8	6	6
	HFUS	-	-	-	-	-	-	-	-	-	-
100	SHG	18	10	9	9	7	7	6	6	5	5
	HFUS	-	-	-	-	-	-	-	-	-	-
120	SHG	-	8	8	8	6	6	5	5	4	4
	HFUS	-	-	-	-	-	-	-	-	-	-
160	SHG	-	-	6	6	5	5	4	4	3	3
	HFUS	-	-	-	-	-	-	-	-	-	-

You will find more information on this in the Engineering data chapter.

Torsional stiffness

Table 1.4.11 **SHG-/HFUS-2A**

	Symbol [Unit]	Size									
		14	17	20	25	32	40	45	50	58	65
Limit torques	T1 [Nm]	2.0	3.9	7.0	14.0	29.0	54.0	76.0	108.0	168.0	235.0
	T2 [Nm]	6.9	12.0	25.0	48.0	108.0	196.0	275.0	382.0	598.0	843.0
i=30	K_3 [x 10⁴ Nm/rad]	0.34	0.67	1.10	2.10	4.90	-	-	-	-	-
	K_2 [x 10⁴ Nm/rad]	0.24	0.44	0.71	1.30	3.00	-	-	-	-	-
	K_1 [x 10⁴ Nm/rad]	0.19	0.34	0.57	1.00	2.40	-	-	-	-	-
i=50	K_3 [x 10⁴ Nm/rad]	0.57	1.30	2.30	4.40	9.80	18.00	26.00	34.00	54.00	78.00
	K_2 [x 10⁴ Nm/rad]	0.47	1.10	1.80	3.40	7.80	14.00	20.00	28.00	44.00	61.00
	K_1 [x 10⁴ Nm/rad]	0.34	0.81	1.30	2.50	5.40	10.00	15.00	20.00	31.00	44.00
i≥80	K_3 [x 10⁴ Nm/rad]	0.71	1.60	2.90	5.70	12.00	23.00	33.00	44.00	71.00	98.00
	K_2 [x 10⁴ Nm/rad]	0.61	1.40	2.50	5.00	11.00	20.00	29.00	40.00	61.00	88.00
	K_1 [x 10⁴ Nm/rad]	0.47	1.00	1.60	3.10	6.70	13.00	18.00	25.00	40.00	54.00

Table 1.4.12 **TriSHG-2A**

	Symbol [Unit]	Size	
		25	32
Limit torques	T1 [Nm]	14	29
	T2 [Nm]	48	108
i≥100	K_3 [x 10⁴ Nm/rad]	7.4	20.6
	K_2 [x 10⁴ Nm/rad]	6.5	16.9
	K_1 [x 10⁴ Nm/rad]	5.0	13.5

No load starting torque

Table 1.4.13 **SHG-/HFUS-2A [Ncm]**

Ratio	Series	Size									
		14	17	20	25	32	40	45	50	58	65
30	HFUS	4.8	7.2	12.0	18.0	50.0	-	-	-	-	-
50	SHG	3.7	5.7	7.3	14.0	28.0	50.0	70.0	-	-	-
	HFUS	-	-	-	-	-	-	-	94	140	-
80	SHG	2.8	3.8	4.8	8.9	19.0	33.0	47.0	63.0	94.0	128.0
100	SHG	2.4	3.3	4.3	7.9	18.0	29.0	41.0	56.0	83.0	114.0
120	SHG	-	3.1	3.9	7.3	15.0	27.0	37.0	51.0	76.0	104.0
160	SHG	-	-	3.4	6.4	14.0	24.0	33.0	44.0	68.0	94.0

Table 1.4.14 **TriSHG-2A [Ncm]**

Ratio	Series	Size	
		25	32
100	TriSHG	12	-
160		-	12

No load back driving torque

Table 1.4.15 **SHG-/HFUS-2A [Nm]**

Ratio	Series	Size									
		14	17	20	25	32	40	45	50	58	65
30	HFUS	2.3	3.5	6.1	11.0	23.0	-	-	-	-	-
50	SHG	2.2	3.4	4.4	8.2	17.0	30.0	42.0	-	-	-
	HFUS	-	-	-	-	-	-	-	56	84	-
80	SHG	2.7	3.7	4.6	8.6	18.0	32.0	45.0	60.0	90.0	123.0
100	SHG	2.8	4.0	5.2	9.5	21.0	35.0	49.0	67.0	100.0	137.0
120	SHG	-	4.5	5.6	10.0	21.0	40.0	54.0	73.0	110.0	151.0
160	SHG	-	-	6.6	12.0	26.0	45.0	64.0	85.0	130.0	180.0

Table 1.4.16 **TriSHG-2A [Nm]**

Ratio	Series	Size	
		25	32
100	TriSHG	17	-
160		-	-

You will find more information on this in the Engineering data chapter.

• No load running torque

The diagrams apply to Harmonic Drive® Grease SK-2 (size 14, 17) or SK-1A (size ≥ 20).

Illustration 1.4.4 **SHG-/HFUS-2A**

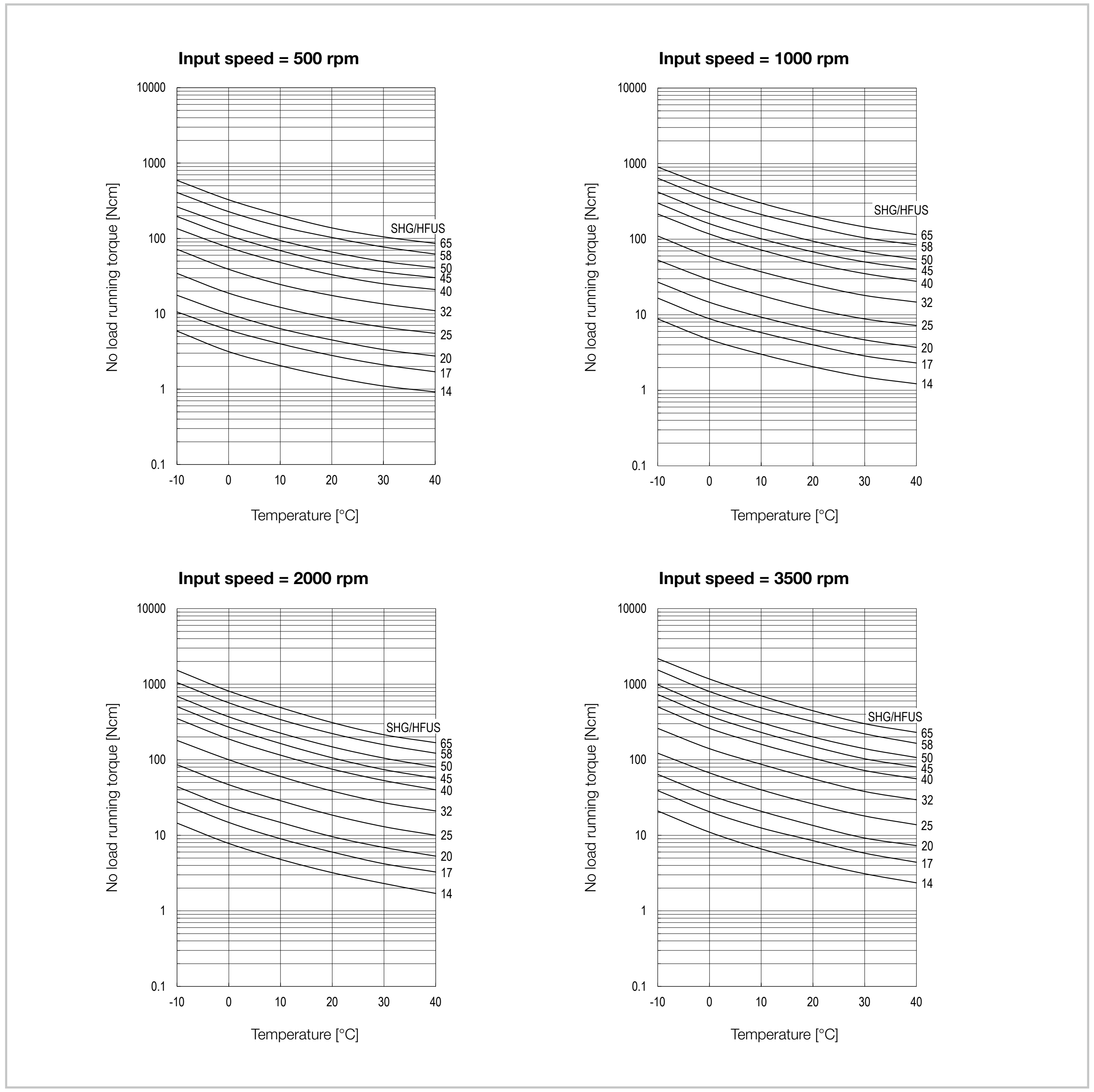
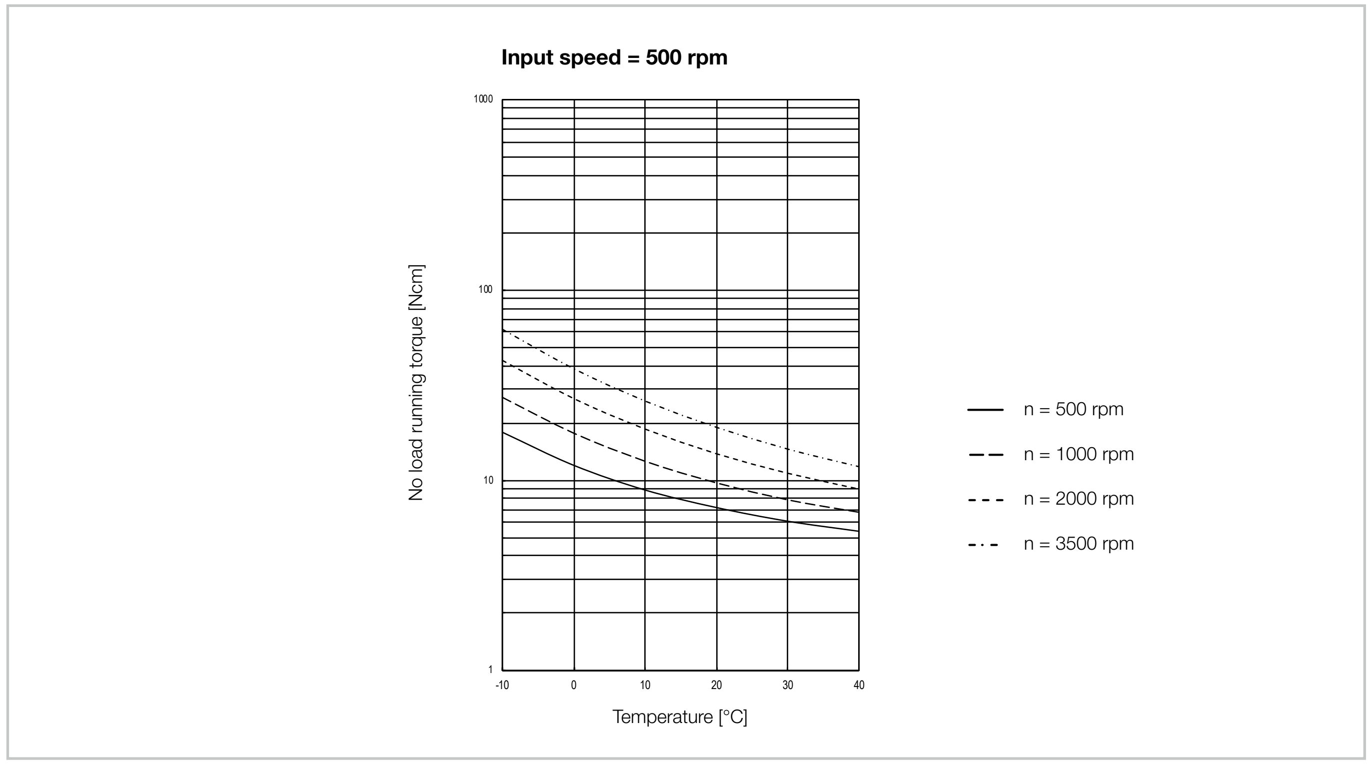


Illustration 1.4.5 **TriSHG-2A**



Compensation values for no load running torque

When using gears with ratios other than i = 100 please apply the compensation values from the table to the values taken from the curves.

Table 1.4.17 **[Ncm]**

Ratio	Size									
	14	17	20	25	32	40	45	50	58	65
30	1.2	2.1	3.1	5.7	11.7	-	-	-	-	-
50	0.5	0.9	1.4	2.5	5.2	9.2	12.7	17.0	25.8	–
80	0.1	0.1	0.2	0.4	0.8	1.4	2.0	2.6	4.0	5.4
120	–	-0.1	-0.2	-0.3	-0.6	-1.0	-1.4	-1.9	-2.9	-4.0
160	–	–	-0.4	-0.7	-1.4	-2.5	-3.5	-4.6	-7.0	-9.7

Efficiency

Efficiency for grease lubrication at rated torque

The diagrams apply to Harmonic Drive® Grease SK-2 (size 14, 17) or SK-1A (size ≥ 20).

Illustration 1.4.6

SHG-/HFUS-2A

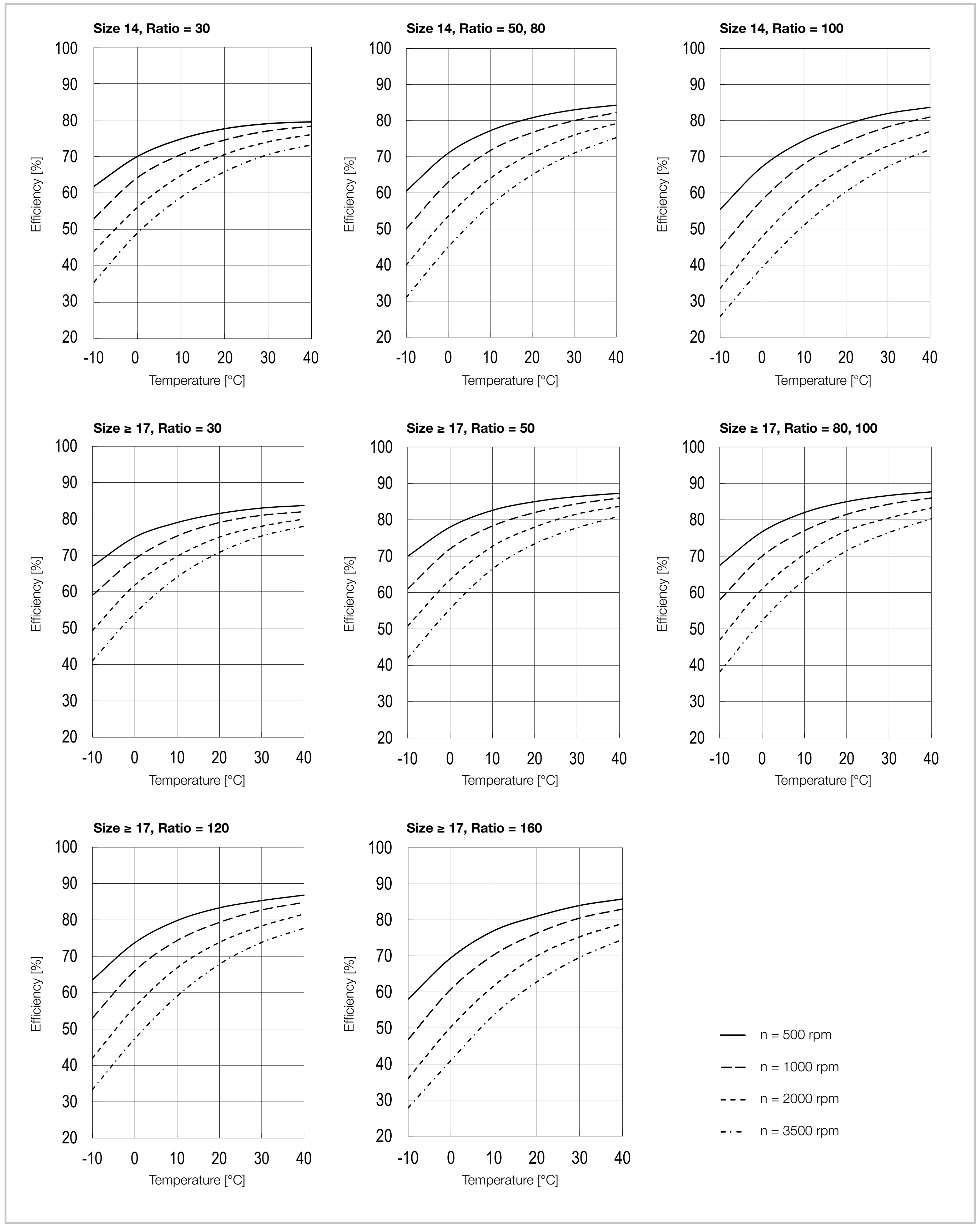
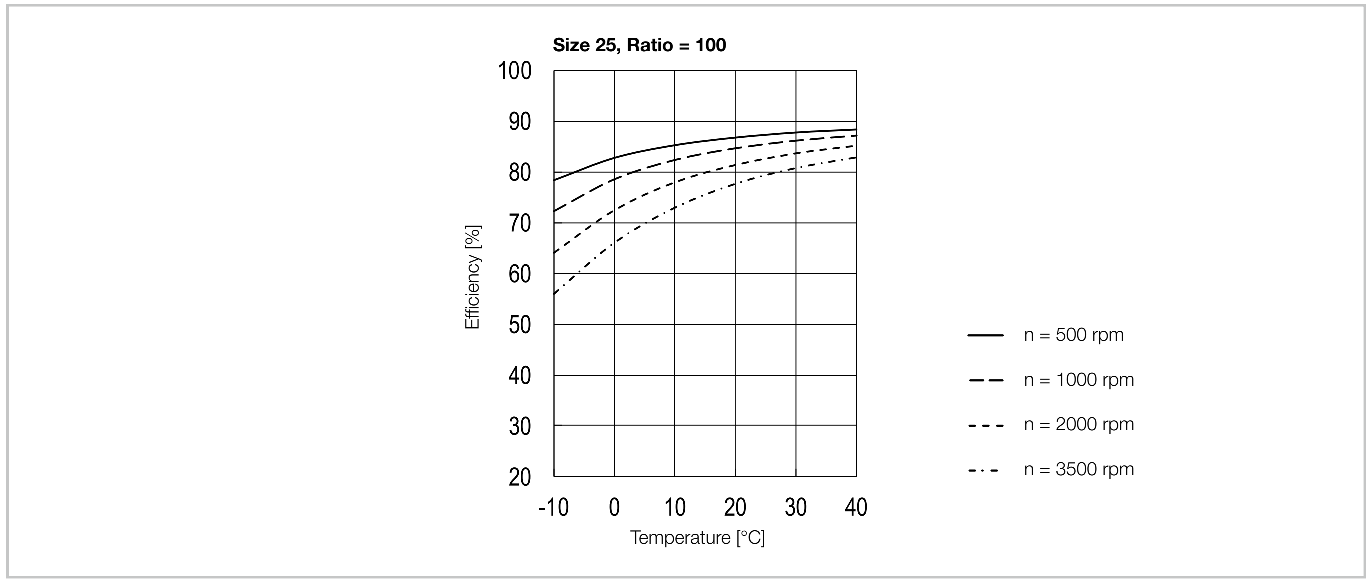


Illustration 1.4.7

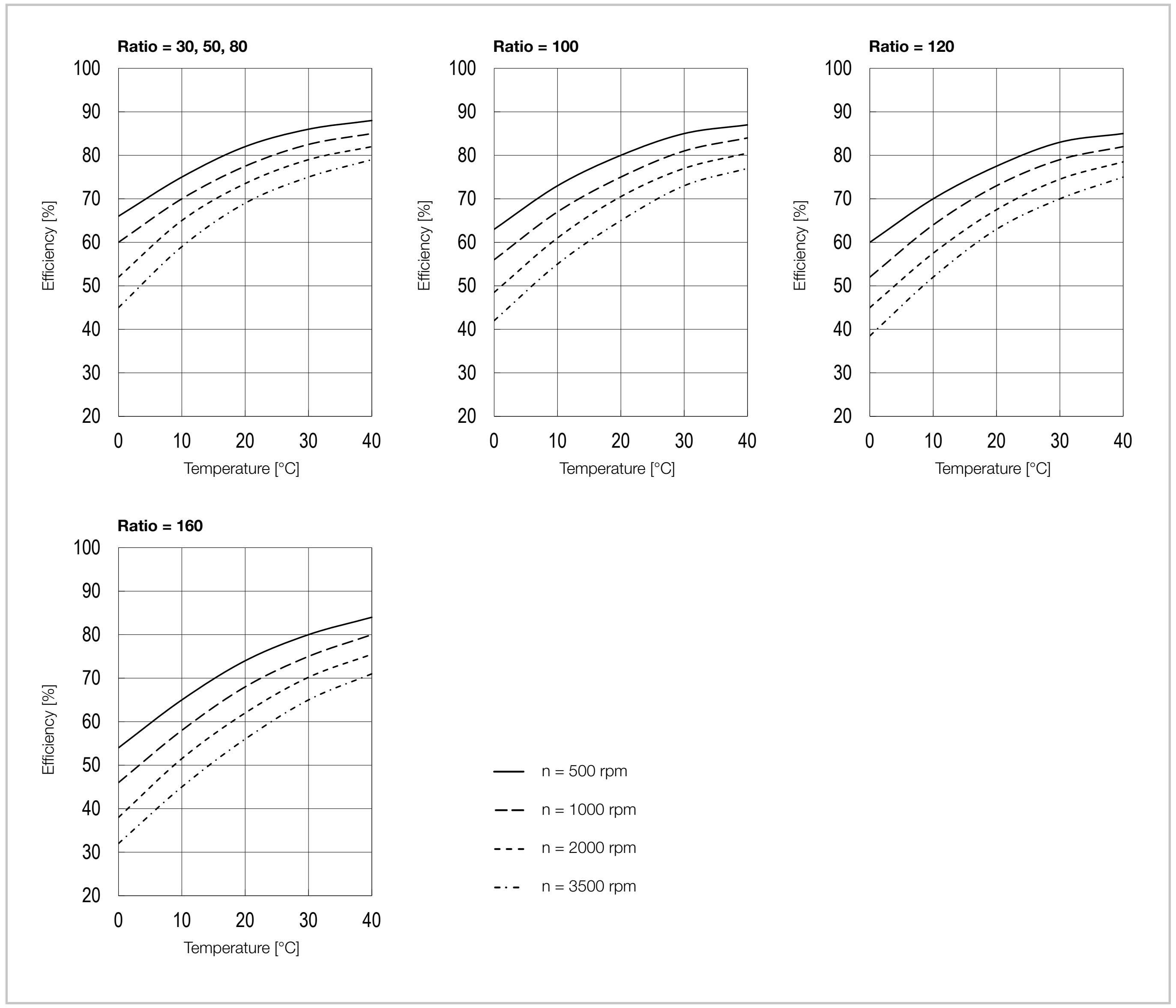
TriSHG-2A



Efficiency for oil lubrication at rated torque

The diagrams apply to mineral oil DEA CLP 68.

Illustration 1.4.8



You will find more information on this in the Engineering data chapter.

Efficiency calculation

The efficiency depends on the following parameters: Gear ratio, input speed, load torque, temperature, lubricant and lubricant quantity. If the load torque is lower than the rated torque, the efficiency will be lower than the efficiency indicated in the efficiency curves. The torque specific efficiency is determined by means of the calculation factor K.

Calculation example

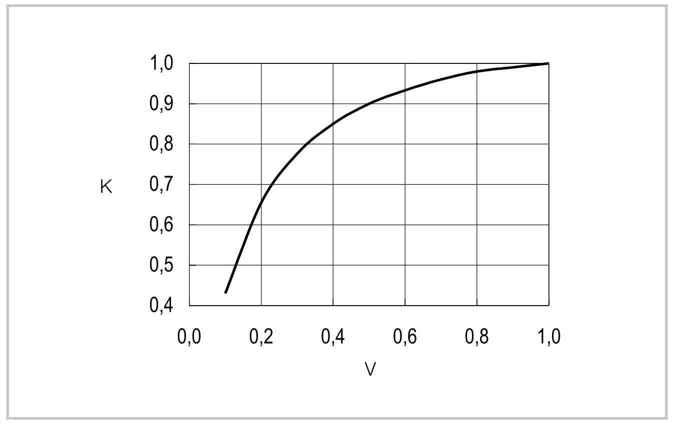
Product: SHG-20-80-2A-GR

- Input speed: 1000 rpm
- (Average) load torque T_{av}: 20 Nm
- Rated torque T_N (catalogue reference): 44 Nm
- Grease lubrication with Harmonic Drive® Grease SK-1A, lubricant temperature: 20 °C.

1. Calculation of the torque factor
   $V = T_{av}/T_N = 20/44 = 0.45$ (For V > 1 is K = 1)
2. Reading the calculation factor K from diagram figure Illustration 1.4.9: K = 0.87
3. Reading the efficiency from the efficiency curve figure Illustration 1.4.6: η = 82 %
4. Calculation of the load dependant efficiency
   $\eta_L = 82\ \% \cdot 0.87 = 71\ \%$

Illustration 1.4.9

Calculation factor K



Design guidelines

- Grease lubrication

To ensure optimum lubrication, the gear housing should be kept compact, for example see Illustration 1.4.10 and Table 1.4.18.

If the gear housing is filled with more than 50 % grease, the risk of leakage increases. Therefore the grease volume/gear housing ratio should be less than 0.5. When installing with a predominantly top or bottom mounted Wave Generator, the gap c should be filled with an additional amount of grease according to Table 1.4.18.

Materials used:

- Circular Spline: Grey cast iron, bright
- Wave Generator, Flexspline: Steel, bright

Illustration 1.4.10

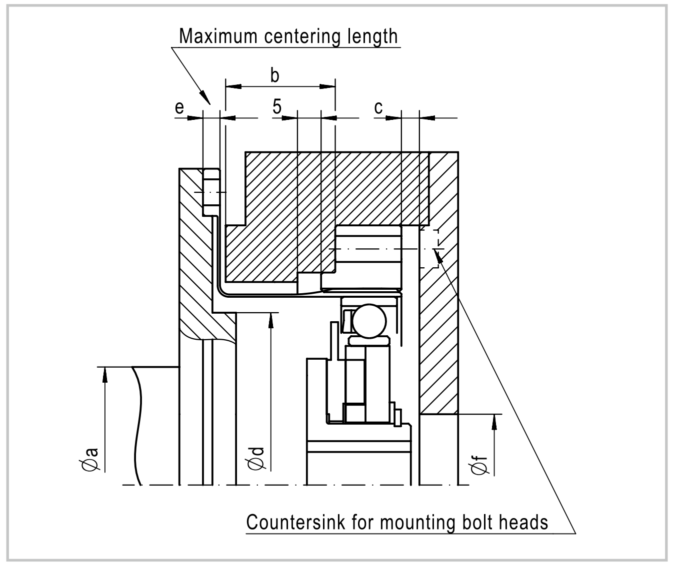


Table 1.4.18 **[mm]**

Symbol	Size									
	14	17	20	25	32	40	45	50	58	65
øa	38	45	53	66	86	106	119	133	154	172
b	14.6	16.4	17.8	19.8	23.2	28.6	31.9	34.2	40.1	43
c[1]	1	1	1.5	1.5	1.5	2	2	2	2.5	2.5
c[2]	3	3	4.5	4.5	4.5	6	6	6	7.5	7.5
ød	31	38	45	56	73	90	101	113	131	150
e	1.7	2.1	2	2	2	2	2.3	2.5	2.9	3.5
øf	16	26	30	37	37	45	45	45	56	62

[1] Axis horizontal or vertical, Wave Generator below
[2] Axis vertical, Wave Generator on top

You will find more information on this in the Engineering data chapter.

Lubrication

Harmonic Drive® Gear Component Sets are supplied without lubricant as standard. Before commissioning they must be lubricated according to the following diagrams.

• Grease lubrication

We recommend the use of the greases listed in Table 1.4.19.

Table 1.4.19

SHG-/HFUS-2A

Ratio	Harmonic Drive® Grease	Size 14	17	20	25	32	40	45 … 58	65
30	Flexolub®-A1 [1]	O	O	O	O	O	-	-	-
	SK-1A	-	-	Δ	Δ	Δ	-	-	-
	SK-2	Δ	Δ	-	-	-	-	-	-
	4BNo.2	□	□	□	□	□	-	-	-
≥50	SK-1A	-	-	O	O	O	O	O	O
	SK-2	O	O	Δ	Δ	Δ	Δ	-	-
	4BNo.2	□	□	□	□	□	□	□	□
	Flexolub®-A1 [1]	Δ	Δ	Δ	Δ	Δ	Δ	Δ	-

Table 1.4.20

TriSHG-2A

Ratio	Harmonic Drive® Grease	Size 25 … 32
100 … 160	Flexolub®-A1 [1]	O
	SK-1A	-
	SK-2	Δ
	4BNo.2	Δ

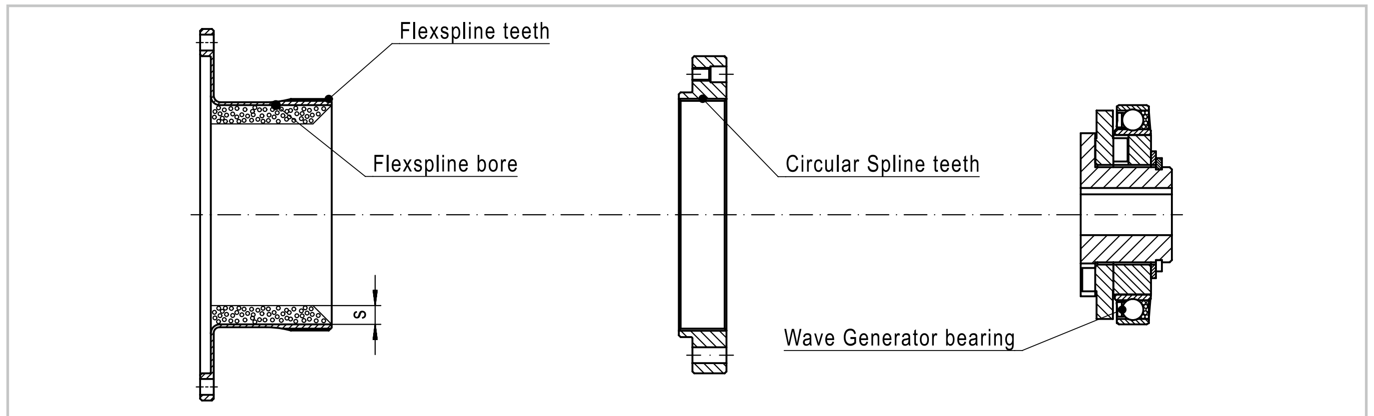
[1] Only for HFUS-2A Series
O Standard grease
□ Recommended for very high loads or very high demands on the service life of the grease
Δ Optional grease, please consult us

ⓘ You will find more information on this in the Engineering data chapter.

The gear component sets must be lubricated in four areas before commissioning, see Illustration 1.4.11.

- Flexspline: Place a grease reservoir all around the inner wall of the flexspline. The dimension „s“ should be approximately the height of the Wave Generator ball bearing.
- Toothing: Fill the gaps between the teeth with grease.
- Wave Generator ball bearings: Apply a generous amount of grease to the area of the bearing balls and bearing cage.

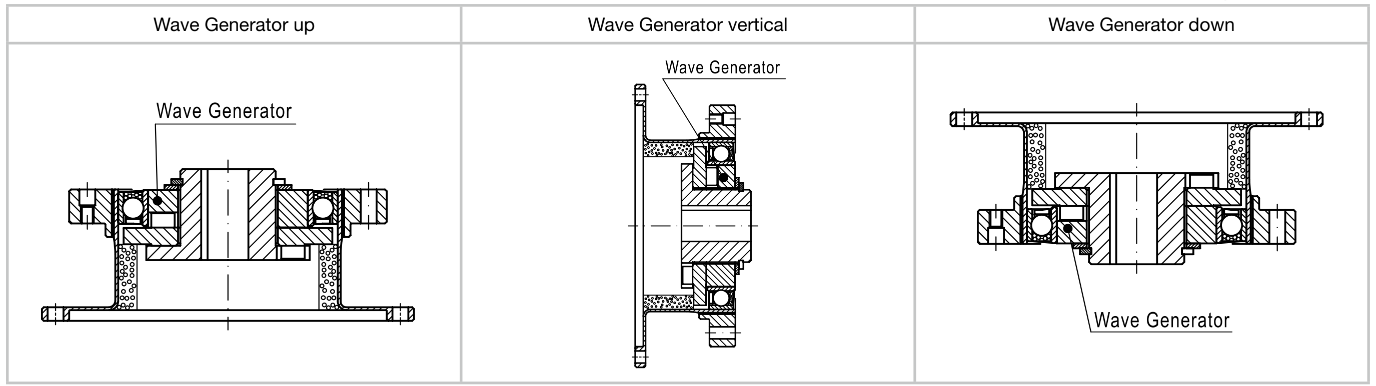
Illustration 1.4.11



The required grease quantity depends not only on the size but also on the operating position of the gear. The operating positions „Wave Generator up“ and „Wave Generator down“ defined in the text below refer to the relative position of the Wave Generator to the Flexspline flange, see Illustration 1.4.12.

Illustration 1.4.12

Operating position



In case of predominant use with the Wave Generator on top or on the bottom, additional grease is required, see Illustration 1.4.13 and Table 1.4.21.

Illustration 1.4.13

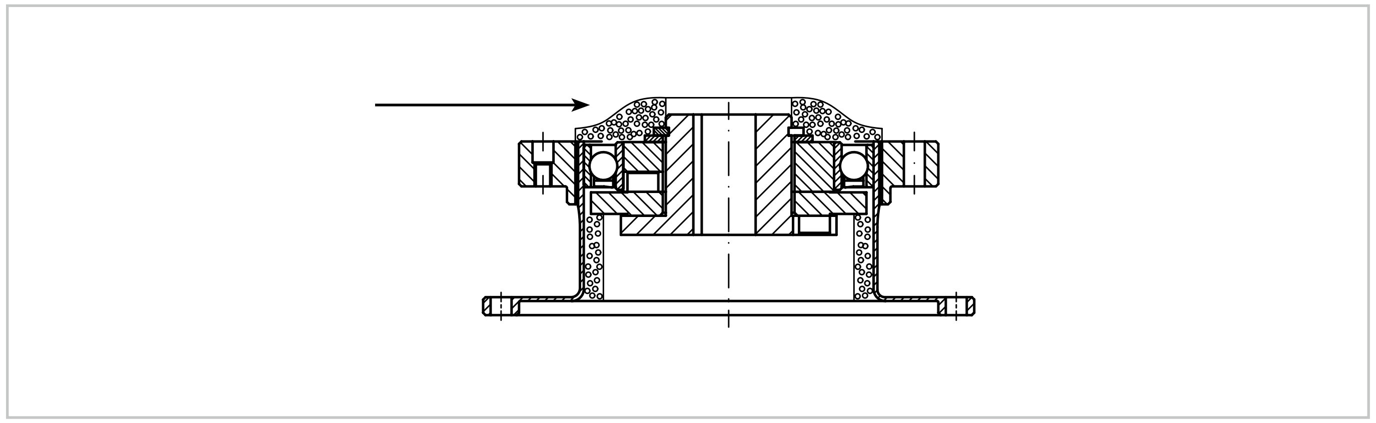


Table 1.4.21

Grease quantity [g]

		Size 14	17	20	25	32	40	45	50	58	65
Mounting position	Wave Generator vertical	5.8	11.0	18.0	32.0	64.0	120.0	185.0	235.0	385.0	495.0
	Wave Generator down	7.5	13.0	19.0	37.0	74.0	130.0	200.0	255.0	400.0	530.0
	Wave Generator up	8.9	15.0	22.0	42.0	84.0	150.0	230.0	290.0	480.0	630.0

• Oil lubrication

Oil lubrication is possible for Harmonic Drive® SHG-2A/HFUS-2A Gear Component Sets. A separate lubrication space must be provided. Illustration 1.4.14 and Table 1.4.22 show recommended oil levels for horizontal and vertical mounting positions.

Illustration 1.4.14

Operating position

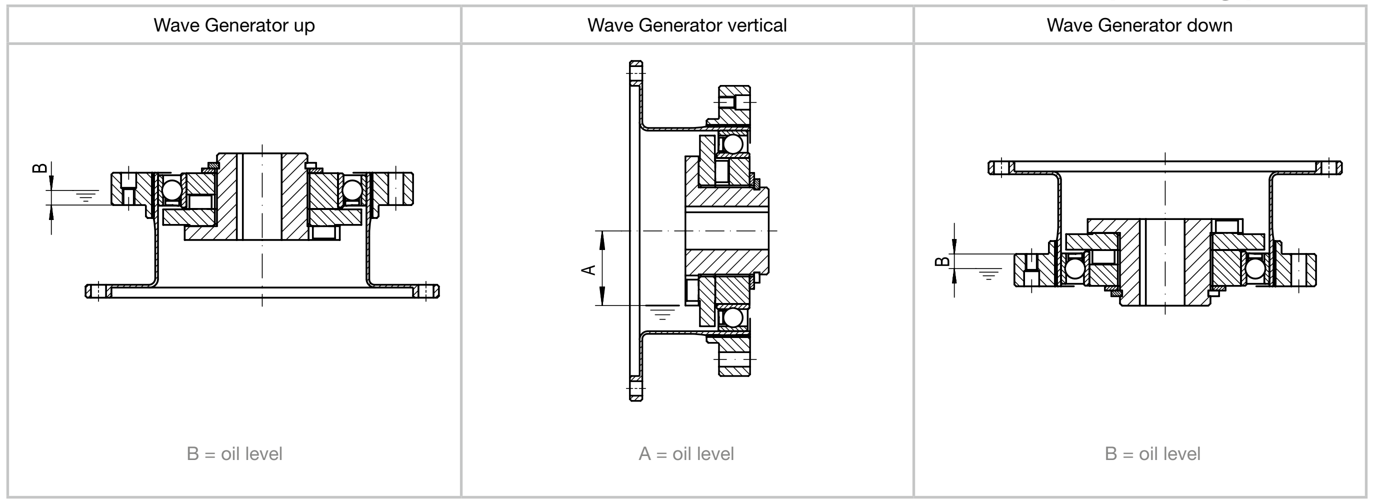


Table 1.4.22

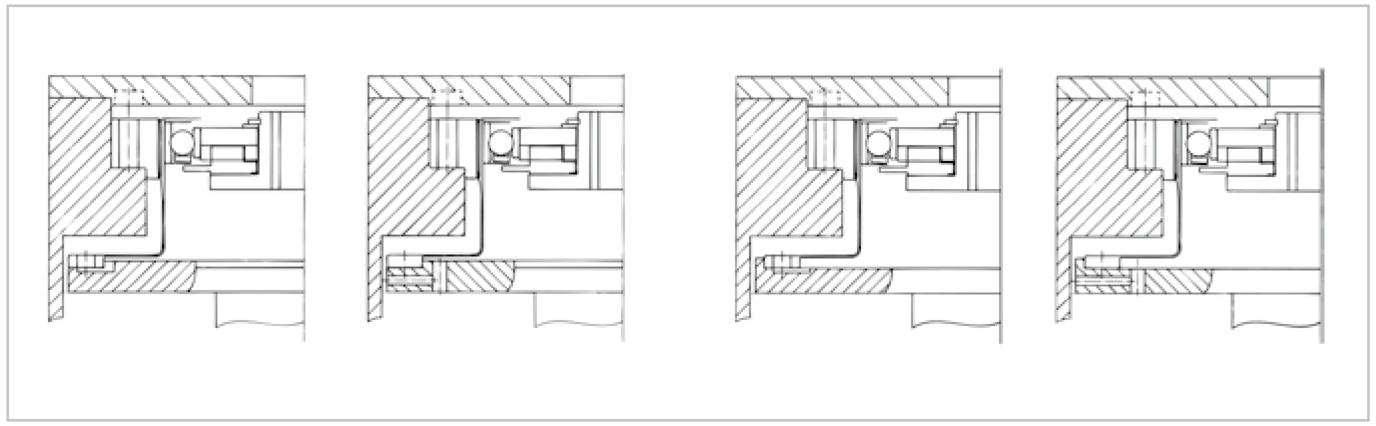
Oil levels [mm]

	Size									
	14	17	20	25	32	40	45	50	58	65
A	10	12	14	17	24	31	35	38	44	50
B	2.5	3.0	3.0	5.0	7.0	9.0	10.0	12.0	13.0	15.0

Lube holes

In the case of a vertical axis with an overhead Wave Generator, design measures must be taken to ensure that the oil thrown out of the Flexspline by the Wave Generator can flow back again. This can be achieved by connecting the two oil areas by means of lube holes in the Flexspline flange. Exemplary construction see Illustration 1.4.15. Please contact Harmonic Drive SE.

Illustration 1.4.15



Assembly tolerances

We recommend observing the following tolerances during assembly:

Illustration 1.4.16

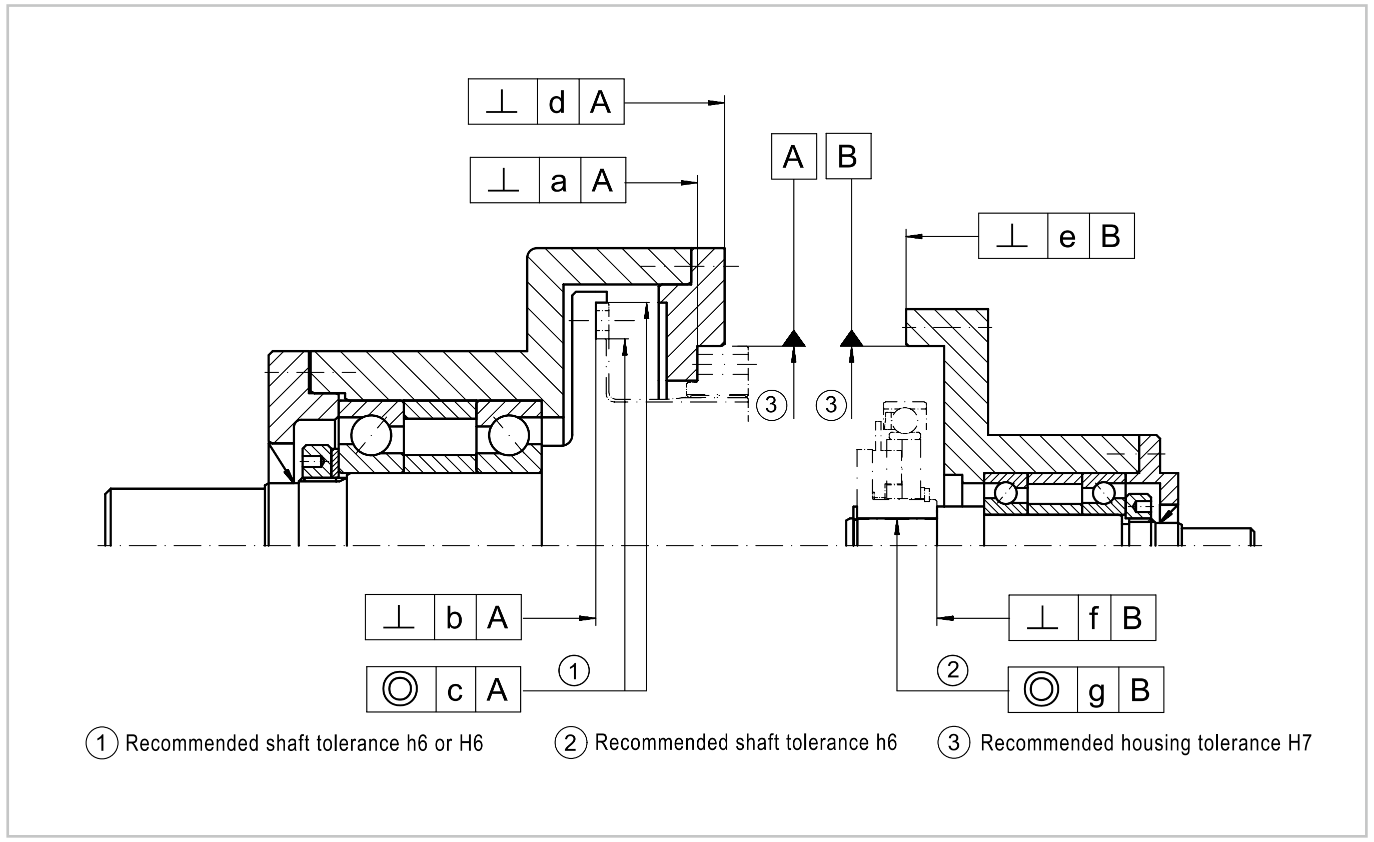


Table 1.4.23

[mm]

Symbol	Size									
	14	17	20	25	32	40	45	50	58	65
a	0.011	0.012	0.013	0.014	0.016	0.016	0.017	0.018	0.020	0.023
b	0.016	0.021	0.024	0.035	0.042	0.048	0.053	0.057	0.062	0.035
c	0.015	0.018	0.019	0.022	0.022	0.024	0.027	0.030	0.032	0.035
d	0.011	0.015	0.017	0.024	0.026	0.026	0.027	0.028	0.031	0.034
e	0.011	0.015	0.017	0.024	0.026	0.026	0.027	0.028	0.031	0.034
f	0.017 (0.008)	0.020 (0.010)	0.024 (0.012)	0.024 (0.012)	0.024 (0.012)	0.032 (0.012)	0.032 (0.013)	0.032 (0.015)	0.032 (0.015)	0.032 (0.015)
g	0.030 (0.016)	0.034 (0.018)	0.044 (0.019)	0.047 (0.022)	0.050 (0.022)	0.063 (0.024)	0.065 (0.027)	0.066 (0.030)	0.068 (0.033)	0.070 (0.035)

The values in brackets are recommended tolerances for a Wave Generator without Oldham coupling. This coupling is used to compensate for eccentricity errors of the motor shaft and is installed in the standard gear. If the Wave Generator is mounted directly on the motor shaft without Oldham coupling (option), the motor shaft tolerances should comply with DIN 42955 R.

Assembly

• Assembly of the Flexspline

When mounting the Flexspline, care must be taken that bolt heads, washers, pins or nuts do not hinder the deformation of the Flexspline, otherwise the proper functioning of the gear cannot be guaranteed and failure may occur.

Therefore, the fastening elements must not protrude into the area marked by the dimension ø D, see Illustration 1.4.17, Illustration 1.4.18 and Table 1.4.24.

Illustration 1.4.17

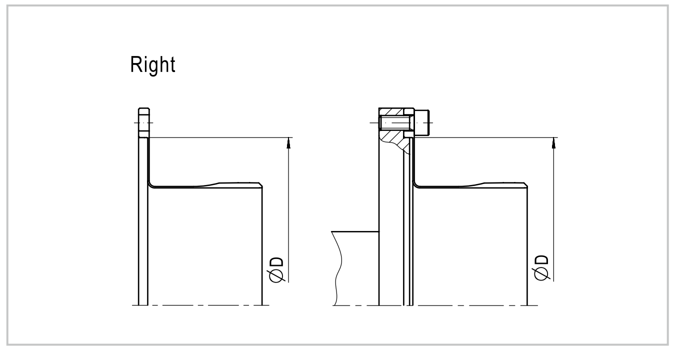


Illustration 1.4.18

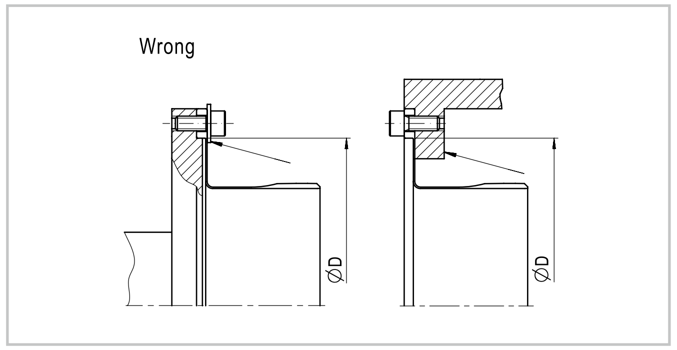


Table 1.4.24

Symbol	Size									
	14	17	20	25	32	40	45	50	58	65
ø D	48	60	70	88	114	140	158	175	203	232

Screws Flexspline (SHG-2A Series)

Table 1.4.25

	[Unit]	Size									
		14	17	20	25	32	40	45	50	58	65
Number of screws		8	12	12	12	12	12	18	12	16	16
Size of screws		M3	M3	M3	M4	M5	M6	M6	M8	M8	M10
Pitch circle diameter	[mm]	54	66	76	96	124	152	180	200	226	258
Screw tightening torque	[Nm]	2.4	2.4	2.4	5.4	10.8	18.4	18.4	44.0	44.0	74.0
Torque transmitting capacity	[Nm]	108	198	228	486	1000	1740	3098	4163	6272	9546

12.9 quality screws, friction coefficient μ=0,15.

Screws Flexspline (HFUS-2A Series)

Table 1.4.26

	[Unit]	Size						
		14	17	20	25	32	50	58
Number of screws		8	12	12	12	12	12	16
Size of screws		M3	M3	M3	M4	M5	M8	M8
Pitch circle diameter	[mm]	54	66	76	96	124	190	218
Screw tightening torque	[Nm]	2.0	2.0	2.0	4.5	9.0	37.0	37.0
Torque transmitting capacity	[Nm]	88	157	186	402	843	3312	5076

12.9 quality screws, friction coefficient μ=0,15.

• Assembly of the Circular Spline

Screws Circular Spline (SHG-2A Series)

Table 1.4.27

	[Unit]	Size									
		14	17	20	25	32	40	45	50	58	65
Number of screws		8	16	16	16	16	16	16	16	16	16
Size of screws		M3	M3	M3	M4	M5	M6	M8	M8	M10	M10
Pitch circle diameter	[mm]	44	54	62	75	100	120	140	150	175	195
Screw tightening torque	[Nm]	2.0	2.0	2.0	4.5	9.0	15.3	37.0	37.0	74.0	74.0
Torque transmitting capacity	[Nm]	72	175	196	419	901	1530	3238	3469	6475	7215

Screws Circular Spline (HFUS-2A Series)

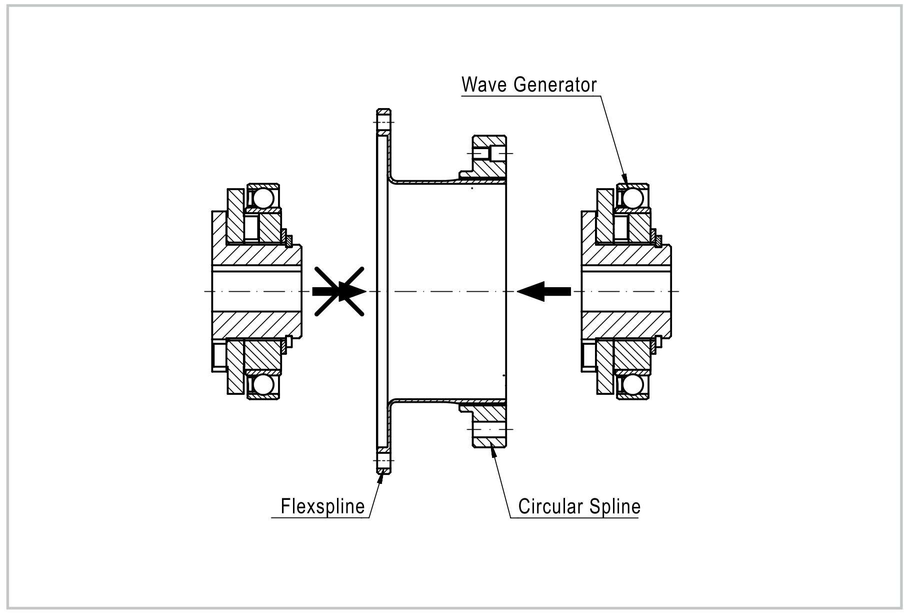
Table 1.4.28

	[Unit]	Size						
		14	17	20	25	32	50	58
Number of screws		6	12	12	12	12	12	12
Size of screws		M3	M3	M3	M4	M5	M8	M10
Pitch circle diameter	[mm]	44	54	62	75	100	150	175
Screw tightening torque	[Nm]	2.0	2.0	2.0	4.5	9.0	37.0	74.0
Torque transmitting capacity	[Nm]	54	131	147	314	676	2620	4820

• Assembly of the Wave Generator

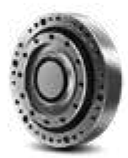
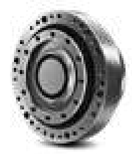
The Wave Generator must be mounted in the direction of the arrow, see Illustration 1.4.19. When mounting, the axial mounting dimension (relative axial position to Flexspline flange "B", Table 1.4.7) must be considered.

Illustration 1.4.19



You will find more information on this in the Engineering data chapter.

Harmonic Drive® Gears with output bearing

Series	CSG-2UH/ HFUC-2UH	CSF-ULW	CPU-M	CPU-H		CPU-S	CSG-CPM	CSG-CPH	CSG-CPS	CSD-2UH
										
Type	M	M	M	CH		S	M	CH	S	M
Torque capacity and service life	•••/••	••	••	••		••	•••	•••	•••	•
Transmission accuracy	•••	•••	•••	•••		•••	•••	•••	•••	•••
Small outer diameter	••	••	•	•		•	•	•	•	••
Short design	••	•••	••	•		•	••	•	•	•••
Tilting moment output bearing	••	••	•••	•••		•••	•••	•••	•••	••
Low weight	••	•••	•	•		•	•	•	•	•••
Chapter / Page	2.1 / 104	2.2 / 124	2.3 / 136	2.3 / 136		2.3 / 136	2.4 / 166	2.4 / 166	2.4 / 166	2.5 / 198
Key data										
Maximum torque [Nm]	9 … 6840	1.8 … 92	9 … 1840	9 … 1840		9 … 1840	34 … 586	34 … 586	34 … 586	12 … 823
Tilting moment output bearing [Nm]	41 … 4210	2.9 … 18.9	73 … 2222	73 … 2222		73 … 2222	114 … 886	114 … 886	114 … 886	41 … 759
Hollow shaft diameter [mm]	-	3 … 19	-	14 … 70		-	-	19 … 46	-	-
Configurations										
Sizes	14 … 90	8 … 20	14 … 58	14 … 58		14 … 58	17 … 40	17 … 40	17 … 40	14 … 50
Ratio	30 … 160	30 … 160	30 … 160	30 … 160		30 … 160	50 … 160	50 … 160	50 … 160	50 … 160

Series	CSD-2UF	SHG-2UH/ HFUS-2UH	SHG-2SH/ HFUS-2SH	SHG-2SO/ HFUS-2SO		SHD-2SH	CSF Mini (different versions)	PMG	CSF-2UP	FBS-2UH
										
Type	M	CH	OH	M		M	M/S	M/S	M	CH
Torque capacity and service life	•	•••/••	•••/••	•••/••		•	••	•	••	•
Transmission accuracy	•••	•••	•••	•••		•••	•••	••	•••	••
Small outer diameter	•	•	•	•		••	•••	•••	••	••
Short design	•••	•	••	••		•••	•••	•	•••	•
Tilting moment output bearing	•••	•••	•••	•••		••	•	•	•••	••
Low weight	•••	•	••	••		•••	•••	•••	••	•
Chapter / Page	2.5 / 198	2.6 / 216	2.6 / 216	2.6 / 216		2.7 / 246	2.8 / 260	2.9 / 282	2.10 / 292	2.11 / 304
Key data										
Maximum torque [Nm]	12 … 453	9 … 3419	9 … 3419	9 … 3419		12 … 453	0.09 … 28	0.3 … 14.7	1.8 … 28	25 … 106
Tilting moment output bearing [Nm]	91 … 849	74 … 2740	74 … 2740	74 … 2740		37 … 424	0.27 … 13.2	-	15 … 75	93 … 129
Hollow shaft diameter [mm]	9 … 37	14 … 80	14 … 80	-		11 … 40	-	-	-	41.0 … 55.1
Configurations										
Sizes	14 … 40	14 … 65	14 … 65	14 … 65		14 … 40	3 … 14	5 … 14	8 … 14	25, 32
Ratio	50 … 160	30 … 160	30 … 160	30 … 160		50 … 160	30 … 100	50 … 110	30 … 100	30 … 100

Description:
Type: Gear with output bearing
M Motor mounting gear
OH Open hollow shaft gear
CH Closed hollow shaft gear
S Input shaft gear

••• perfect •• optimal • good

Content

Content

Product description

Highest torque capacity and lifelong precision

The CSG-2UH Series Gears with output bearing are characterised by maximum torque capacity and service life with a small outer diameter as well as lifelong precision and freedom from backlash. The gears with output bearing of the HFUC-2UH Series complement the available CSG sizes and ratios with a slightly lower service life in comparison.

By using aluminum in the area of the gear housing, the lightweight version (LW) weighs 30 % less and is therefore ideally suited for weight optimised applications. It is available in the CSG and HFUC Series with unchanged performance data.

In addition to the proven strain wave gear technology, CSG-2UH Series is also available in Triangle Technology. Setting new standards in torsional stiffness, transmission accuracy and dynamics.

Features:

- Highest torque capacity
- Outstanding lifelong precision with zero backlash
- Long lifetime
- Large torque range
- Integrated precision cross roller bearing

Ordering code

Table 2.1.1

Ordering code	CSG	-	20	-	100	-	2UH	-	LW	-	SP
Series	CSG HFUC										
Size (corresponds to the pitch circle diameter of the Flexspline toothing in inches x 10)			14 17 20 25 32 40 45 50 58 65 80 90								
Ratio (in drive configuration: Circular Spline (CS) fixed, Wave Generator (WG) input, Flexspline (FS) output)					30 50 80 100 120 160						
Version Gears for motor mounting							2UH				
Option Lightweight construction Standard design (field remains empty) Lightweight version									[ ] LW		
Customised design Standard design (field remains empty) Special design (on request)											[ ] SP

Please refer to the table of possible combinations.

Combinations

Table 2.1.2

CSG-2UH/2UH-LW

		Size									
		14	17	20	25	32	40	45	50	58	65
Ratio	30	-	-	-	-	-	-	-	-	-	-
	50	●	●	●	●	●	●	●	-	-	-
	80	●	●	●	●	●	●	●	●	●	●
	100	●	●	●	●	●	●	●	●	●	●
	120	-	●	●	●	●	●	●	●	●	●
	160	-	-	●	●	●	●	●	●	●	●

Table 2.1.3

HFUC-2UH/CSF-2UH-LW

		Size											
		14	17	20	25	32	40	45	50	58	65	80[1]	90[1]
Ratio	30	●	●	●	●	●	-	-	-	-	-	-	-
	50	-	-	-	-	-	-	-	●	●	●	●	●
	80	-	-	-	-	-	-	-	-	-	-	●	●
	100	-	-	-	-	-	-	-	-	-	-	●	●
	120	-	-	-	-	-	-	-	-	-	-	●	●
	160	-	-	-	-	-	-	-	-	-	-	●	●

● available o on request - not available

1) Only available in the standard version HFUC-2UH.

Technical data

• Performance data

Table 2.1.4

Series	Size	Ratio	Limit for repeated peak torque	Limit for average torque	Rated torque at rated speed 2000 rpm	Limit for momentary peak torque	Max. input speed [rpm]	Limit for average input speed [rpm]	Moment of inertia	Weight	
			T_R [Nm]	T_A [Nm]	T_N [Nm]	T_M [Nm]	Lubrication Grease	Lubrication Grease	[kgm^2]	[kg] 2UH	[kg] 2UH-LW
HFUC	14	30	9,0	6,8	4,0	17,0	8500	3500	0.033×10^{-4}	0.52	0.32
CSG	14	50	23	9	7	46					
	14	80	30	14	10	58[2]					
	14	100	36	14	10	58[2]					
HFUC	17	30	16,0	12,0	8,8	30,0	7300	3500	0.079×10^{-4}	0.68	0.46
CSG	17	50	44	34	21	91					
	17	80	56	35	29	109[2]					
	17	100	70	51	31	109[2]					
	17	120	70	51	31	109[2]					
HFUC	20	30	27	20	15	50	6500	3500	0.193×10^{-4}	0.98	0.64
CSG	20	50	73	44	33	127					
	20	80	96	61	44	165					
	20	100	107	64	52	191					
	20	120	113	64	52	191					
	20	160	120	64	52	191					
HFUC	25	30	50	38	27	95	5600	3500	0.413×10^{-4}	1.50	1.10
CSG	25	50	127	72	51	242					
	25	80	178	113	82	332					
	25	100	204	140	87	369					
	25	120	217	140	87	395 (382)[3]					
	25	160	229	140	87	408 (382)[3]					
HFUC	32	30	100	75	54	200	4800	3500	1.690×10^{-4}	3.20	2.20
CSG	32	50	281	140	99	497					
	32	80	395	217	153	738					
	32	100	433	281	178	841					
	32	120	459	281	178	892					
	32	160	484	281	178	892					
CSG	40	50	523	255	178	892	4000	3000	4.500×10^{-4}	5.00	3.50
	40	80	675	369	268	1270					
	40	100	738	484	345	1400					
	40	120	802	586	382	1530 (1488)[3]					
	40	160	841	586	382	1530 (1488)[3]					
CSG	45	50	650	345	229	1235	3800	3000	8.680×10^{-4}	7.00	5.10
	45	80	918	507	407	1651					
	45	100	982	650	459	2041					
	45	120	1070	806	523	2288					
	45	160	1147	819	523	2483					
HFUC	50	50[1]	715	175	122	1430	3500	2500	12.50×10^{-4}	8.90	7.00
CSG	50	80	1223	675	484	2418					
	50	100	1274	866	611	2678					
	50	120	1404	1057	688	2678					
	50	160	1534	1096	688	3185					
HFUC	58	50[1]	1020	260	176	1960	3000	2200	27.30×10^{-4}	14.60	11.30
CSG	58	80	1924	1001	714	3185					
	58	100	2067	1378	905	4134					
	58	120	2236	1547	969	4329					
	58	160	2392	1573	969	4459					
HFUC	65	50[1]	1420	360	245	2830	2800	1900	46.80×10^{-4}	20.90	16.20
CSG	65	80	2743	1352	969	4836					
	65	100	2990	1976	1236	6175					
	65	120	3263	2041	1236	6175					
	65	160	3419	2041	1236	6175					
HFUC	80	50[1]	2440	630	436	4870	2300	1500	122.0×10^{-4}	30.80	-
	80	80	3430	1830	1320	6590					
	80	100	4220	2360	1700	7910					
	80	120	4590	3130	1990	7910					
	80	160	4910	3130	1990	7910					
HFUC	90	50[1]	3530	860	590	6660	2000	1300	214.0×10^{-4}	42.50	-
	90	80	3990	2510	1550	7250					
	90	100	5680	3360	2270	9020					
	90	120	6160	4300	2570	9800					
	90	160	6840	4300	2700	11300					

1) With special design of the gearbox with oil lubrication a higher average torque T_{av} and Rated torque T_N are possible.
2) The collision torque is limited by the transmittable torque of the screw connection.
3) The values in brackets are valid for the CSG-LW version. The collision torque is limited by the transmittable torque of the screw connection.

You will find more information on this in the Engineering data chapter.

• Dimensions

Illustration 2.1.1

CSG-14-2UH/2UH-LW … CSG-58-2UH/2UH-LW [mm]

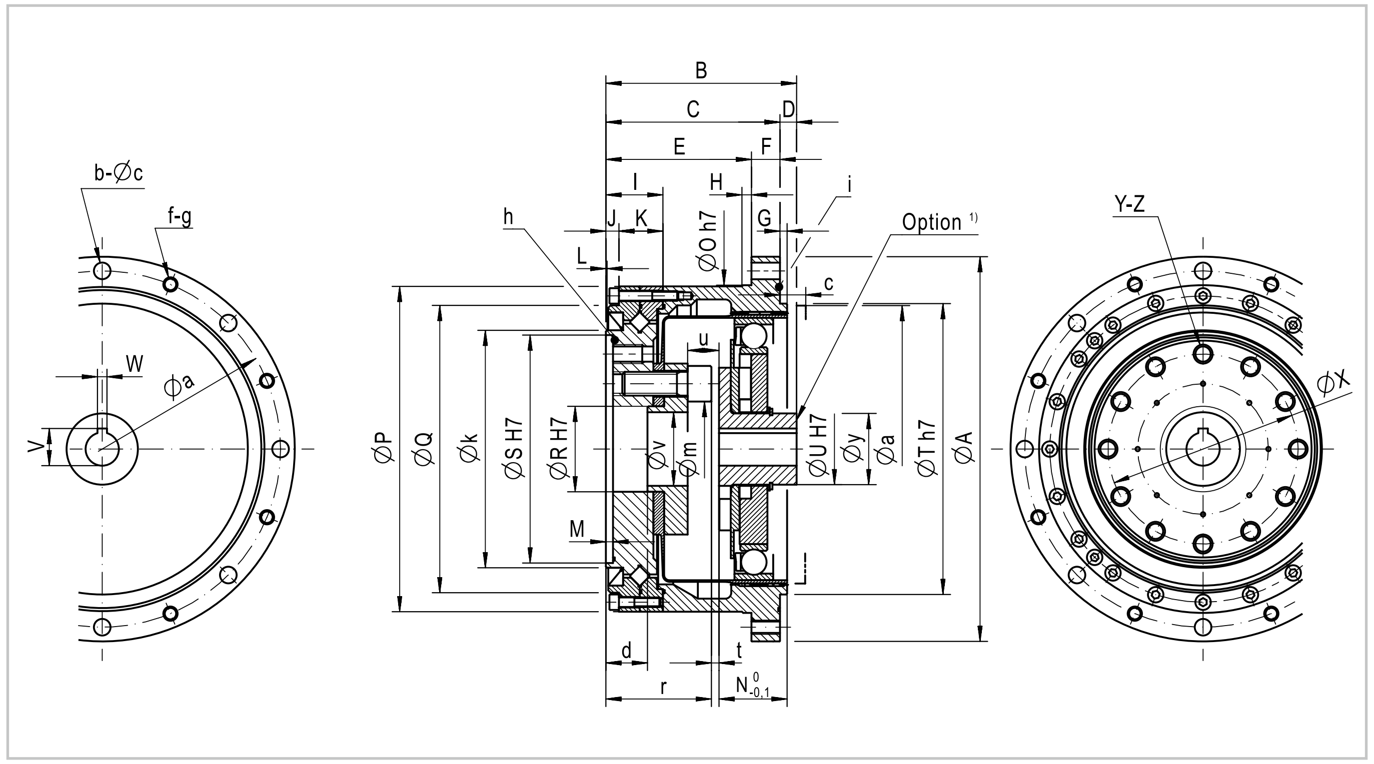
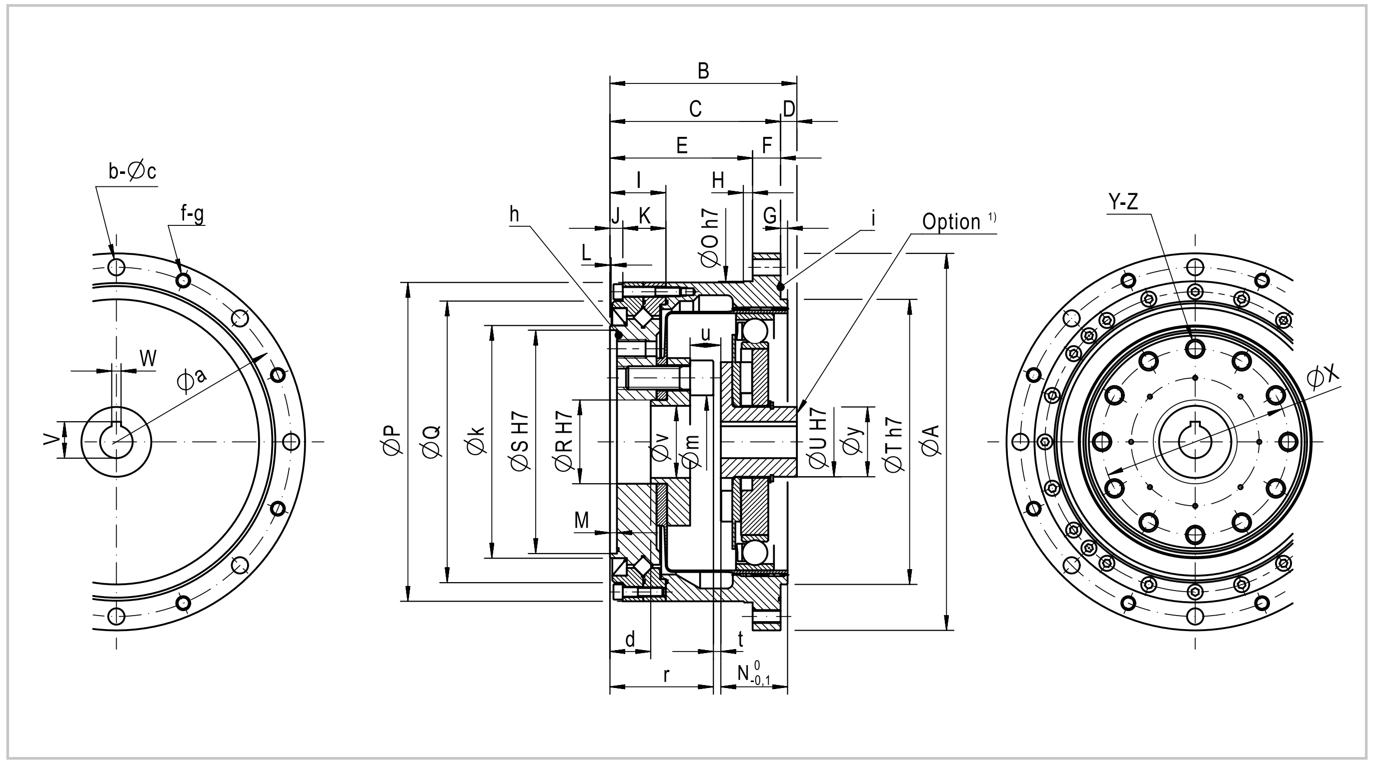


Illustration 2.1.2

CSG-65-2UH/2UH-LW [mm]



1) Hub without keyway or with other diameter see chapter „ Engineering data“.

CAD drawings for download: www.harmonicdrive.co.uk

Table 2.1.5

CSG-2UH/2UH-LW [mm]

Symbol		Size									
		14	17	20	25	32	40	45	50	58	65
ØA		73	79	93	107	138	160	180	190	226	260
B		$41.0^{0}_{-0.4}$	$45.0^{0}_{-0.4}$	$45.5^{0}_{-0.4}$	$52.0^{0}_{-0.5}$	$62.0^{0}_{-0.6}$	$72.5^{0}_{-0.6}$	$79.5^{0}_{-0.6}$	$90.0^{0}_{-0.6}$	$104.5^{0}_{-0.6}$	$115.0^{0}_{-0.6}$
C		34.0	37.0	38.0	46.0	57.0	66.5	74.0	85.0	97.0	108.5
D		7.0	8.0	7.5	6.0	5.0	6.0	5.5	5.0	7.5	6.5
E		27.0	29.0	28.0	36.0	45.0	50.5	58.0	69.0	77.0	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	3.5	4.0	5.0	5.0	5.0	5.0	6.0	6.0	6.0	6.0
	CSG-LW	4	4	5	5	5	5	6	6	6	6
I		16.5	16.5	16.5	18.5	22.5	24.0	27.0	31.0	35.0	39.0
J		4.5	4.5	4.0	4.5	5.5	7.5	7.0	8.0	8.5	8.5
K		12.0	12.0	12.5	14.0	17.0	16.5	20.0	23.0	26.5	30.5
L	CSG	0.5	0.5	0.5	0.5	1.0	1.5	1.0	1.0	1.5	1.5
	CSG-LW	1.1	1.1	1.1	1.1	1.2	1.6	1.6	1.0	1.5	1.5
M		9.4	9.5	9.0	12.0	15.0	5.0	6.0	8.0	10.0	4.0
$N^{0}_{-0,1}$		18.5	20.7	21.5	21.6	23.6	29.7	30.5	34.8	38.3	44.6
ØO h7		56	63	72	86	113	127	148	158	186	212
ØP	CSG	56	62	70	85	112	123	147	157	185	210
	CSG-LW	54.6	61.6	69.6	85.0	110.0	124.5	143.0	155.0	183.4	208.4
ØQ	CSG	42.5	49.5	58.0	73.0	96.0	109.0	127.0	137.0	161.0	186.0
	CSG-LW	40.5	47.5	55.5	71.0	91.1	103	123	130	155	180
ØR H7		11	10	14	20	26	32	32	40	46	52
ØS H7		-	-	-	-	-	-	-	-	-	142
ØT h7		38	48	56	67	90	110	124	135	156	177
ØU 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
ØX		23	27	32	42	55	68	82	84	100	110
Y		6	6	8	8	8	8	8	8	8	8
Z		M4x8	M5x10	M6x9	M8x12	M10x15	M10x15	M12x18	M14x21	M16x24	M16x24
Øa		65	71	82	96	125	144	164	174	206	236
b	CSG	8	8	8	10	12	10	12	14	12	8
	CSG-LW	6	8	8	10	12	10	16	18	16	12
Øc		4.5	4.5	5.5	5.5	6.6	9.0	9.0	9.0	11.0	14.0
d		-	-	-	-	-	-	-	-	-	10
f	CSG	8	8	8	10	12	10	12	14	12	8
	CSG-LW	6	8	8	10	12	10	16	18	16	12
g		M4	M4	M5	M5	M6	M8	M8	M8	M10	M12
h (O ring)		29.00x0.50	34.50x0.80	40.64x1.14	53.28x0.99	70.50x2.00	82.27x1.78	99.50x2.00	104.5x2.00	124.5x2.00	134.5x2.00
i (O ring)		49.5x2.0	55.5x2.0	66.5x2.0	79.5x2.0	104.5x2.0	124.5x2.0	144.5x2.0	154.5x2.0	179.5x2.0	204.5x2.0
Øk		31	38	45	58	78	90	107	112	135	155
Øm		10.0	10.5	15.5	20.0	27.0	34.0	36.0	39.0	46.0	56.0
r		21.4	23.5	23.0	29.0	37.0	39.5	45.5	53.0	62.8	66.5
t		1.1	0.8	1.0	1.4	1.4	3.3	3.5	2.2	3.4	3.9
u		5.1	5.8	6.0	7.4	9.4	13.3	15.5	16.2	19.4	19.9
Øv		8	7	10	15	20	24	25	32	38	44
Øy		14	18	21	26	26	32	32	32	40	48

Wave Generator Details

Illustration 2.1.3

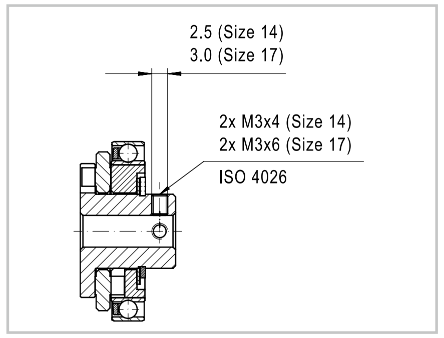
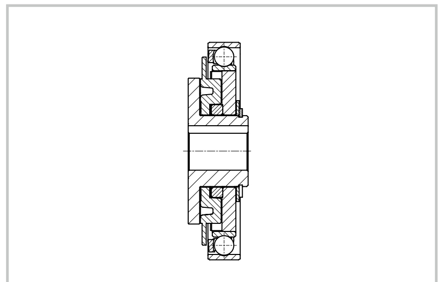
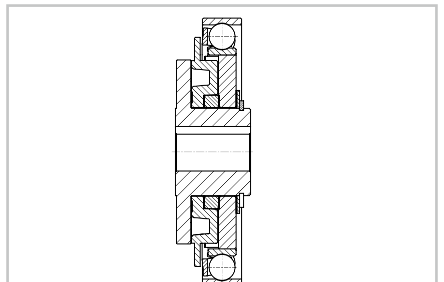


Illustration 2.1.4



Wave Generator for CSG sizes 20, 25, 32, 45, 58

Illustration 2.1.5



Wave Generator for CSG sizes 40, 50, 65

2.1 CSG-2UH/HFUC-2UH

Illustration 2.1.6

HFUC-14-2UH/CSF-2UH-LW … HFUC-58-2UH/CSF-2UH-LW

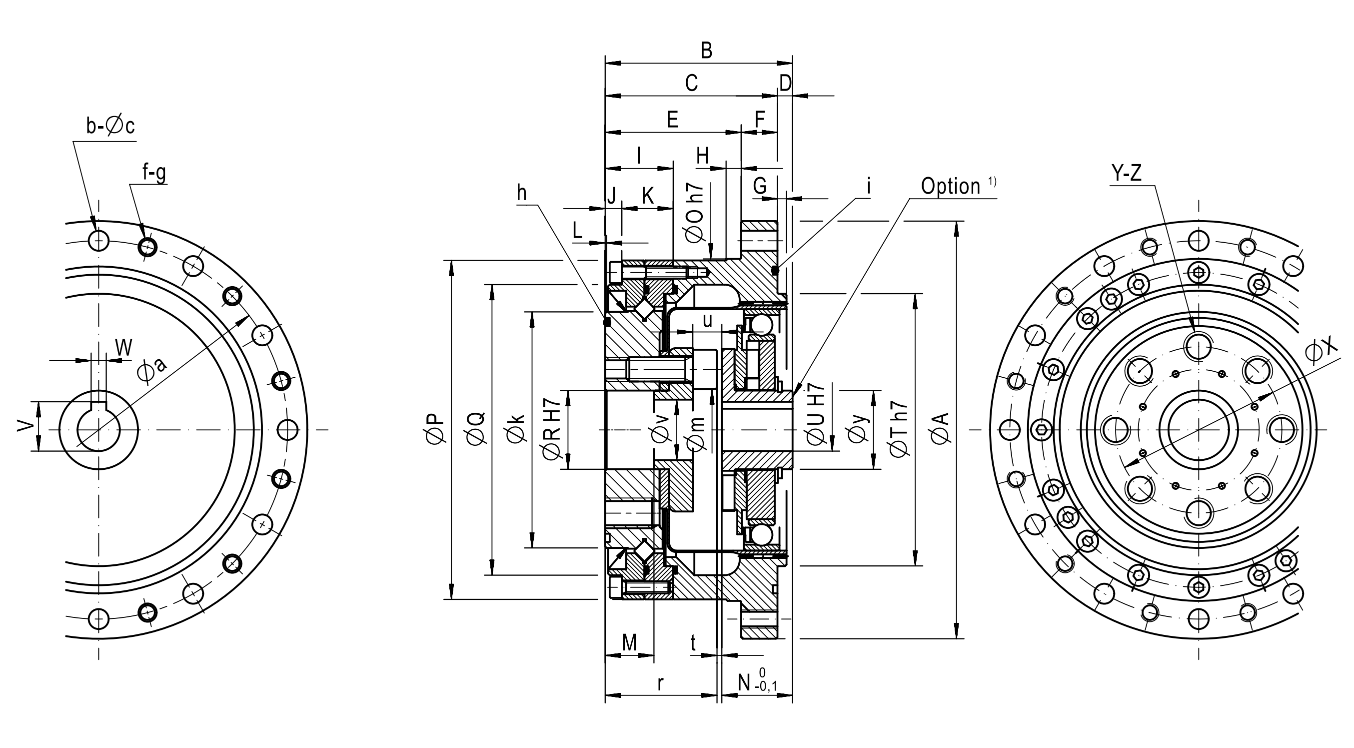
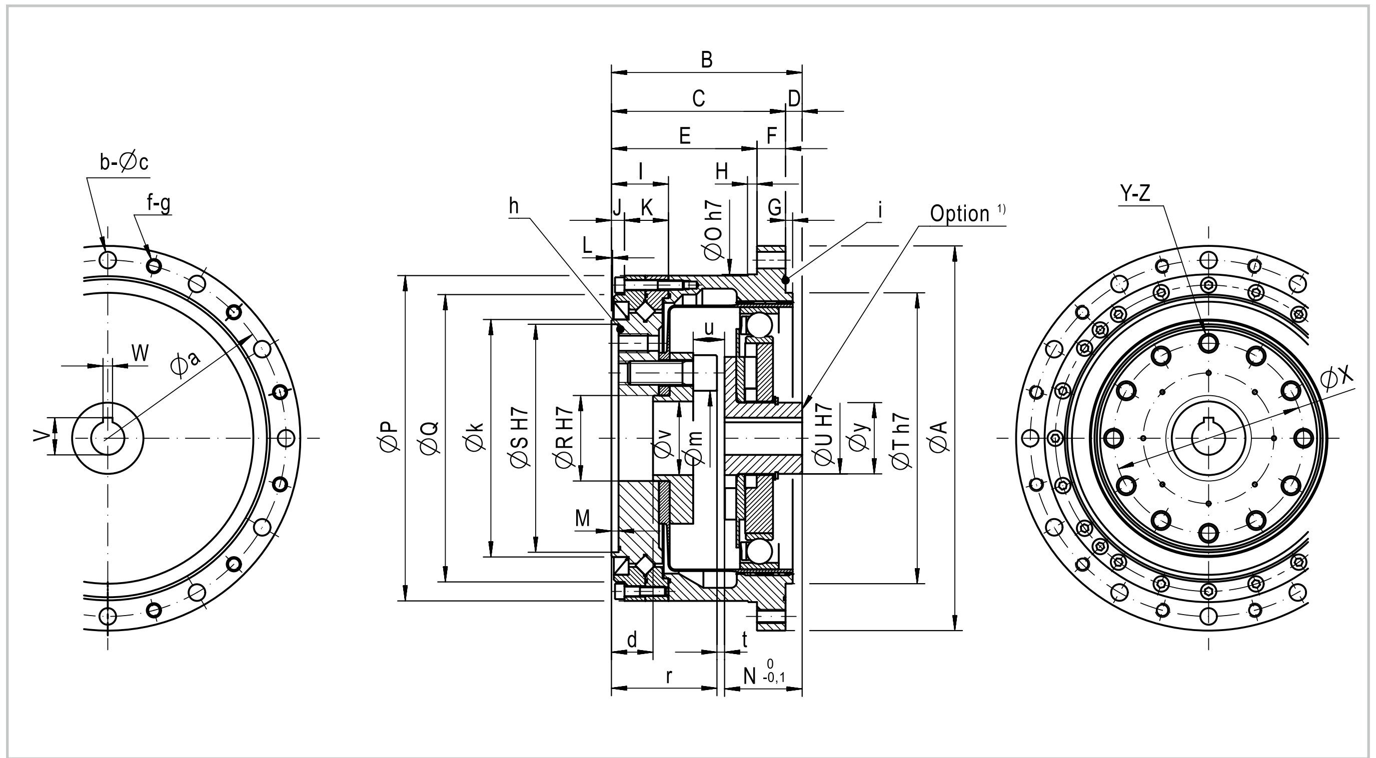


Illustration 2.1.7

HFUC-65-2UH/CSF-65-2UH-LW … HFUC-90-2UH



1) Hub without keyway or with other diameter see chapter „ Engineering data".

CAD drawings for download: www.harmonicdrive.co.uk

Table 2.1.6

HFUC-2UH/CSF-2UH-LW [mm]

Symbol		Size											
		14	17	20	25	32	40	45	50	58	65	80	90
ØA		73	79	93	107	138	-	-	190	226	260	294	324
B		$41.0^{0}_{-0.9}$	$45.0^{0}_{-0.9}$	$45.5^{0}_{-1.0}$	$52.0^{0}_{-1.0}$	$62.0^{0}_{-1.1}$	-	-	$90.0^{0}_{-1.3}$	$104.5^{0}_{-1.3}$	$115.0^{0}_{-1.3}$	$137.0^{0}_{-1.3}$	$152.5^{0}_{-1.3}$
C		34.0	37.0	38.0	46.0	57.0	-	-	85.0	97.0	108.5	130.0	146.5
D		7.0	8.0	7.5	6.0	5.0	-	-	5.0	7.5	6.5	7.0	6.0
E		27.0	29.0	28.0	36.0	45.0	-	-	69.0	77.0	84.5	106.0	122.5
F		7	8	10	10	12	-	-	16	20	24	24	24
G		2	2	3	3	3	-	-	4	5	5	6	6
H	HFUC	3.5	4.0	5.0	5.0	5.0	-	-	6.0	6.0	6.0	8.0	8.0
	HFUC-LW	4	4	5	5	5	-	-	6	6	6	-	-
I		16.5	16.5	16.5	18.5	22.5	-	-	31.0	35.0	39.0	45.0	48.0
J		4.5	4.5	4.0	4.5	5.5	-	-	8.0	8.5	8.5	12.0	11.0
K		12.0	12.0	12.5	14.0	17.0	-	-	23.0	26.5	30.5	33.0	37.0
L	HFUC	0.5	1.1	1.1	1.1	1.2	-	-	1.0	1.5	1.5	2.0	2.0
	HFUC-LW	1.1	1.1	1.1	1.1	1.2	-	-	1.0	1.5	1.5	-	-
M		9.4	9.5	9.0	12.0	15.0	-	-	8.0	10.0	4.0	6.0	6.0
$N^{0}_{-0,1}$		17.6	19.5	20.1	20.2	22.0	-	-	32.0	34.9	40.9	49.1	48.2
ØO h7		56	63	72	86	113	-	-	158	186	212	248	276
ØP	HFUC	55	62	70	85	112	-	-	157	185	210	246	274
	HFUC-LW	54.6	61.6	69.6	85.0	110.0	-	-	155.0	183.4	208.4	-	-
ØQ	HFUC	42.5	49.5	58.0	73.0	96.0	-	-	137.0	161.0	186.0	212.0	242.0
	HFUC-LW	40.5	47.5	55.5	71.0	91.1	-	-	130.0	155.0	180.0	-	-
ØR H7		11	10	14	20	26	-	-	40	46	52	80	72
ØS H7		-	-	-	-	-	-	-	-	-	142	168	192
ØT h7	i ≥ 50	38	48	56	67	90	-	-	135	156	177	218	245
	i = 30	38	48	56	68	90	-	-	-	-	-	-	-
ØU H7		6	8	12	14	14	-	-	19	22	24	28	28
V		-	-	$13.8^{+0.1}_{0}$	$16.3^{+0.1}_{0}$	$16.3^{+0.1}_{0}$	-	-	$21.8^{+0.1}_{0}$	$24.8^{+0.1}_{0}$	$27.3^{+0.2}_{0}$	$31.3^{+0.2}_{0}$	$31.3^{+0.2}_{0}$
W JS9		-	-	4	5	5	-	-	6	6	8	8	8
ØX		23	27	32	42	55	-	-	84	100	110	135	160
Y		6	6	8	8	8	-	-	8	8	8	12	12
Z		M4x8	M5x10	M6x9	M8x12	M10x15	-	-	M14x21	M16x24	M16x24	M16x24	M16x24
Øa		65	71	82	96	125	-	-	174	206	236	270	300
b	HFUC	6	6	6	8	12	-	-	12	12	8	12	12
	HFUC-LW	6	8	8	10	12	-	-	18	16	12	-	-
Øc		4.5	4.5	5.5	5.5	6.6	-	-	9.0	11.0	14.0	14.0	14.0
d		-	-	-	-	-	-	-	-	-	10	12	35
f	HFUC	6	6	6	8	12	-	-	12	12	8	12	12
	HFUC-LW	6	8	8	10	12	-	-	18	16	12	-	-
g		M4	M4	M5	M5	M6	-	-	M8	M10	M12	M12	M12
h (O ring)		29.00x0.50	34.50x0.80	40.64x1.14	53.28x0.99	70.50x2.00	-	-	104.5x2.00	124.5x2.00	134.5x2.00	159.5x2.70	184.5x2.70
i (O ring)		49.5x2.0	55.5x2.0	66.5x2.0	79.5x2.0	104.5x2.0	-	-	154.5x2.0	179.5x2.0	204.5x2.0	234.5x2.7	267.5x2.7
Øk		31	38	45	58	78	-	-	112	135	155	180	200
Øm		10.0	10.5	15.5	20.0	27.0	-	-	39.0	46.0	56.0	81.0	80.0
r		21.4	23.5	23.0	29.0	37.0	-	-	53.0	62.8	66.5	75.0	89.0
t		2.0	2.0	2.4	2.8	3.0	-	-	5.0	6.8	7.6	12.9	15.3
u		6.0	7.0	7.4	8.8	11.0	-	-	19.0	22.8	23.6	28.9	35.3
Øv		8	7	10	15	20	-	-	32	38	44	55	62
Øy		14	18	21	26	26	-	-	32	40	48	55	60

Wave Generator Details

Illustration 2.1.8

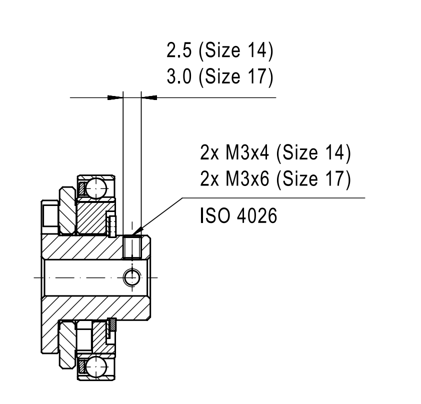
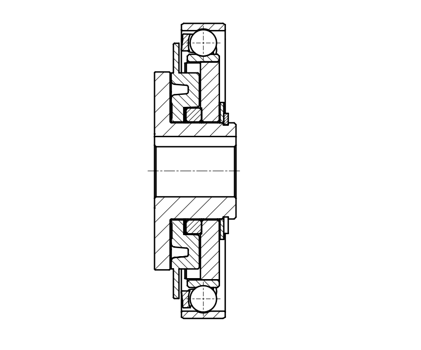
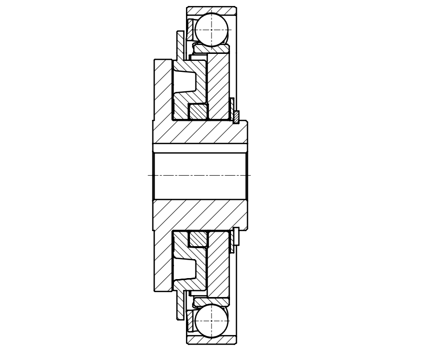


Illustration 2.1.9



Wave Generator for HFUC
sizes 20, 25, 32, 45, 58, 90

Illustration 2.1.10



Wave Generator for HFUC
sizes 40, 50, 65, 80

• Accuracy

Table 2.1.7 **[arcmin]**

	Size																
	14			17			20			25			32			40 ... 90	
Ratio	30	50	≥80	30	50	≥80	30	50	≥80	30	50	≥80	30	50	≥80	50	≥80
Transmission accuracy	<2.0	<1.5		<1.5			<1.5	<1.0		<1.5	<1.0		<1.5	<1.0		<1.0	
Hysteresis loss	<3.0	<2.0	<1.0	<3.0	<2.0	<1.0	<3.0	<2.0	<1.0	<3.0	<2.0	<1.0	<3.0	<2.0	<1.0	<2.0	<1.0
Lost motion	< 1																
Repeatability	< ± 0.1																

• Accuracy of the Oldham coupling

Harmonic Drive® Gears are zero backlash. If an Oldham coupling is used, a small backlash in the range of a few seconds of arc occurs outside the tooth engagement, see Table 2.1.8. This small amount of backlash does not occur with a Solid Wave Generator.

Table 2.1.8 **[arcsec]**

Ratio	Series	Size 8	11	14	17	20	25	32	40	45	50	58	65	80	90
30	HFUC	59	49	60	33	28	28	23	-	-	-	-	-	-	-
50	CSG	-	-	36	20	17	17	14	14	12	-	-	-	-	-
	HFUC	35	24	-	-	-	-	-	-	-	12	10	10	10	8
80	CSG	-	-	23	13	11	11	9	9	8	8	6	6	-	-
	HFUC	-	-	-	-	-	-	-	-	-	-	-	-	5	5
100	CSG	-	-	18	10	9	9	7	7	6	6	5	5	-	-
	HFUC	18	15	-	-	-	-	-	-	-	-	-	-	5	4
120	CSG	-	-	-	8	8	8	6	6	5	5	4	4	-	-
	HFUC	-	-	-	-	-	-	-	-	-	-	-	-	4	3
160	CSG	-	-	-	-	6	6	5	5	4	4	3	3	-	-
	HFUC	-	-	-	-	-	-	-	-	-	-	-	-	3	2

You will find more information on this in the Engineering data chapter.

• Torsional stiffness

Table 2.1.9

	Symbol [Unit]	Size 14	17	20	25	32	40	45	50	58	65	80	90
Limit torques	T_1 [Nm]	0.2	3.9	7.0	14	29	54	76	108	168	235	430	618
	T_2 [Nm]	6.9	12.0	25	48	108	196	275	382	598	843	1570	2260
i = 30	K_3 [x 10^4 Nm/rad]	0.34	0.67	1.10	2.10	4.90	-	-	-	-	-	-	-
	K_2 [x 10^4 Nm/rad]	0.24	0.44	0.71	1.30	3.00	-	-	-	-	-	-	-
	K_1 [x 10^4 Nm/rad]	0.19	0.34	0.57	1.00	2.40	-	-	-	-	-	-	-
i = 50	K_3 [x 10^4 Nm/rad]	0.57	1.30	2.30	4.40	9.80	18	26	34	54	78	145	206
	K_2 [x 10^4 Nm/rad]	0.47	1.10	1.80	3.40	7.80	14	20	28	44	61	115	162
	K_1 [x 10^4 Nm/rad]	0.34	0.81	1.30	2.50	5.40	10	15	20	31	44	81	118
i ≥ 80	K_3 [x 10^4 Nm/rad]	0.71	1.60	2.90	5.70	12.00	23	33	44	71	98	185	263
	K_2 [x 10^4 Nm/rad]	0.61	1.40	2.50	5.00	11.00	20	29	40	61	88	162	230
	K_1 [x 10^4 Nm/rad]	0.47	1.00	1.60	3.10	6.70	13	18	25	40	54	100	145

• No load starting torque

Illustration 2.1.11 **[Ncm]**

Ratio	Series	Size 14	17	20	25	32	40	45	50	58	65	80	90
30	HFUC	6.4	9.3	15	25	54	-	-	-	-	-	-	-
50	CSG	4.5	6.7	8.6	17	34	61	85	-	-	-	-	-
	HFUC	-	-	-	-	-	-	-	110	160	220	360	500
80	CSG	3.1	4.4	5.4	10	21	39	54	73	108	154	-	-
	HFUC	-	-	-	-	-	-	-	-	-	-	230	320
100	CSG	2.8	3.7	4.7	8.8	20	34	47	64	97	132	-	-
	HFUC	-	-	-	-	-	-	-	-	-	-	200	280
120	CSG	-	3.4	4.2	8.0	17	31	43	57	88	121	-	-
	HFUC	-	-	-	-	-	-	-	-	-	-	190	250
160	CSG	-	-	3.6	6.9	15	26	36	50	75	102	-	-
	HFUC	-	-	-	-	-	-	-	-	-	-	155	220

• No load back driving torque

Illustration 2.1.12 **[Nm]**

Ratio	Series	Size 14	17	20	25	32	40	45	50	58	65	80	90
30	HFUC	2.4	3.8	6.2	11	23	-	-	-	-	-	-	-
50	CSG	1.8	3.3	5.2	9.9	20	36	52	-	-	-	-	-
	HFUC	-	-	-	-	-	-	-	62	95	130	220	300
80	CSG	1.8	3.3	5.3	10	21	36	53	69	106	154	-	-
	HFUC	-	-	-	-	-	-	-	-	-	-	220	300
100	CSG	2.0	3.6	5.6	11	22	40	56	75	121	165	-	-
	HFUC	-	-	-	-	-	-	-	-	-	-	230	330
120	CSG	-	3.9	6.1	12	24	43	61	80	121	176	-	-
	HFUC	-	-	-	-	-	-	-	-	-	-	250	350
160	CSG	-	-	7.0	14	29	51	70	94	143	198	-	-
	HFUC	-	-	-	-	-	-	-	-	-	-	300	410

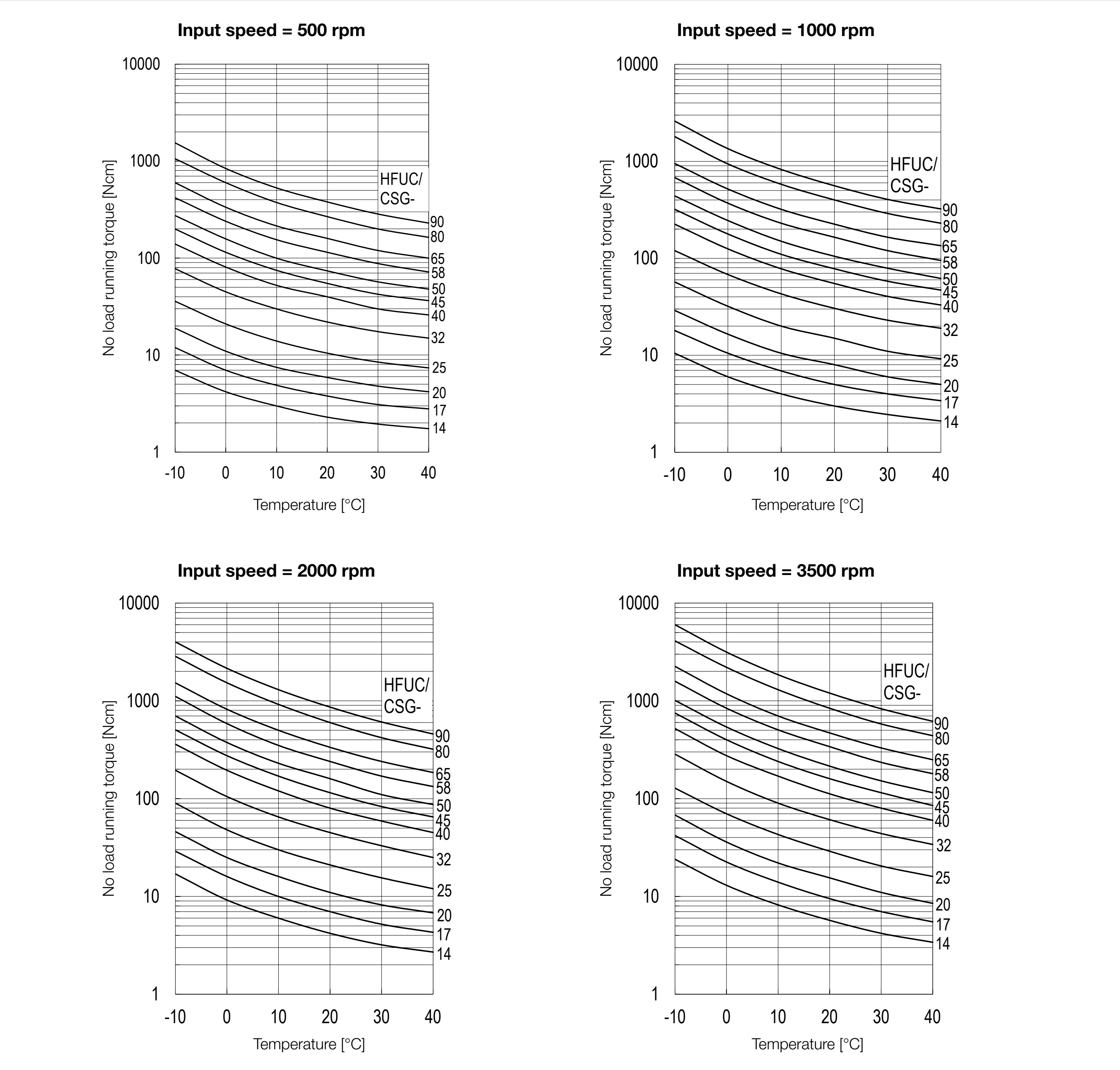
You will find more information on this in the Engineering data chapter.

No load running torque

The diagrams apply to Harmonic Drive® Grease SK-2 (size 14, 17) and SK-1A (size ≥ 20).

Illustration 2.1.13

CSG-2UH/HFUC-2UH/CSF-2UH-LW



Compensation values for no load running torque

Table 2.1.10

[Ncm]

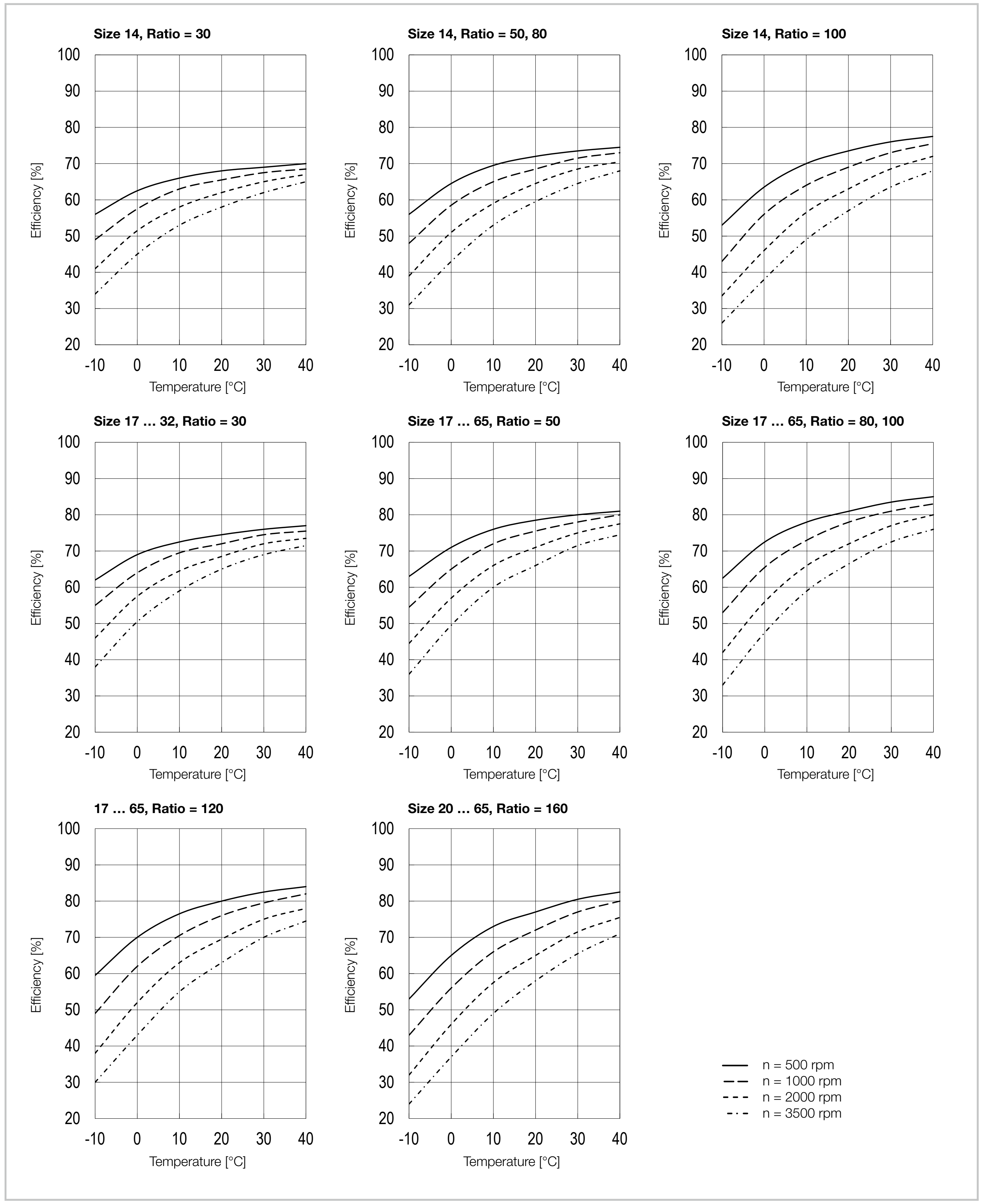
Ratio	Size											
	14	17	20	25	32	40	45	50	58	65	80	90
30	2.5	3.8	5.4	8.8	16.0	-	-	-	-	-	-	-
50	1.1	1.6	2.3	3.8	7.1	12.0	16.0	21.0	30.0	41.0	67.0	91.0
80	0.2	0.3	0.5	0.7	1.3	2.1	2.9	3.7	5.3	7.2	12.0	17.0
120	-	-0.2	-0.3	-0.5	-0.9	-1.5	-2.1	-2.6	-3.8	-5.1	-8.0	-12.0
160	-	-	-0.8	-1.2	-2.2	-3.5	-4.9	-6.2	-8.9	-12.0	-21.0	-30.0

Efficiency

Efficiency for grease lubrication at rated torque

The diagrams apply to Harmonic Drive® Grease SK-2 (size 14, 17) and SK-1A (size ≥ 20).

Illustration 2.1.14

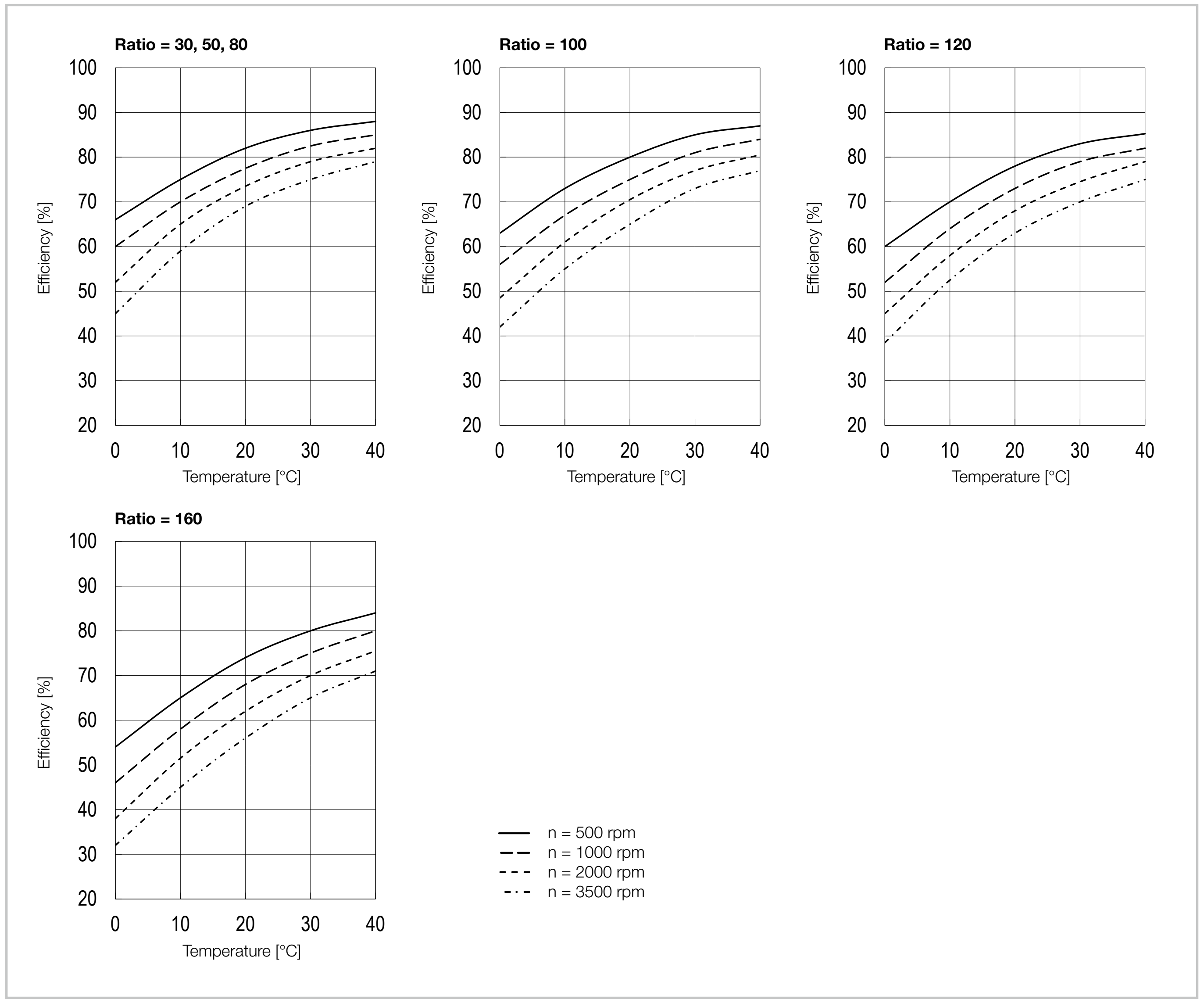


You will find more information on this in the Engineering data chapter.

Efficiency for oil lubrication at rated torque

The diagrams apply to mineral oil DEA CLP 68.

Illustration 2.1.15



You will find more information on this in the Engineering data chapter.

Efficiency calculation

The efficiency depends on the following parameters: Gear ratio, input speed, load torque, temperature, lubricant and lubricant quantity. If the load torque is lower than the rated torque, the efficiency will be lower than the efficiency indicated in the efficiency curves. The torque specific efficiency is determined by means of the calculation factor K.

Calculation example

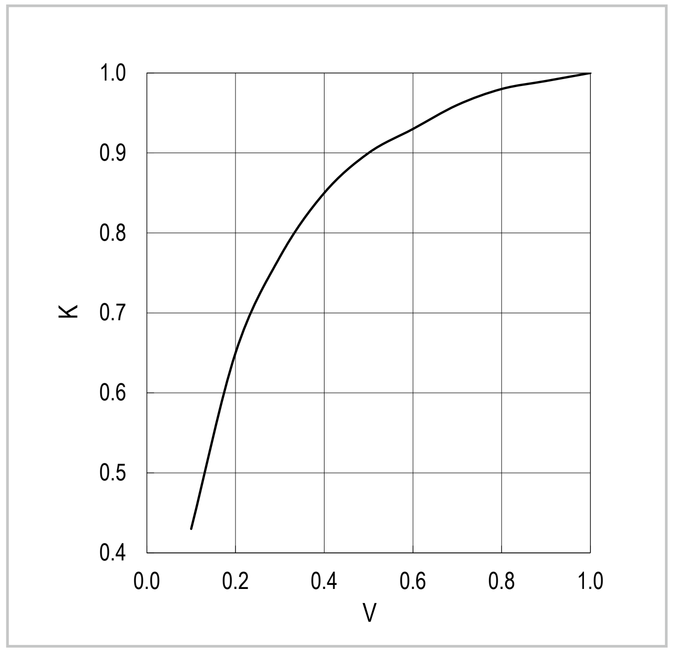
Product: CSG-20-80-2UH

- Input speed: 1000 rpm
- (Average) load torque T_{av}: 36 Nm
- Rated torque T_N (catalogue reference): 44 Nm
- Grease lubrication with Harmonic Drive® Grease SK-1A, lubricant temperature: 20 °C.

1. Calculation of the torque factor
   $V = T_{av}/T_N = 36/44 = 0{,}82$ (For V > 1 is K = 1)
2. Reading the calculation factor K from diagram Illustration 2.1.16: K = 0.97
3. Reading the efficiency from the efficiency curve Illustration 2.1.14: η = 79 %
4. Calculation of the load dependant efficiency
   $\eta_L = 79\ \% \cdot 0.97 = 77\ \%$

Illustration 2.1.16

Calculation factor K



Output bearing

- Performance data

Table 2.1.11

CSG-2UH/HFUC-2UH

	Symbol [Unit]	Size											
		14	17	20	25	32	40	45	50	58	65	80	90
Bearing type[1]		C	C	C	C	C	C	C	C	C	C	C	C
Pitch circle diameter	d_p [m]	0.035	0.0425	0.050	0.062	0.080	0.096	0.111	0.119	0.141	0.160	0.185	0.214
Distance[2]	R [m]	0.0095	0.0095	0.0095	0.0115	0.0130	0.0145	0.0155	0.0180	0.0205	0.0225	0.0260	0.0285
Dynamic load rating	C [N]	4700	5290	5780	9600	15000	21300	23000	34800	51800	55600	76400	83200
Static load rating	C_0 [N]	6070	7550	9000	15100	25000	36500	42600	60200	90400	103000	143000	168000
Permissible dynamic tilting moment[3)4)]	M [Nm]	41	64	91	156	313	450	686	759	1180	1860	2740	4210
Tilting moment stiffness[5]	K_B [Nm/arcmin]	13	22.5	37	70	157	265	410	497	823	1175	1900	2943
Permissible axial load[4]	F_a [N]	1004	1130	1235	2051	3205	4550	4914	7435	11066	11878	16322	17582
Permissible radial load[4]	F_r [N]	673	757	827	1374	2147	3049	3292	4981	7414	7958	10936	11780

1) Bearing type C = Cross roller bearing; F = Four point contact bearing
2) Distance between the centre of the rolling bearing and the screw mounting surface on the output side, see chapter Gear dimensioning.
3) These values are valid for moving gears. They are not based on the equation for lifetime of the output bearing but on the maximum allowable deflection of the Harmonic Drive® Gear Component Set. The values indicated in the table must not be exceeded even if the lifetime equation of the bearing permits higher values.
4) These data are valid for **M**: $F_a = 0, F_r = 0$ I **F_a**: $M = 0, F_r = 0$ I **F_r**: $M = 0, F_a = 0$
5) The value of tilting moment stiffness is the average value (±20 %).

Table 2.1.12

CSG-2UH-LW/CSF-2UH-LW

	Symbol [Unit]	Size									
		14	17	20	25	32	40	45	50	58	65
Bearing type[1]		C	C	C	C	C	C	C	C	C	C
Pitch circle diameter	d_p [m]	0.035	0.043	0.050	0.064	0.083	0.096	0.111	0.119	0.141	0.160
Distance[2]	R [m]	0.0093	0.0091	0.0098	0.0118	0.0133	0.0148	0.0158	0.0180	0.0205	0.0185
Dynamic load rating	C [N]	4700	5290	5780	9600	15000	21300	23000	34800	51800	55600
Static load rating	C_0 [N]	6070	7550	9000	15100	25000	36500	42600	60200	90400	103000
Permissible dynamic tilting moment[3][4]	M [Nm]	33.6	52.5	74.6	127.9	256.7	369.0	562.5	622	838	1525
Tilting moment stiffness[5]	K_B [Nm/arcmin]	10.5	18.6	30.5	57.6	128.6	217	336	407	585	963
Permissible axial load[4]	F_a [N]	1004	1130	1235	2051	3205	4550	4914	7435	11066	11878
Permissible radial load[4]	F_r [N]	673	757	827	1374	2147	3049	3292	4981	7414	7958

1) Bearing type C = Cross roller bearing; F = Four point contact bearing
2) Distance between the centre of the rolling bearing and the screw mounting surface on the output side, see chapter Gear dimensioning.
3) These values are valid for moving gears. They are not based on the equation for lifetime of the output bearing but on the maximum allowable deflection of the Harmonic Drive® Gear Component Set. The values indicated in the table must not be exceeded even if the lifetime equation of the bearing permits higher values.
4) These data are valid for **M**: $F_a = 0$, $F_r = 0$ I **F_a**: $M = 0$, $F_r = 0$ I **F_r**: $M = 0$, $F_a = 0$
5) The value of tilting moment stiffness is the average value (±20 %).

• Output bearing and housing tolerances

Data applies to rotating output flange.

Illustration 2.1.17

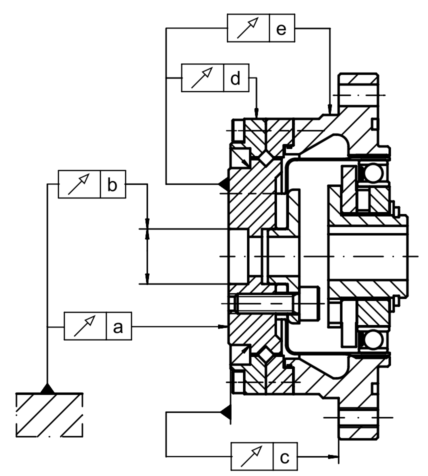


Table 2.1.13

[mm]

Symbol	Size											
	14	17	20	25	32	40	45	50	58	65	80	90
a (axial runout)	0.010	0.010	0.010	0.015	0.015	0.015	0.018	0.018	0.018	0.018	0.022	0.022
b (radial runout)	0.010	0.012	0.012	0.013	0.013	0.015	0.015	0.015	0.017	0.017	0.020	0.020
c	0.024	0.026	0.038	0.045	0.056	0.060	0.068	0.069	0.076	0.085	0.090	0.090
d	0.010	0.010	0.010	0.010	0.010	0.015	0.015	0.015	0.015	0.015	0.020	0.020
e	0.038	0.038	0.047	0.049	0.054	0.060	0.065	0.067	0.070	0.075	0.080	0.090

Assembly

• Assembly tolerances

Illustration 2.1.18

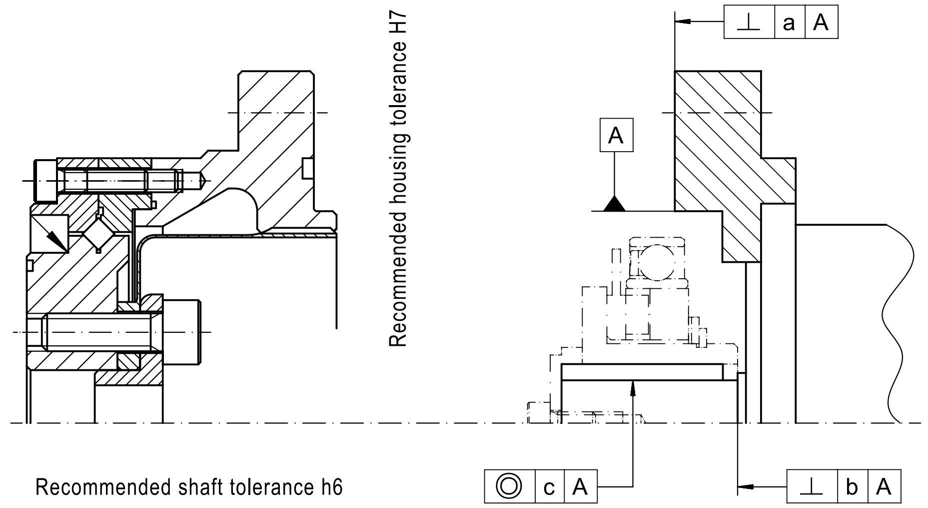


Table 2.1.14

[mm]

Symbol	Recommended tolerance shaft/Bore of connection components	Size											
		14	17	20	25	32	40	45	50	58	65	80	90
a		0.011	0.015	0.017	0.024	0.026	0.026	0.027	0.028	0.031	0.034	0.043	0.050
b		0.017	0.020	0.020	0.024	0.024	0.032	0.032	0.032	0.032	0.032	0.036	0.036
		(0.008)	(0.010)	(0.010)	(0.012)	(0.012)	(0.012)	(0.013)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
Øc	h6	0.030	0.034	0.044	0.047	0.050	0.063	0.065	0.066	0.068	0.070	0.090	0.091
		(0.016)	(0.018)	(0.019)	(0.022)	(0.022)	(0.024)	(0.027)	(0.030)	(0.033)	(0.035)	(0.043)	(0.046)

The values in brackets are recommended tolerances for a Wave Generator without Oldham coupling. This coupling is used to compensate for eccentricity errors of the motor shaft and is installed in the standard gear. In case of a direct coupling of the Wave Generator on the motor shaft without Oldham coupling (option), the motor shaft tolerances should correspond to DIN 42955 R.

ⓘ You will find more information on this in the Engineering data chapter.

• Recommended housing dimensions

The gears are supplied with lifetime grease lubrication. Additional lubrication of the gears during assembly is not necessary. When assembling, the dimensions according to Table 2.1.15 should be taken into account.

Illustration 2.1.19

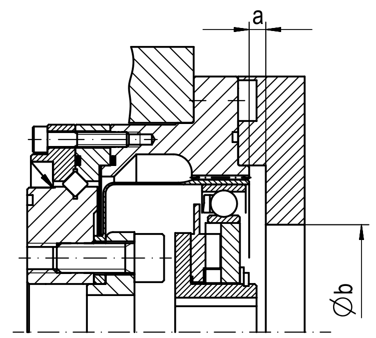


Table 2.1.15

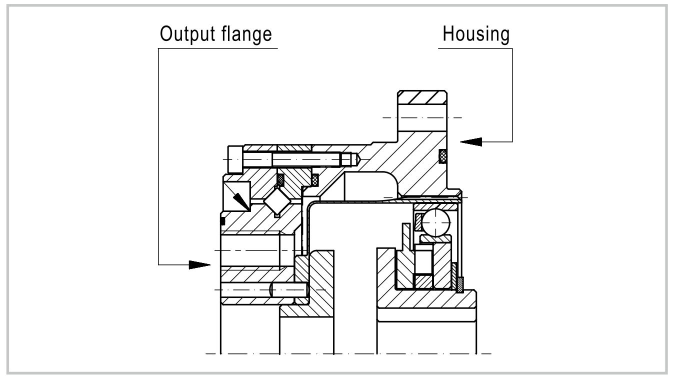
[mm]

Symbol	Size											
	14	17	20	25	32	40	45	50	58	65	80	90
a*	1.0	1.0	1.5	1.5	1.5	2.0	2.0	2.0	2.5	2.5	3.0	3.0
a**	3.0	3.0	4.5	4.5	4.5	6.0	6.0	6.0	7.5	7.5	9.0	9.0
Øb	16	26	30	37	37	45	45	45	56	62	67	73

*Wave Generator arranged vertically of downwards
**Wave Generator arranged upwards

Screw connection

Illustration 2.1.20



Screw connection on the output side

Table 2.1.16

CSG-2UH

	[Unit]	Size									
		14	17	20	25	32	40	45	50	58	65
Number of screws		6	6	8	8	8	8	8	8	8	8
Size of screws		M4	M5	M6	M8	M10	M10	M12	M14	M16	M16
Pitch circle diameter	[mm]	23	27	32	42	55	68	82	84	100	110
Screw tightening torque	[Nm]	5.4	10.8	18.4	45	89	89	154	246	383	383
Torque transmitting capacity	[Nm]	58	109	245	580	1220	1510	2624	3690	5981	6579

12.9 quality screws, friction coefficient μ = 0.15

Table 2.1.17

CSG-2UH-LW

	[Unit]	Size									
		14	17	20	25	32	40	45	50	58	65
Number of screws		6	6	8	8	8	8	8	8	8	8
Size of screws		M4	M5	M6	M8	M10	M10	M12	M14	M16	M16
Pitch circle diameter	[mm]	23	27	32	42	55	68	82	84	100	110
Screw tightening torque	[Nm]	5.4	10.8	18.4	45	89	89	154	246	383	383
Torque transmitting capacity	[Nm]	58	109	245	580	1220	1510	2624	3690	5981	6579

12.9 quality screws, friction coefficient μ = 0.15

Table 2.1.18

HFUC-2UH

	[Unit]	Size											
		14	17	20	25	32	40	45	50	58	65	80	90
Number of screws		6	6	8	8	8	-	-	8	8	8	12	12
Size of screws		M4	M5	M6	M8	M10	-	-	M14	M16	M16	M16	M16
Pitch circle diameter	[mm]	23	27	32	42	55	-	-	84	100	110	135	160
Screw tightening torque	[Nm]	4.5	9.0	15.3	37	74	-	-	205	319	319	319	319
Torque transmitting capacity	[Nm]	49	91	204	486	1108	-	-	3070	4980	5480	10200	12100

12.9 quality screws, friction coefficient μ = 0.15

Table 2.1.19

CSF-2UH-LW

	[Unit]	Size									
		14	17	20	25	32	40	45	50	58	65
Number of screws		6	6	8	8	8	-	-	8	8	8
Size of screws		M4	M5	M6	M8	M10	-	-	M14	M16	M16
Pitch circle diameter	[mm]	23	27	32	42	55	-	-	84	100	110
Screw tightening torque	[Nm]	4.5	9.0	15.3	37	74	-	-	205	319	319
Torque transmitting capacity	[Nm]	49	91	204	486	1019	-	-	3070	4980	5480

12.9 quality screws, friction coefficient μ = 0.15

Screw connection on the housing side

Table 2.1.20

CSG-2UH

	[Unit]	Size									
		14	17	20	25	32	40	45	50	58	65
Number of screws		8	8	8	10	12	10	12	14	12	8
Size of screws		M4	M4	M5	M5	M6	M8	M8	M8	M10	M12
Pitch circle diameter	[mm]	65	71	82	96	125	144	164	174	206	236
Screw tightening torque	[Nm]	4.5	4.5	9.0	9.0	15.3	37	37	37	74	128
Torque transmitting capacity	[Nm]	182	196	365	538	1200	2100	2844	3251	5717	6293

12.9 quality screws, friction coefficient μ = 0.15

Table 2.1.21

CSG-2UH-LW

	[Unit]	Size									
		14	17	20	25	32	40	45	50	58	65
Number of screws		6	8	8	10	12	10	16	18	16	12
Size of screws		M4	M4	M5	M5	M6	M8	M8	M8	M10	M12
Pitch circle diameter	[mm]	65	71	82	96	125	144	164	174	206	236
Screw tightening torque	[Nm]	3.2	3.2	6.4	6.4	10.8	26.5	26.5	26.5	51.9	90.0
Torque transmitting capacity	[Nm]	98	143	261	382	842	1488	2712	3237	5350	6649

12.9 quality screws, friction coefficient μ = 0.15

Table 2.1.22

HFUC-2UH

	[Unit]	Size											
		14	17	20	25	32	40	45	50	58	65	80	90
Number of screws		6	6	6	8	12	-	-	12	12	8	12	12
Size of screws		M4	M4	M5	M5	M6	-	-	M8	M10	M12	M12	M12
Pitch circle diameter	[mm]	65	71	82	96	125	-	-	174	206	236	270	300
Screw tightening torque	[Nm]	4.5	4.5	9.0	9.0	15.3	-	-	37	74	128	128	128
Torque transmitting capacity	[Nm]	137	147	274	431	1200	-	-	3040	5717	6293	10025	11245

12.9 quality screws, friction coefficient μ = 0.15

Table 2.1.23

CSF-2UH-LW

	[Unit]	Size									
		14	17	20	25	32	40	45	50	58	65
Number of screws		6	8	8	10	12	-	-	18	16	12
Size of screws		M4	M4	M5	M5	M6	-	-	M8	M10	M12
Pitch circle diameter	[mm]	65	71	82	96	125	-	-	174	206	236
Screw tightening torque	[Nm]	3.2	3.2	6.4	6.4	10.8	-	-	26.5	51.9	90.0
Torque transmitting capacity	[Nm]	9.8	143	261	382	842	-	-	3237	5350	6649

12.9 quality screws, friction coefficient μ = 0.15

- Materials and coatings used

Material:
Output bearing: Bright steel
Circular Spline: Bright grey cast iron
- CSG/HFUC-2UH: Bright grey cast iron (one piece with integrated Circular Spline)
- CSG/CSF-2UH-LW: Bright aluminium

Flexspline: Bright steel
Wave Generator: Bright steel

Optional materials and coatings are available on request from Harmonic Drive SE.

Lubrication

- Grease lubrication

The gears with output bearing HFUC-/CSG-2UH are supplied fully greased. They are provided with lifetime grease lubrication at the factory. We recommend the use of the greases listed in Table 2.1.24. The output bearing is greased with Harmonic Drive® Grease 4BNo.2.

Table 2.1.24

Ratio	Harmonic Drive® Grease	Size							
		14	17	20	25	32	40	45 … 58	65 … 90
30 (HFUC)	Flexolub®-A1	O	O	O	O	O	-	-	-
	SK-1A	-	-	Δ	Δ	Δ	-	-	-
	SK-2	Δ	Δ	-	-	-	-	-	-
	4BNo.2	Δ	Δ	□	□	□	-	-	-
≥50	SK-1A	-	-	O	O	O	O	O	O
	SK-2	O	O	Δ	Δ	Δ	Δ	-	-
	4BNo.2	□	□	□	□	□	□	□	□
	Flexolub®-A1 1)	Δ	Δ	Δ	Δ	Δ	Δ	Δ	-

1) Only for HFUC Series
O Standard grease
□ Recommended for very high loads or very high demands on the service life of the grease
Δ Optional grease, please consult us

- Oil lubrication

Harmonic Drive® Gears with output bearing including oil lubrication are customised special designs. Lubrication and relubrication are determined individually.

You will find more information on this in the Engineering data chapter.

Product description

Outstanding low weight combined with a short design

The CSF-ULW Series Gears are characterised by lowest weight combined with a short overall length. The ULW Series achieves the same performance data as the HFUC-2UH Series with a weight saving of approx. 50 % and a length reduction of approx. 30 %. These precision gears are ideal for use in hand axes of small and collaborative robots, as well as for industrial applications where low weight is required.

Features:

- Outstanding low weight
- Short length
- Integrated output bearing
- High precision

Ordering code

Table 2.2.1

Ordering code	CSF	-	14	-	80	-	2UH	-	ULW	-	SP
Series											
Size (corresponds to the pitch circle diameter of the Flexspline toothing in inches x 10)			8 11 14 17 20								
Ratio (in drive configuration: Circular Spline (CS) fixed, Wave Generator (WG) input, Flexspline (FS) output)					30 50 80 100 120 160						
Version Gears for motor mounting							2UH				
Specification Ultra light weight type (Lightweight version)									ULW		
Customised design Standard design (field remains empty) Special design (on request)											[ ] SP

Combinations

Table 2.2.2

		Size 8	11	14	17	20
Ratio	30	•	•	-	-	-
	50	•	•	•	•	•
	80	-	-	•	•	•
	100	•	•	•	•	•
	120	-	-	-	•	•
	160	-	-	-	-	•

• available   o on request   - not available

Technical data

• Performance data

Table 2.2.3

Size	Ratio	Limit for repeated peak torque	Limit for average torque	Rated torque at rated speed 2000 rpm	Limit for momentary peak torque	Max. input speed [rpm]	Limit for average input speed [rpm]	Moment of inertia	Weight
	i	T_R [Nm]	T_A [Nm]	T_N [Nm]	T_M [Nm]	Lubrication Grease	Lubrication Grease	[kgm²]	[kg]
8	30	1.8	1.4	0.9	3.3	8500	3500	1.7×10^{-7}	0.090
	50	3.3	2.3	1.8	6.6				
	100	4.8	3.3	2.4	9.0				
11	30	4.5	3.4	2.2	8.5	8500	3500	8.6×10^{-7}	0.150
	50	8.3	5.5	3.5	17.0				
	100	11.0	8.9	5.0	25.0				
14	50	18.0	6.9	5.4	35.0	8500	3500	2.2×10^{-6}	0.230
	80	23.0	11.0	7.8	47.0				
	100	28.0	11.0	7.8	54.0				
17	50	34	26	16	70	7300	3500	5.5×10^{-6}	0.320
	80	43	27	22	87				
	100	54	39	24	108				
	120	54	39	24	86				
20	50	56	34	25	98	6500	3500	1.1×10^{-5}	0.450
	80	74	47	34	127				
	100	82	49	40	147				
	120	87	49	40	147				
	160	92	49	40	147				

You will find more information on this in the Engineering data chapter.

• Dimensions

Illustration 2.2.1

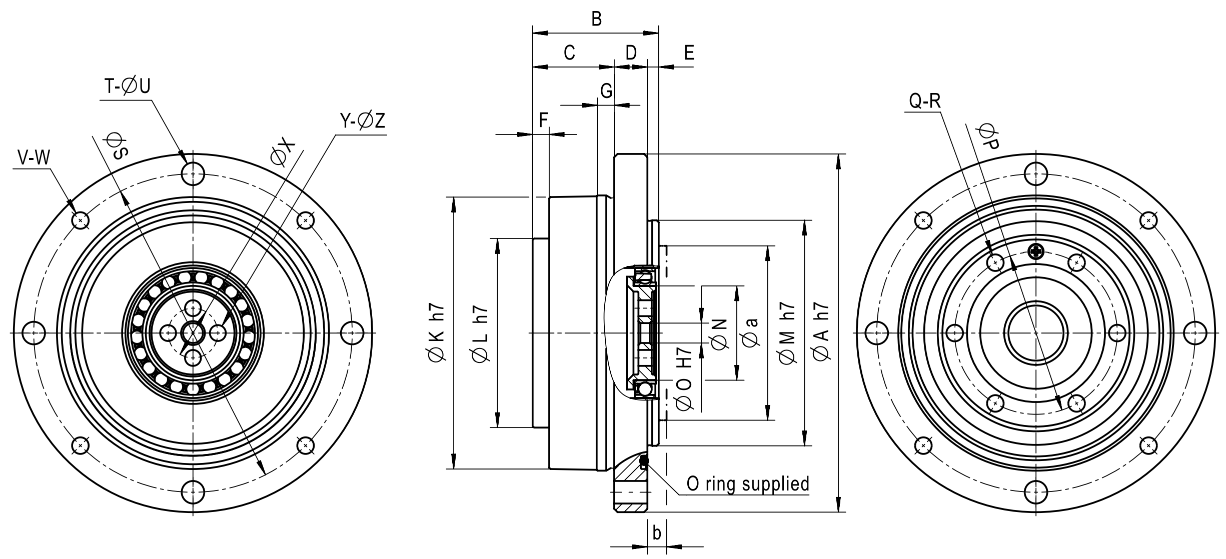


Illustration 2.2.2

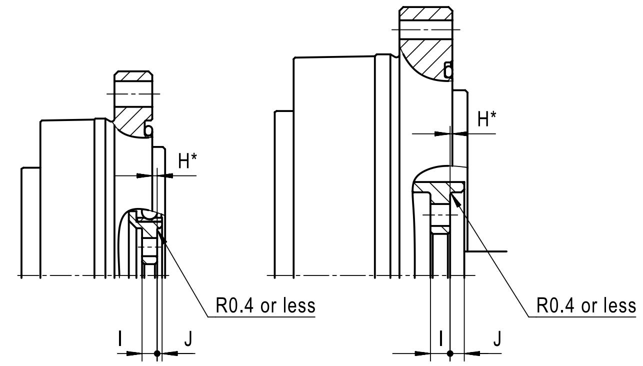


Table 2.2.4

[mm]

Symbol	Size 8	11	14	17	20
ø A h7	54	63	71	81	93
B	19.0	21.5	25.5	28.5	31.5
C	12.3	13.0	16.5	18.0	20.5
D	5.0	6.5	7.0	8.0	8.0
E	1.7	2.0	2.0	2.5	3.0
F	2.5	2.5	2.5	2.5	2.5
G	2.5	3.3	3.0	3.0	3.0
H*	$0.65^{0}_{-0.3}$	$0.35^{0}_{-0.7}$	$0.30^{+0.8}_{0}$	$0.20^{0}_{-0.9}$	$0.30^{0}_{-1.0}$
I	2.0	2.4	2.6	2.7	3.1
J	0.70	1.30	1.88	2.00	2.60
ø K h7	41.5	50.5	58.5	67.5	77.0
ø L h7	28.5	36.5	43.5	52.0	60.5
ø M h7	34	42	49	57	63
ø N	12.5	18.2	22.0	26.5	31.5
ø O H7	3	7	11	13	19
ø P	24.5	32.0	39.0	47.5	56.0
Q	6	8	10	16	18
R	M3x4.0	M3x4.5	M3x4.5	M3x4.5	M3x4.5
ø S	48.0	57.0	65.0	74.5	84.5
T	4	4	6	10	12
øU	3.4	3.4	3.4	3.4	3.4
V	4	4	6	10	12
W	M3	M3	M3	M3	M3
øX	7.5	12.0	16.0	19.5	25.5
Y	4	4	4	4	4
øZ	2.4	2.9	2.9	3.4	3.4
Øa	21.5	30.0	38.0	45.0	53.0
b	2.2	2.5	3.0	3.5	4.5

* Dimension H is the axial Wave Generator position. Please note the tolerances given in the table.

CAD drawings for download: www.harmonicdrive.co.uk

Accuracy

Table 2.2.5 **[arcmin]**

	Size									
	8		11		14		17		20	
Ratio	30	≥50	30	≥50	50	≥80	50	≥80	50	≥80
Transmission accuracy	<2.0		<2.0	<1.5	<1.5		<1.5		<1.0	
Hysteresis loss	<3.0	<2.0	<3.0	<2.0	<2.0	<1.0	<2.0	<1.0	<2.0	<1.0

Torsional stiffness

Table 2.2.6

	Symbol [Unit]	Size				
		8	11	14	17	20
Limit torques	T_1 [Nm]	0.29	0.80	2.00	3.90	7.00
	T_2 [Nm]	0.75	2.00	6.90	12.00	25.00
i = 30	K_3 [x 10^4 Nm/rad]	0.054	0.160	-	-	-
	K_2 [x 10^4 Nm/rad]	0.044	0.130	-	-	-
	K_1 [x 10^4 Nm/rad]	0.034	0.084	-	-	-
i = 50	K_3 [x 10^4 Nm/rad]	0.084	0.320	0.570	1.300	2.300
	K_2 [x 10^4 Nm/rad]	0.067	0.300	0.470	1.100	1.800
	K_1 [x 10^4 Nm/rad]	0.044	0.220	0.340	0.810	1.300
i ≥ 80	K_3 [x 10^4 Nm/rad]	0.120	0.440	0.710	1.600	2.900
	K_2 [x 10^4 Nm/rad]	0.100	0.340	0.610	1.400	2.500
	K_1 [x 10^4 Nm/rad]	0.091	0.270	0.470	1.000	1.600

No load starting torque

Table 2.2.7 **[Ncm]**

Ratio	Size				
	8	11	14	17	20
30	1.5	3.0	-	-	-
50	0.9	1.8	3.6	5.5	7.2
80	-	-	2.6	3.6	4.5
100	0.7	1.2	2.3	3.1	4.0
120	-	-	-	2.9	3.6
160	-	-	-	-	3.1

No load back driving torque

Table 2.2.8 **[Nm]**

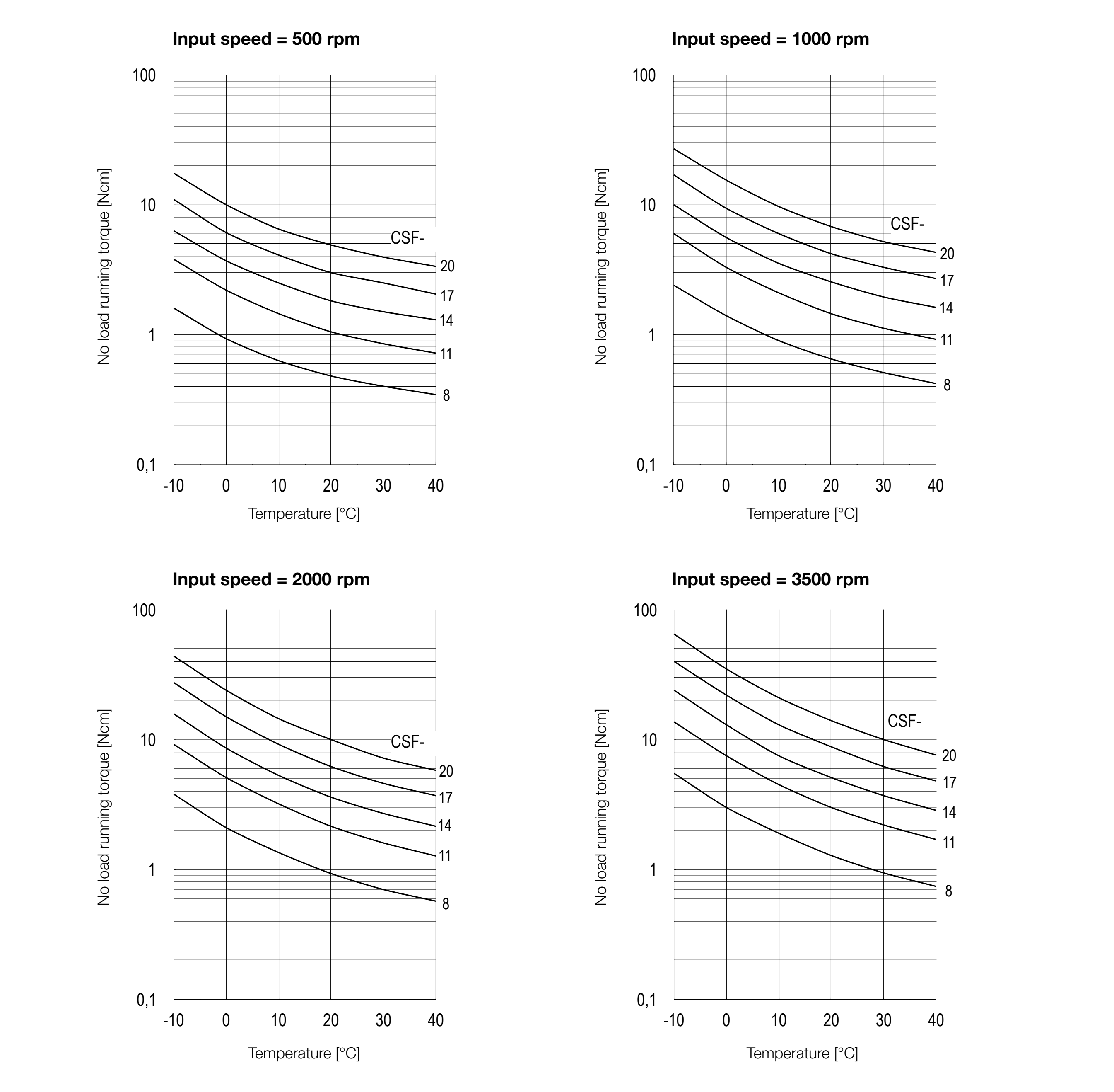
Ratio	Size				
	8	11	14	17	20
30	0.70	1.4	-	-	-
50	0.55	1.1	1.6	2.7	4.3
80	-	-	1.6	2.7	4.5
100	0.75	1.5	1.9	3.0	4.8
120	-	-	-	3.3	5.2
160	-	-	-	-	6.1

You will find more information on this in the Engineering data chapter.

No load running torque

The diagrams apply to Harmonic Drive® Grease SK-2 (size 8 … 17) and SK-1A (size 20).

Illustration 2.2.3



Compensation values for no load running torque

Table 2.2.9 **[Ncm]**

Ratio	Size				
	30	50	80	120	160
8	0.54	0.23	-	-	-
11	1.05	0.43	-	-	-
14	-	0.63	0.11	-	-
17	-	1.01	0.17	-0.13	-
20	-	1.54	0.27	-0.19	-0.45

Efficiency

Efficiency for grease lubrication at rated torque

The diagrams apply to Harmonic Drive® Grease SK-2 (size 8 … 17) and SK-1A (size 20).

Illustration 2.2.4

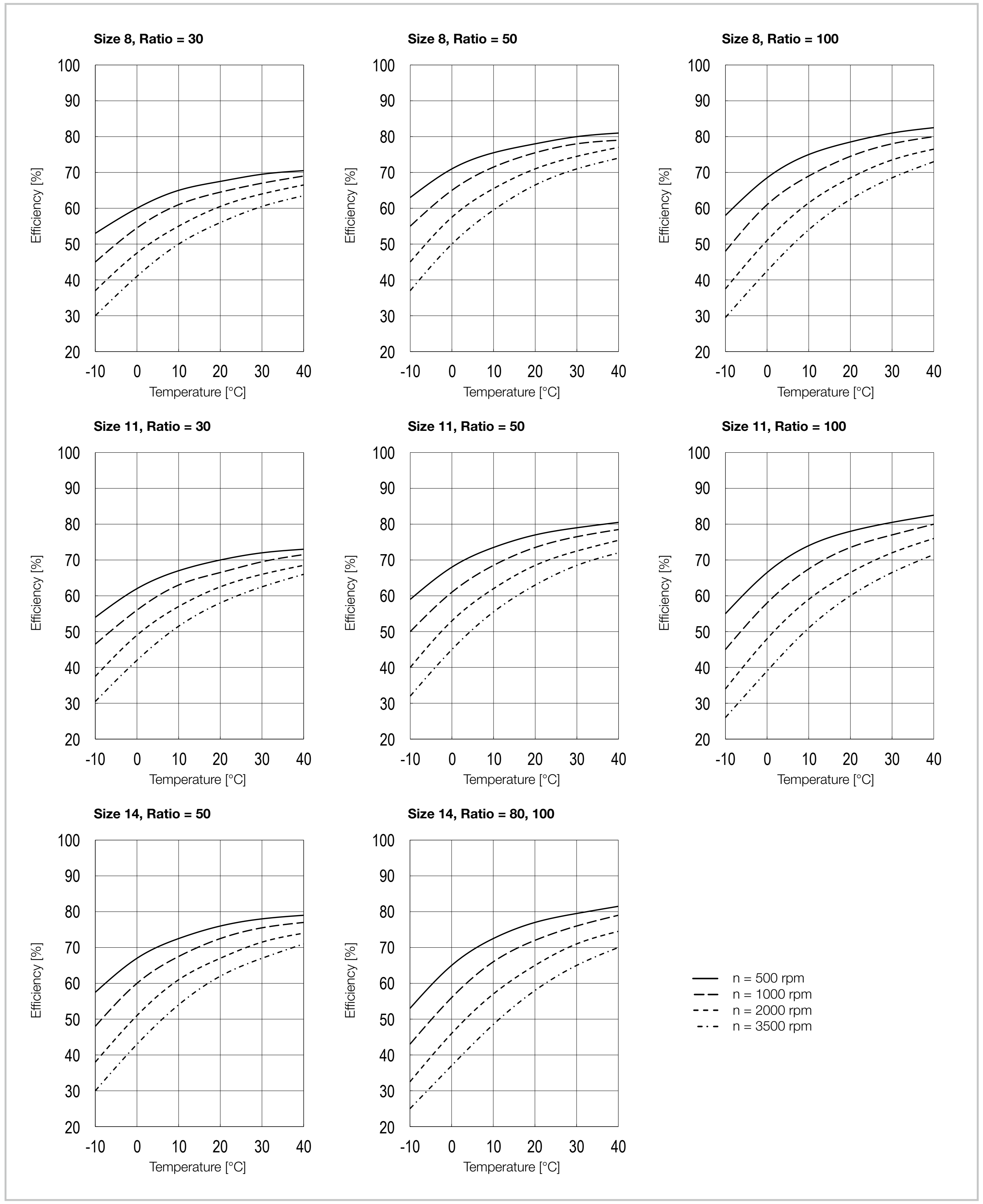
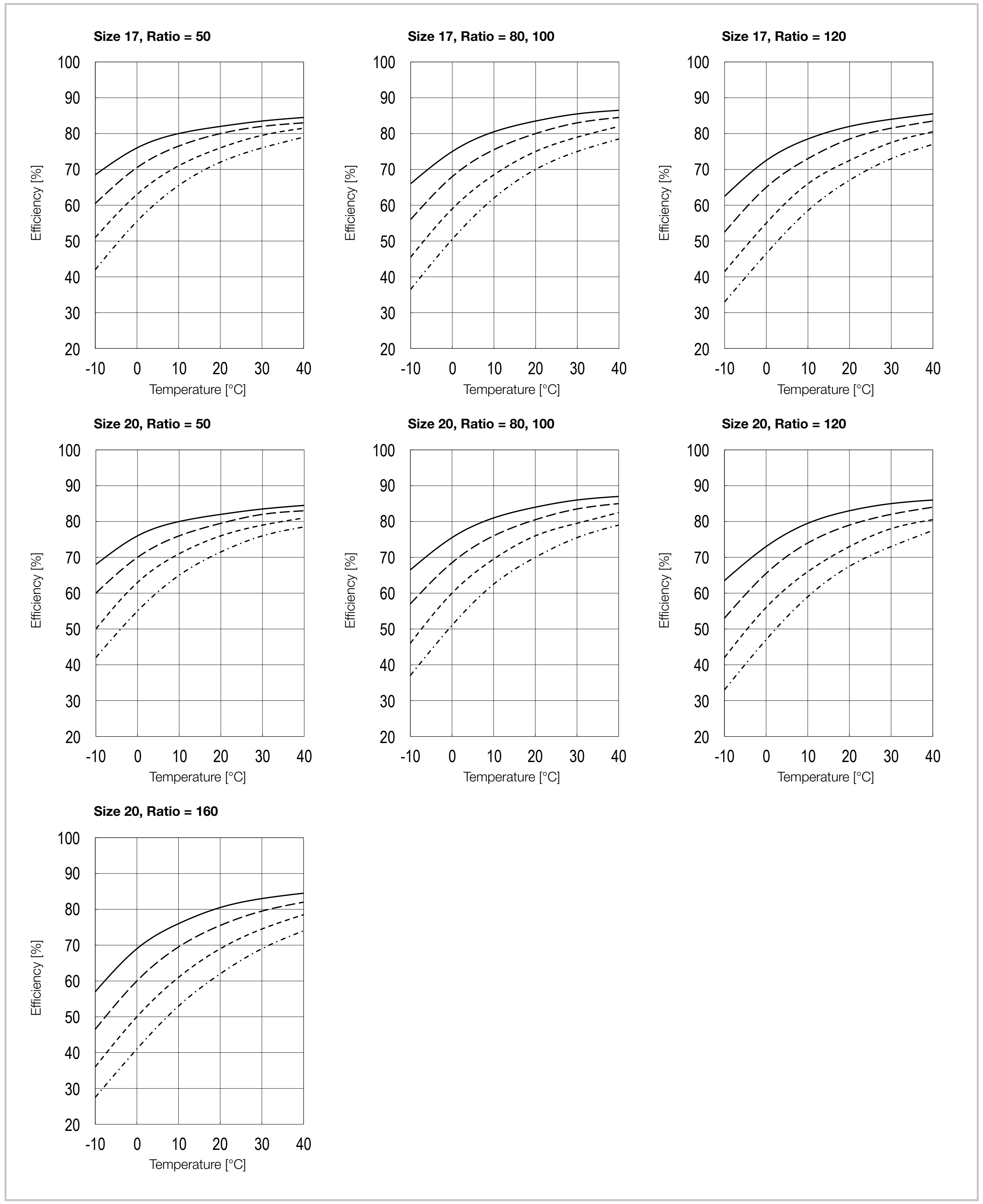


Illustration 2.2.5



You will find more information on this in the Engineering data chapter.

Efficiency calculation

The efficiency depends on the following parameters: Gear ratio, input speed, load torque, temperature, lubricant and lubricant quantity. If the load torque is lower than the rated torque, the efficiency will be lower than the efficiency indicated in the efficiency curves. The torque specific efficiency is determined by means of the calculation factor K.

Calculation example:

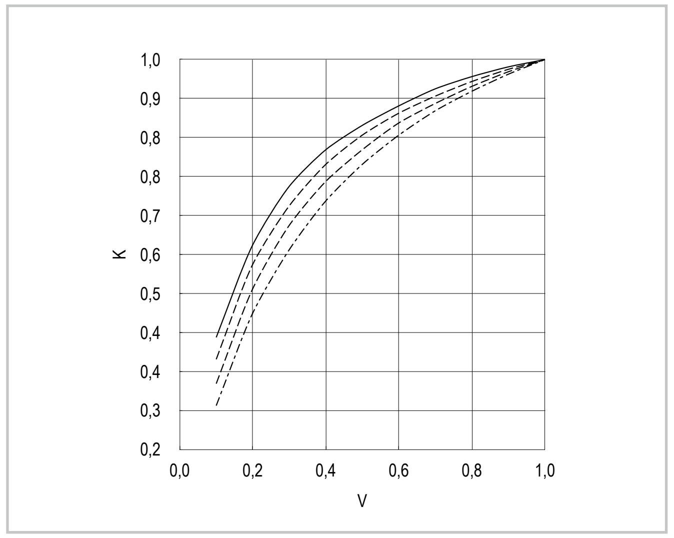
Product: CSF-14-80-2UH-ULW

- Input speed: 1000 rpm
- (Average) load torque T_{av}: 6,0 Nm
- Rated torque T_N (catalogue reference): 7.8 Nm
- Grease lubrication with Harmonic Drive® Grease SK-2, lubricant temperature: 20 °C

1. Calculation of the torque factor
   $V = T_{av}/T_N = 6.0/7.8 = 0.77$ (For V > 1 is K = 1)
2. Reading the calculation factor K from diagram Illustration 2.2.6: K = 0.94
3. Reading the efficiency from the efficiency curve Illustration 2.2.4: η = 73 %
4. Calculation of the load dependant efficiency
   $\eta_L = 73\ \% \cdot 0.94 = 69\ \%$

Illustration 2.2.6

Calculation factor K



n = 500 rpm
n = 1000 rpm
n = 2000 rpm
n = 3500 rpm

Output bearing

The CSF-ULW Gears are equipped with a four point contact bearing for direct support of the external loads.

Table 2.2.10

	Symbol [Unit]	Size 8	11	14	17	20
Bearing type 1)		F	F	F	F	F
Pitch circle diameter	d_p [m]	0.0290	0.0371	0.0443	0.0527	0.0614
Distance 2)	R [m]	0.00790	0.00815	0.00840	0.00920	0.00970
Dynamic load rating	C [N]	1800	2800	3900	5200	6700
Static load rating	C_0 [N]	2200	3500	5000	7000	9400
Permissible dynamic tilting moment 3)4)	M [Nm]	8.7	14.0	26.0	40.0	56.0
Tilting moment stiffness 5)	K_B [Nm/arcmin]	2.9	5.0	8.7	13.4	18.9
Permissible axial load 4)	F_a [N]	353	548	764	1019	1312
Permissible radial load 4)	F_r [N]	236	367	512	682	879

1) Bearing type C = Cross roller bearing; F = Four point contact bearing
2) Distance between the centre of the rolling bearing and the screw mounting surface on the output side, see chapter Gear dimensioning.
3) These values are valid for moving gears. They are not based on the equation for lifetime of the output bearing but on the maximum allowable deflection of the Harmonic Drive® Gear Component Set. The values indicated in the table must not be exceeded even if the lifetime equation of the bearing permits higher values.
4) These data are valid for **M**: $F_a = 0$, $F_r = 0$ I **F_a**: $M = 0$, $F_r = 0$ I **F_r**: $M = 0$, $F_a = 0$
5) The value of tilting moment stiffness is the average value (±20 %).

• Output bearing and housing tolerances

Data applies to rotating output flange.

Illustration 2.2.7

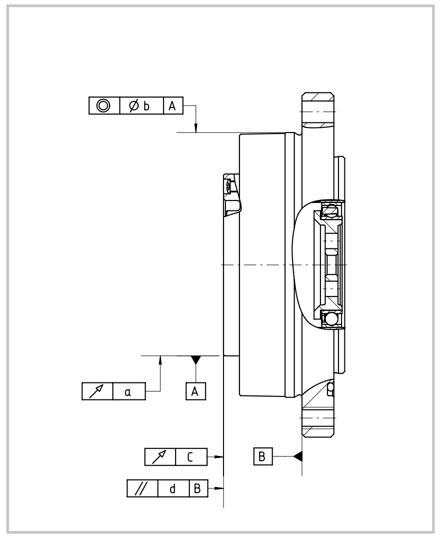


Table 2.2.11 **[mm]**

Symbol	Size 8	11	14	17	20
a (radial runout)	0,010	0,010	0,010	0,010	0,010
ø b	0,050	0,050	0,060	0,060	0,070
c (axial runout)	0,010	0,010	0,010	0,010	0,010
d	0,025	0,025	0,025	0,025	0,025

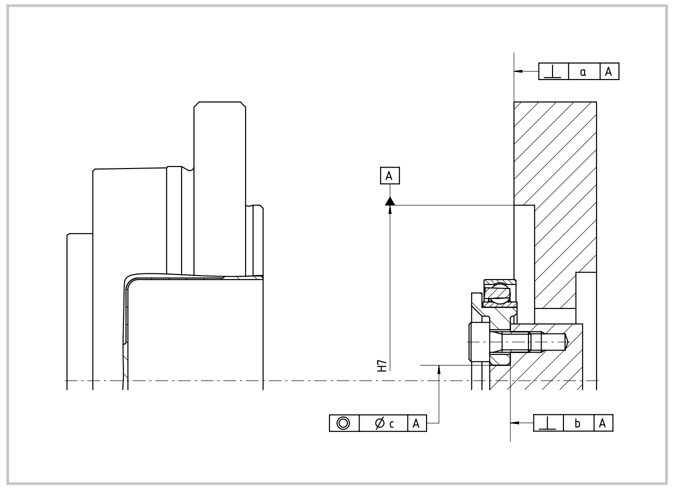
Assembly

• Assembly tolerances

Table 2.2.12 **[mm]**

Symbol	Recommended tolerance shaft/Bore of connection components	Size 8	11	14	17	20
a		0.010	0.011	0.011	0.015	0.017
b		0.006	0.007	0.008	0.010	0.010
ø c	h6	0.006	0.007	0.016	0.018	0.019

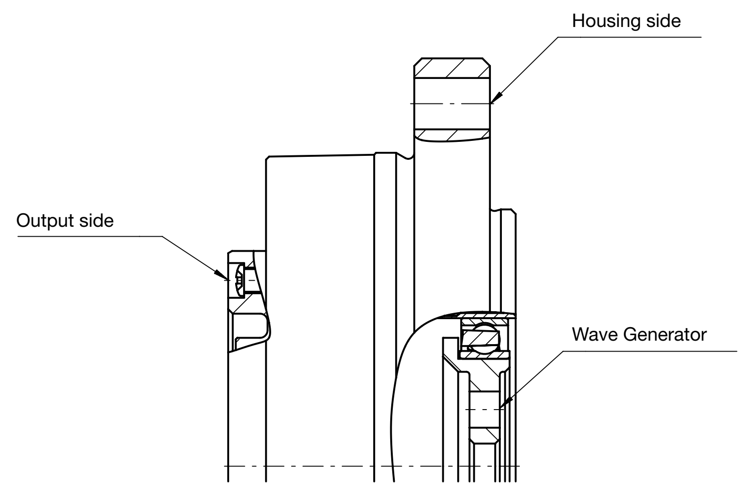
Illustration 2.2.8



You will find more information on this in the Engineering data chapter.

• Screw connection

Illustration 2.2.9



• Screw connection on the output side

Table 2.2.13

	[Unit]	Size 8	11	14	17	20
Number of screws		6	8	10	16	18
Size of screws		M3	M3	M3	M3	M3
Pitch circle diameter	[mm]	24.54	32.00	39.00	47.50	56.00
Screw tightening torque	[Nm]	2.0	2.0	2.0	2.0	2.0
Torque transmitting capacity	[Nm]	30.6	53.3	81.2	158.0	210.0

12.9 quality screws, friction coefficient μ = 0,15

• Screw connection on the housing side

Table 2.2.14

	[Unit]	Size 8	11	14	17	20
Number of screws		4	4	6	10	12
Size of screws		M3	M3	M3	M3	M3
Pitch circle diameter	[mm]	48.0	57.0	65.0	74.5	84.5
Screw tightening torque	[Nm]	1.4	1.4	1.4	1.4	1.4
Torque transmitting capacity	[Nm]	28.0	33.2	56.8	108.0	147.0

12.9 quality screws, friction coefficient μ =0 ,15

• Screw connection on the Wave Generator

Table 2.2.15

	[Unit]	Size 8	11	14	17	20
Number of screws		4	4	4	4	4
Size of screws		M2	M2.5	M2.5	M3	M3
Pitch circle diameter	[mm]	7.5	12.0	16.0	19.5	25.5
Screw tightening torque	[Nm]	0.54	1.08	1.08	2.00	2.00
Torque transmitting capacity	[Nm]	2.53	6.48	8.64	16.20	21.20

12.9 quality screws, friction coefficient μ = 0,15

• Materials and coatings used

Material:
Output bearing: Bright steel
Circular Spline: Bright grey cast iron
Flexspline: Bright steel
Wave Generator: Bright steel
Housing: Bright Aluminium

Optional materials and coatings are available on request from Harmonic Drive SE.

Lubrication

Grease lubrication is standard for the CSF-2UH-ULW Gears. The gears are supplied fully greased. Additional grease is not required during assembly. The lubricant used is Harmonic Drive® SK-1A or SK-2 is used. The output bearing is greased with Multemp HL-D. We recommend the use of the greases listed in Table 2.2.16.

Table 2.2.16

Harmonic Drive® Grease	Size 8	11	14	17	20
SK-1A	-	-	-	-	O
SK-2	O	O	O	O	Δ

O Standard grease
□ Recommended for very high loads or very high demands on the service life of the grease
Δ Optional grease, please consult us

You will find more information on this in the Engineering data chapter.

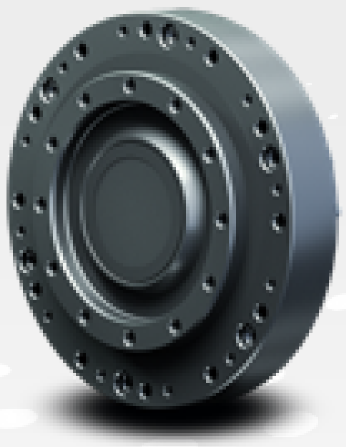
Product description

Flexible gear configuration and reinforced output bearing

The CPU Series Gears consist of a precise HFUC Gear Component Set and a tilt resistant output bearing. They are available with hollow shaft, input shaft or for direct motor mounting.

Features

- Three versions for different installation situations
- Highest transmission accuracy
- Integrated tilt resistant output bearing
- Optional corrosion protection
- Large torque range



CPU-M
Gear for direct motor mounting

CPU-H
Hollow shaft gear to feed through supply lines for further gear systems

CPU-S
with input shaft to drive with belt pulley or spur gear

Ordering code

Table 2.3.1

Ordering code	CPU	-	25	-	100	-	M	-	11.2	-	SP
Series	CPU										
Size (corresponds to the pitch circle diameter of the Flexspline toothing in inches x 10)			14 17 20 25 32 40 45 50 58								
Ratio (in drive configuration: Circular Spline (CS) fixed, Wave Generator (WG) input, Flexspline (FS) output)					30 50 80 100 120 160						
Version Gear for motor mounting Closed hollow shaft gear with input bearing Gear with input shaft							M H S				
Motor adaptation code Only for CPU-M if supplied with specific motor adapter flange. The code is determined by Harmonic Drive SE.											
Customised design Standard design (field remains empty) Special design (on request)											[ ] SP

Please refer to the table of possible combinations.

Combinations

Table 2.3.2

CPU

		Size								
		14	17	20	25	32	40	45	50	58
Ratio	30	•	•	•	•	•	-	-	-	-
	50	•	•	•	•	•	•	•	•1)	•1)
	80	•	•	•	•	•	•	•	•	•
	100	•	•	•	•	•	•	•	•	•
	120	-	•	•	•	•	•	•	•	•
	160	-	-	•	•	•	•	•	•	•
Version	M	•								
	H	•								
	S	•								

• available   o on request   - not available

1) Only with oil lubrication. Grease lubrication can be used if the average torque T_{av} is not greater than half the rated torque T_N according to Table 2.3.3.

Technical data

• Rating table

Table 2.3.3

Size	Ratio	Limit for repeated peak torque	Limit for average torque	Rated torque at rated speed 2000 rpm	Limit for momentary peak torque	Max. input speed [rpm]	Limit for average input speed [rpm]	Moment of inertia [x10⁻⁴ kgm²]	Weight [kg]
	i	T_R [Nm]	T_A [Nm]	T_N [Nm]	T_M [Nm]	Grease lubrication	Grease lubrication	M H S	M H S
14	30	9.0	6.8	4.0	17.0	8500	3500[2)] 3000[3)]	0.033 0.091 0.025	0.54 0.67 0.64
	50	18	6.9	5.4	35				
	80	23	11	7.8	47				
	100	28	11	7.8	54				
17	30	16	12	8.8	30	7300	3500[2)] 3000[3]	0.079 0.193 0.059	0.79 1.00 0.95
	50	34	26	16	70				
	80	43	27	22	87				
	100	54	39	24	110				
	120	54	39	24	86				
20	30	27	20	15	50	6500	3500[2)] 3000[3]	0.193 0.404 0.173	1.30 1.55 1.49
	50	56	34	25	98				
	80	74	47	34	127				
	100	82	49	40	147				
	120	87	49	40	147				
	160	92	49	40	147				
25	30	50	38	27	95	5600	3500[2)] 2575[3)]	0.413 1.070 0.320	1.90 2.35 2.30
	50	98	55	39	186				
	80	137	87	63	255				
	100	157	108	67	284				
	120	167	108	67	304				
	160	176	108	67	314				
32	30	100	75	54	200	4800	3500[2)] 1980[3)]	1.69 2.85 1.20	3.95 5.00 4.60
	50	216	108	76	382				
	80	304	167	118	568				
	100	333	216	137	647				
	120	353	216	137	686				
	160	372	216	137	686				
40	50	402	196	137	686	4000	3000[2)] 1300[3)]	4.50 9.28 3.41	6.9 8.9 8.4
	80	519	284	206	980				
	100	568	372	265	1080				
	120	617	451	294	1180				
	160	647	451	294	1180				
45	50	500	265	176	950	3800	3000[2)] 1250[3)]	8.68 13.80 5.80	9.4 12.1 11.8
	80	706	390	313	1270				
	100	755	500	353	1570				
	120	823	620	402	1760				
	160	882	630	402	1910				
50	50	715	175[1)]	122[1)]	1430	3500	2500[2)] 1200[3)]	12.5 25.2 9.95	12.6 16.3 15.8
	80	941	519	372	1860				
	100	980	666	470	2060				
	120	1080	813	529	2060				
	160	1180	843	529	2450				
58	50	1020	260[1)]	176[1)]	1960	3000	2200[2)] 1100[3)]	27.3 49.5 20.5	17.9 22.9 22.3
	80	1480	770	549	2450				
	100	1590	1060	696	3180				
	120	1720	1190	745	3330				
	160	1840	1210	745	3430				

1) When using oil lubrication, a higher rated torque and average torque are possible. Please contact Harmonic Drive SE.
2) Valid for CPU-S und CPU-M.
3) Valid for CPU-H. Higher values on request.

You will find more information on this in the Engineering data chapter.

Accuracy

Table 2.3.4 **[arcmin]**

			Size							
			14 … 17			20 … 32			≥ 40	
Ratio			30	50	≥ 80	30	50	≥ 80	50	≥ 80
Transmission accuracy	CPU-H, -S		< 2.0	< 1.2	< 1.0	< 1.5	< 1.0	< 0.8	< 0.7	< 0.5
	CPU-M	Wave Generator with Oldham coupling								
		Solid Wave Generator [1)]	< 2.0	< 1.5		< 1.5	< 1.0			
Hysteresis loss			< 3	< 2	< 1	< 3	< 2	< 1	< 2	< 1
Lost motion			< 1							
Repeatability			< ±0.1							

1) Higher accuracy on request

• Torsional stiffness

Table 2.3.5

	Symbol [Unit]	Size 14	17	20	25	32	40	45	50	58
Limit torques	T_1 [Nm]	2.0	3.9	7.0	14.0	29.0	54.0	76.0	108.0	168.0
	T_2 [Nm]	6.9	12.0	25.0	48.0	108.0	196.0	275.0	382.0	598.0
i = 30	K_3 [x 10⁴ Nm/rad]	0.34	0.67	1.10	2.10	4.90	-	-	-	-
	K_2 [x 10⁴ Nm/rad]	0.24	0.44	0.71	1.30	3.00	-	-	-	-
	K_1 [x 10⁴ Nm/rad]	0.19	0.34	0.57	1.00	2.40	-	-	-	-
i = 50	K_3 [x 10⁴ Nm/rad]	0.57	1.30	2.30	4.40	9.80	18.0	26.0	34.0	54.0
	K_2 [x 10⁴ Nm/rad]	0.47	1.10	1.80	3.40	7.80	14.0	20.0	28.0	44.0
	K_1 [x 10⁴ Nm/rad]	0.34	0.81	1.30	2.50	5.40	10.0	15.0	20.0	31.0
i ≥ 80	K_3 [x 10⁴ Nm/rad]	0.71	1.60	2.90	5.70	12.0	23.0	33.0	44.0	71.0
	K_2 [x 10⁴ Nm/rad]	0.61	1.40	2.50	5.00	11.0	20.0	29.0	40.0	61.0
	K_1 [x 10⁴ Nm/rad]	0.47	1.00	1.60	3.10	6.70	13.0	18.0	25.0	40.0

Output bearing

• Rating table

Table 2.3.6

	Symbol [Unit]	Size 14	17	20	25	32	40	45	50	58
Bearing type[1)]		C	C	C	C	C	C	C	C	C
Pitch circle diameter	d_p [m]	0.0465	0.0590	0.0700	0.0880	0.1140	0.1340	0.1500	0.1710	0.1920
Distance[2)]	R [m]	0.014	0.014	0.016	0.018	0.020	0.026	0.024	0.028	0.029
Dynamic load rating	C [N]	8250	10700	21000	21800	34500	43300	77600	81600	87400
Static load rating	C_0 [N]	11400	14800	27000	35800	59000	81600	135000	149000	171000
Permissible dynamic tilting moment[3,4)]	M [Nm]	73	114	172	254	578	886	1253	1558	2222
Permissible static tilting moment[4)]	M_0 [Nm]	155	276	603	1050	2242	3645	6750	8493	10944
Tilting moment stiffness[5)]	K_B [Nm/arcmin]	23	40	70	114	350	522	749	1020	1550
Permissible axial load[4)]	F_a [N]	2030	2286	4486	5298	9357	10361	20018	20830	22218
Permissible radial load[4)]	F_r [N]	1360	1532	3006	3550	6269	6942	13412	13956	14886

1) Bearing type C = Crossed roller bearing; F = Four point contact bearing
2) Distance between the centre of the rolling bearing and the screw mounting surface on the output side, see chapter Gear dimensioning.
3) These values are valid for moving gears. They are not based on the equation for lifetime of the output bearing but on the maximum allowable deflection of the Harmonic Drive® Gear Component Set. The values indicated in the table must not be exceeded even if the lifetime equation of the bearing permits higher values.
4) These data are valid for M: $F_a = 0, F_r = 0$ I F_a: $M = 0, F_r = 0$ I F_r: $M = 0, F_a = 0$
5) The value of tilting moment stiffness is the average value (± 20 %).

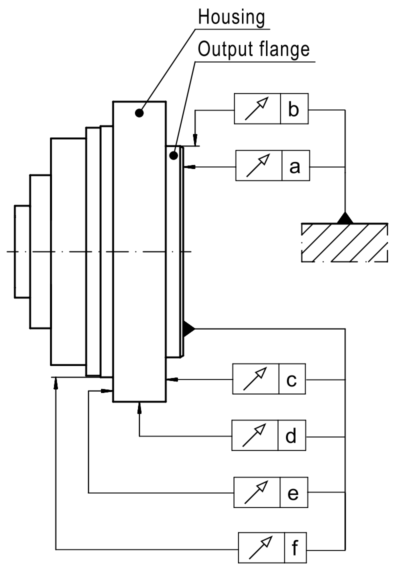
- Output bearing and housing tolerances

Data applies to rotating output flange.

Table 2.3.7 [mm]

Symbol	Size 14	17	20	25	32	40	45	50	58
a (axial runout)	0.010	0.010	0.010	0.010	0.012	0.012	0.012	0.015	0.015
b (radial runout)	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
c	0.010	0.010	0.010	0.010	0.012	0.012	0.012	0.015	0.015
d	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
e	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
f	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015

Illustration 2.3.1



Assembly

- Screw connection

Screw connection on the output side

Table 2.3.8

	[Unit]	Size 14	17	20	25	32	40	45	50	58
Number of screws		12	12	12	12	12	12	12	12	12
Size of screws		M3	M4	M4	M5	M6	M8	M10	M10	M10
Pitch circle diameter	[mm]	43	52	62	76	96	118	135	152	175
Screw tightening torque	[Nm]	2.3	5.1	5.1	10.0	17.4	42.2	83.0	83.0	83.0
Torque transmitting capacity	[Nm]	85	188	228	463	847	1964	3621	4086	4688

12.9 quality screws, friction coefficient μ = 0.15

Screw connection on the housing side

Table 2.3.9

	[Unit]	Size 14	17	20	25	32	40	45	50	58
Number of screws		8	12	12	12	12	12	12	12	12
Size of screws		M3	M3	M3	M4	M5	M6	M8	M8	M10
Pitch circle diameter	[mm]	68	80	89	105	135	168	190	206	236
Screw tightening torque	[Nm]	2.3	2.3	2.3	5.1	10.0	17.4	42.2	42.2	83.0
Torque transmitting capacity	[Nm]	89	158	177	378	805	1482	3158	3419	6317

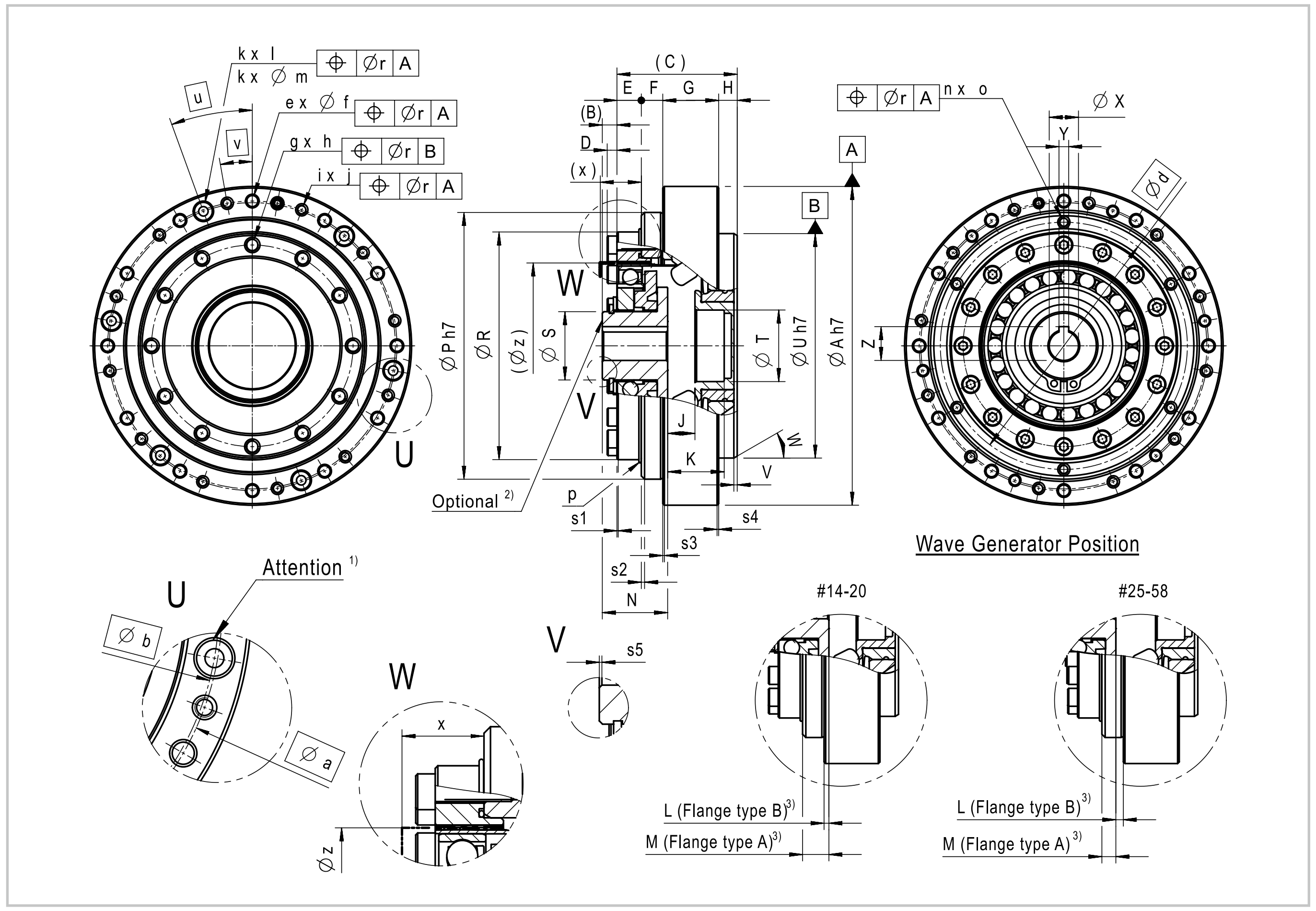
12.9 quality screws, friction coefficient μ = 0.15

Technical data CPU-M

• Dimensions

Illustration 2.3.2

CPU-M [mm]



1) Countersunk hole only for motor adaptation, do not use for load!
2) Hub without keyway or with other diameter see chapter "Engineering data".
3) Explanations see Illustration 2.3.10

Table 2.3.10

CPU-M [mm]

Symbol		Size 14	17	20	25	32	40	45	50	58
ØA h7		78	88	98	116	148	180	206	222	255
B		5.00	6.00	4.5	3.00	2.00	2.00	1.50	1.05	2.50
C		27.0	31.0	37.0	43.0	54.0	63.5	66.5	77.5	84.0
D		3	3	3	4	5	6	8	8	10
E		6.0	6.5	7.5	10.0	14.0	17.0	19.0	22.0	25.0
F		4.0	6.0	6.6	7.5	9.5	10.0	8.5	12.5	11.0
G		12.0	13.5	17.2	19.0	24.0	29.0	32.0	35.0	41.0
H		5.0	5.0	5.7	6.5	6.5	7.5	7.0	8.0	7.0
J		6.7	8.0	8.4	10.8	14.8	16.5	21.1	22.0	29.8
K		12.2	15.5	17.4	21.8	29.8	33.5	36.1	42.0	47.3
L		$2.6^{+0.4}_{0}$	$1.0^{+0.45}_{0}$	$1.5^{+0.5}_{0}$	$0.3^{0}_{-0.5}$	$3.5^{0}_{-0.55}$	$1.5^{0}_{-0.55}$	$1.1^{0}_{-0.6}$	$3.5^{0}_{-0.65}$	$3.6^{0}_{-0.65}$
M		$6.6^{+0.4}_{0}$	$7.0^{+0.45}_{0}$	$8.1^{+0.5}_{0}$	$7.2^{+0.5}_{0}$	$6.0^{+0.55}_{0}$	$8.5^{+0.55}_{0}$	$7.4^{+0.6}_{0}$	$9.0^{+0.65}_{0}$	$7.4^{+0.65}_{0}$
N		$17.6^{0}_{-0.1}$	$19.5^{0}_{-0.1}$	$20.1^{0}_{-0.1}$	$20.2^{0}_{-0.1}$	$22.0^{0}_{-0.1}$	$27.5^{0}_{-0.1}$	$27.9^{0}_{-0.1}$	$32.0^{0}_{-0.1}$	$34.9^{0}_{-0.1}$
Ø P h7		60	72	82	96	125	154	175	190	217
Ø R		$50^{0,01}_{-0,015}$	$60^{0,01}_{-0,02}$	$70^{0,01}_{-0,02}$	$85^{0,01}_{-0,025}$	$110^{0,01}_{-0,025}$	$135^{0,01}_{-0,03}$	$155^{0,01}_{-0,025}$	$170^{0,02}_{-0,02}$	$195^{0,03}_{-0,016}$
Ø S		14	18	21	26	26	32	32	32	40
Ø T		16	19	22	26	37	42	47	52	72
ØU h7		49	59	69	84	110	132	152	168	193
V		0.4	0.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0
W [°]		30	30	30	30	30	30	30	30	30
Ø X H7		6	8	9	11	14	14	19	19	22
Y JS9		-	-	3	4	5	5	6	6	6
Z		-	-	$10.4^{+0.1}_{0}$	$12.8^{+0.1}_{0}$	$16.3^{+0.1}_{0}$	$16.3^{+0.1}_{0}$	$21.8^{+0.1}_{0}$	$21.8^{+0.1}_{0}$	$24.8^{+0.1}_{0}$
Ø a		68	80	89	105	135	168	190	206	236
Ø b		68	78	88	105	135	165	190	206	234
Ø c		43	52	62	76	96	118	135	152	175
Ø d		55.0	66.0	76.0	91.0	118.0	144.0	164.5	180.0	206.0
e		8	12	12	12	12	12	12	12	12
Ø f		3.4	3.4	3.4	4.5	5.5	6.6	9.0	9.0	11.0
g		12	12	12	12	12	12	12	12	12
h		M3 x 6	M4 x 8	M4 x 8	M5 x 10	M6 x 10	M8 x 14	M10 x 14	M10 x 16	M10 x 15
i		8	12	12	12	12	12	12	12	12
j		M3	M3	M3	M4	M5	M6	M8	M8	M10
k		4	6	6	6	6	6	6	6	6
l		Ø 5.5 x 3.0	Ø 5.5 x 3.0	Ø 5.5 x 3.0	Ø 6.5 x 3.4	Ø 8 x 4.4	Ø 10 x 6.0	Ø 11 x 6.8	Ø 11 x 6.4	Ø 15 x 9.0
Ø m		2.9	2.9	2.9	3.4	4.5	5.5	6.6	6.6	9.0
n		6	6	6	6	6	6	8	6	8
o		M2.5 x 5	M3 x 6	M3 x 6	M3 x 6	M4 x 8	M5 x 10	M5 x 10	M6 x 12	M6 x 12
p (O ring)		49.9 x 0.80	59.28 x 0.78	69 x 1.00	83 x 1.00	108 x 1.00	133 x 1.50	150 x 1.50	165 x 1.50	193 x 1.50
Ø r		0.25	0.25	0.3	0.3	0.4	0.5	0.5	0.5	0.5
s1		0.4 x 45 °	0.4 x 45 °	0.4 x 45 °	0.4 x 45 °	0.4 x 45 °	0.4 x 45 °	0.4 x 45 °	0.4 x 45 °	0.4 x 45 °
s2		0.8 x 45 °	0.8 x 45 °	1.0 x 45 °	1.0 x 45 °	1.0 x 45 °	1.0 x 45 °	1.0 x 45 °	1.0 x 45 °	1.0 x 45 °
s3		0.4 x 45 °	0.4 x 45 °	0.5 x 45 °	0.5 x 45 °	0.5 x 45 °	0.5 x 45 °	0.5 x 45 °	0.5 x 45 °	0.5 x 45 °
s4		0.4 x 45 °	0.4 x 45 °	0.5 x 45 °	0.5 x 45 °	0.5 x 45 °	0.5 x 45 °	0.5 x 45 °	0.5 x 45 °	0.5 x 45 °
s5		0.5 x 45 °	0.5 x 45 °	0.4 x 45 °	0.4 x 45 °	0.4 x 45 °	0.4 x 45 °	0.4 x 45 °	0.4 x 45 °	0.4 x 45 °
u [°]		30	20	20	20	20	20	20	20	20
v [°]		15	10	10	8	10	10	10	10	10
Minimum housing clearance	x	7.0	7.5	9.0	11.5	15.5	19.0	21.0	24.0	27.5
	Ø z	38	45	53	66	86	106	119	133	154

CAD drawings for download: www.harmonicdrive.co.uk

Wave Generator Details

Illustration 2.3.3

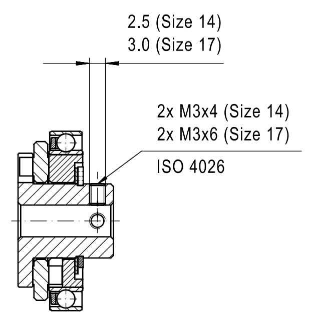
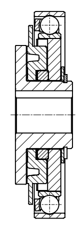
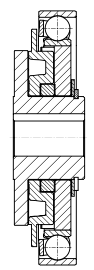


Illustration 2.3.4



Wave Generator
for CPU-M sizes 20, 25, 32, 45, 58

Illustration 2.3.5



Wave Generator
for CPU-M sizes 40, 50

• No load starting torque

Table 2.3.11 **[Ncm]**

Ratio	Size								
	14	17	20	25	32	40	45	50	58
30	6.4	9.3	15.0	25.0	54.0	-	-	-	-
50	4.1	6.1	7.8	15.0	31.0	55.0	77.0	110.0	160.0
80	2.8	4.0	4.9	9.2	19.0	35.0	49.0	66.0	98.0
100	2.5	3.4	4.3	8.0	18.0	31.0	43.0	58.0	88.0
120	-	3.1	3.8	7.3	15.0	28.0	39.0	52.0	80.0
160	-	-	3.3	6.3	14.0	24.0	33.0	45.0	68.0

• No load back driving torque

Table 2.3.12 **[Nm]**

Ratio	Size								
	14	17	20	25	32	40	45	50	58
30	2.4	3.8	6.2	11.0	23.0	-	-	-	-
50	1.6	3.0	4.7	9.0	18.0	33.0	47.0	62.0	95.0
80	1.6	3.0	4.8	9.1	19.0	33.0	48.0	63.0	96.0
100	1.8	3.3	5.1	9.8	20.0	36.0	51.0	68.0	110.0
120	-	3.5	5.5	11.0	22.0	39.0	55.0	73.0	110.0
160	-	-	6.4	13.0	26.0	46.0	64.0	85.0	130.0

• Accuracy of the Oldham coupling

Harmonic Drive® Gears are zero backlash. If an Oldham coupling is used, a small backlash in the range of a few seconds of arc occurs outside the tooth engagement, see Table 2.3.13. This small amount of backlash does not occur with a Solid Wave Generator.

Table 2.3.13 **[arcsec]**

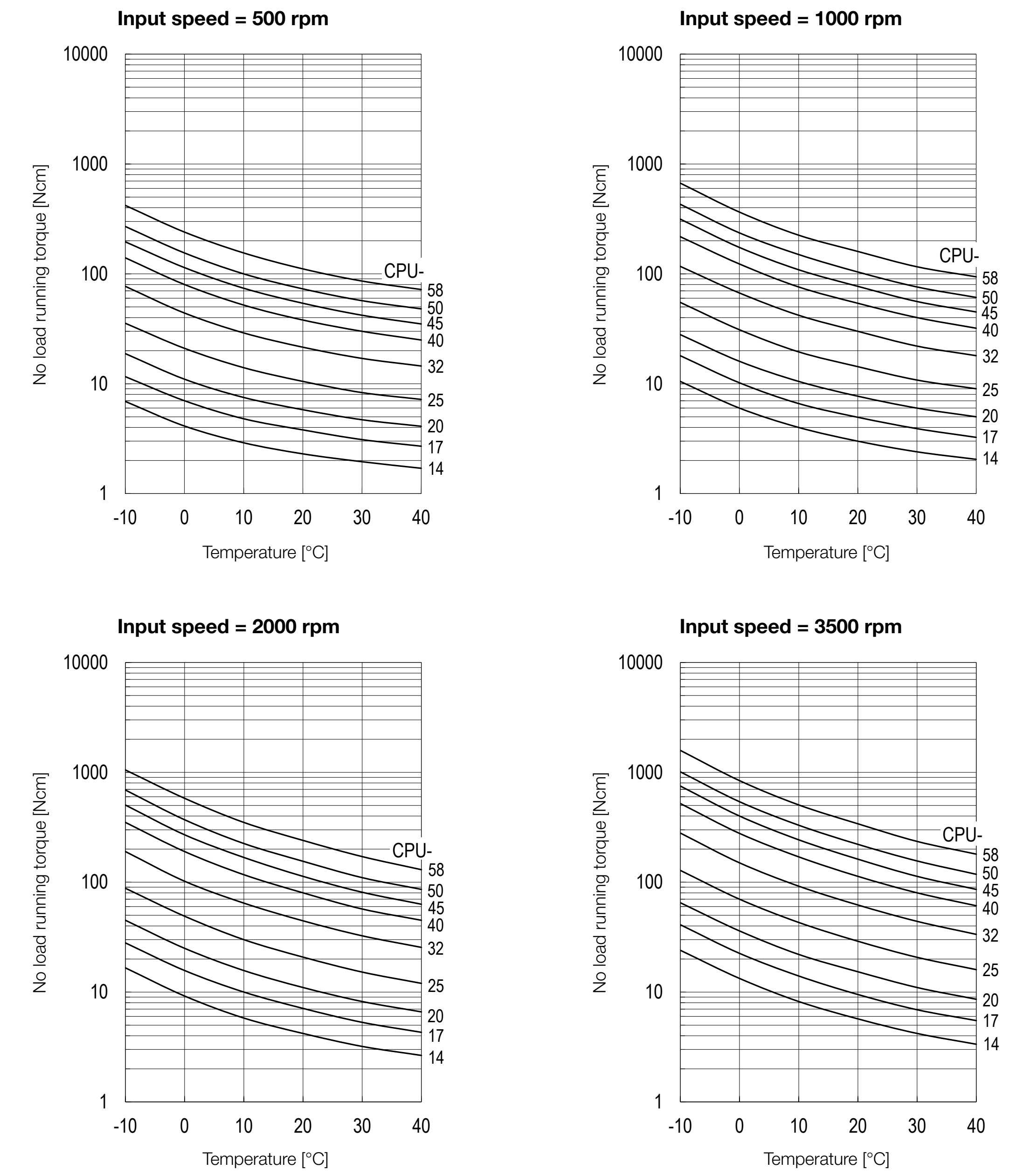
Ratio	Size								
	14	17	20	25	32	40	45	50	58
30	60	33	28	28	23	-	-	-	-
50	36	20	17	17	14	14	12	12	10
80	23	13	11	11	9	9	8	8	6
100	18	10	9	9	7	7	6	6	5
120	-	8	8	8	6	6	5	5	4
160	-	-	6	6	5	5	4	4	3

i You will find more information on this in the Engineering data chapter.

• No load running torque

The diagrams apply to Harmonic Drive® Flexolub®-A1.

Illustration 2.3.6



Compensation values for no load running torque

When using gears with ratios other than i = 100 please add the compensation values from the table to the values taken from the curves.

Table 2.3.14 **[Ncm]**

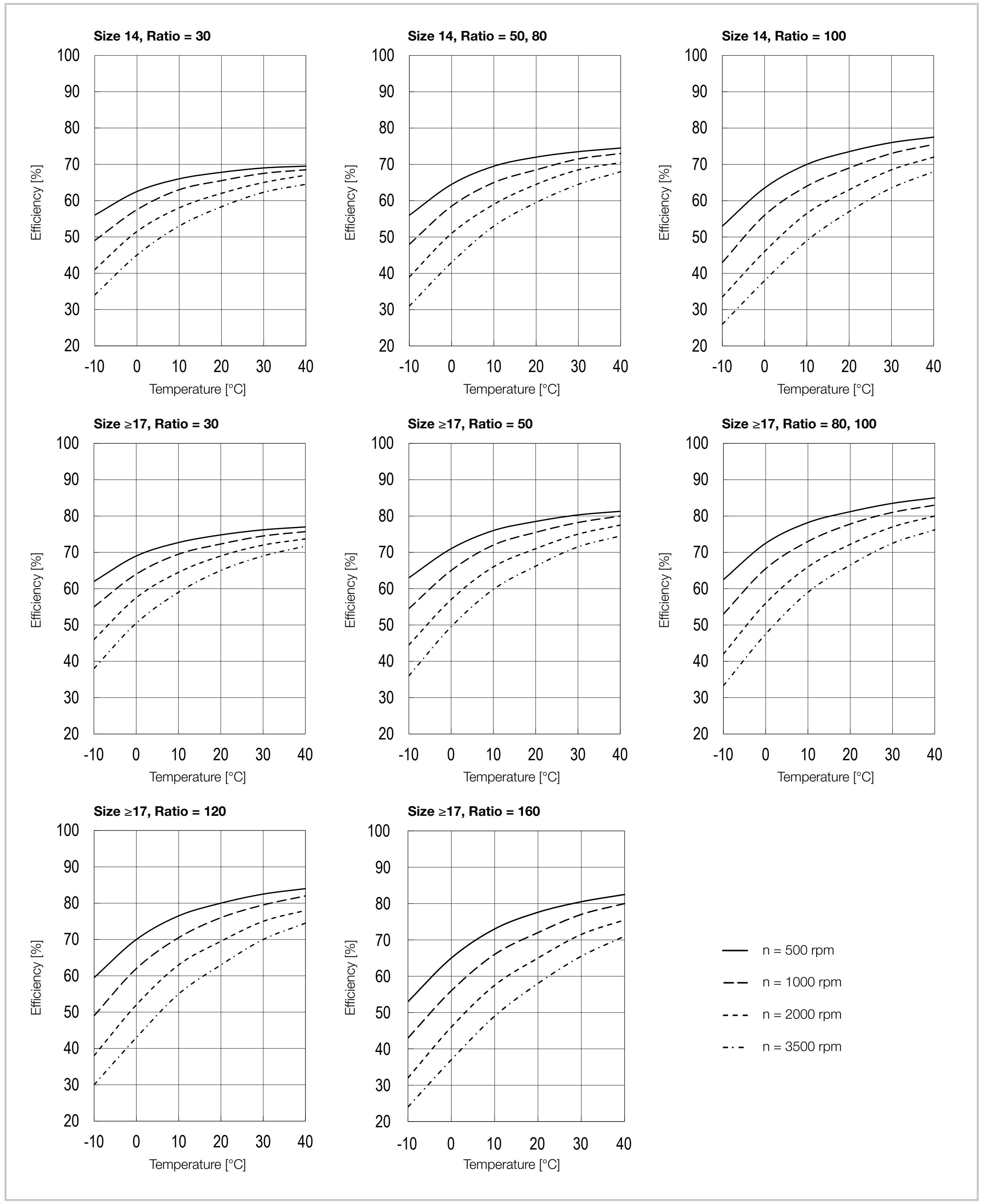
Ratio	Size								
	14	17	20	25	32	40	45	50	58
30	2.5	3.8	5.4	8.8	16.0	-	-	-	-
50	1.1	1.6	2.3	3.8	7.1	12.0	16.0	21.0	30.0
80	0.2	0.3	0.5	0.7	1.3	2.1	2.9	3.7	5.3
120	-	-0.2	-0.3	-0.5	-0.9	-1.5	-2.1	-2.6	-3.8
160	-	-	-0.8	-1.2	-2.2	-3.5	-4.9	-6.2	-8.9

• Efficiency

Efficiency for grease lubrication at rated torque

The diagrams apply to Harmonic Drive® Flexolub®-A1.

Illustration 2.3.7



You will find more information on this in the Engineering data chapter.

Efficiency calculation

The efficiency depends on the following parameters: Gear ratio, input speed, load torque, temperature, lubricant and lubricant quantity. If the load torque is lower than the rated torque, the efficiency will be lower than the efficiency indicated in the efficiency curves. The torque specific efficiency is determined by means of the calculation factor K.

Calculation example:

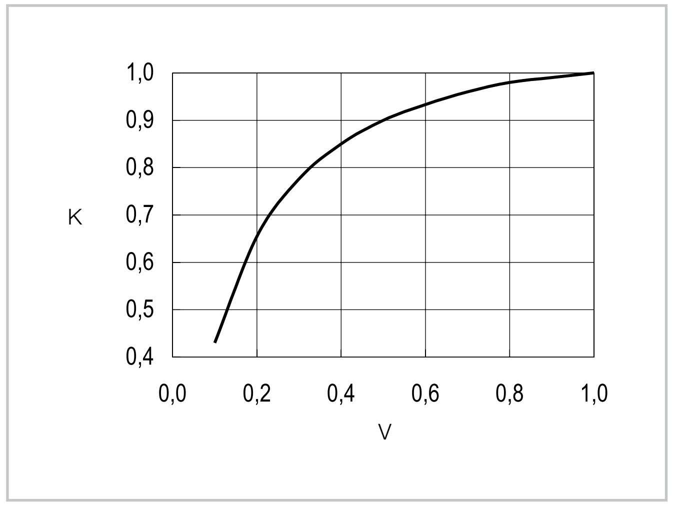
CPU-20A-80-M

- Input speed: 1000 rpm
- (Average) load torque T_{av}: 20 Nm
- Rated torque T_N (catalogue reference): 34 Nm
- Grease lubrication with Harmonic Drive® Grease lubricant temperature: 20 °C.

1. Calculation of the torque factor
   $V = T_{av}/T_N = 20/34 = 0.59$ (For V>1 is K=1)
2. Reading the calculation factor K from diagram Illustration 2.3.8: K = 0.93
3. Reading the efficiency from the efficiency curve Illustration 2.3.7: η = 78 %
4. Calculation of the load dependant efficiency
   $\eta_L = 78\ \% \cdot 0.93 = 73\ \%$

Illustration 2.3.8

Calculation factor K



Assembly tolerances

We recommend to consider the tolerances below when assembling:

Illustration 2.3.9

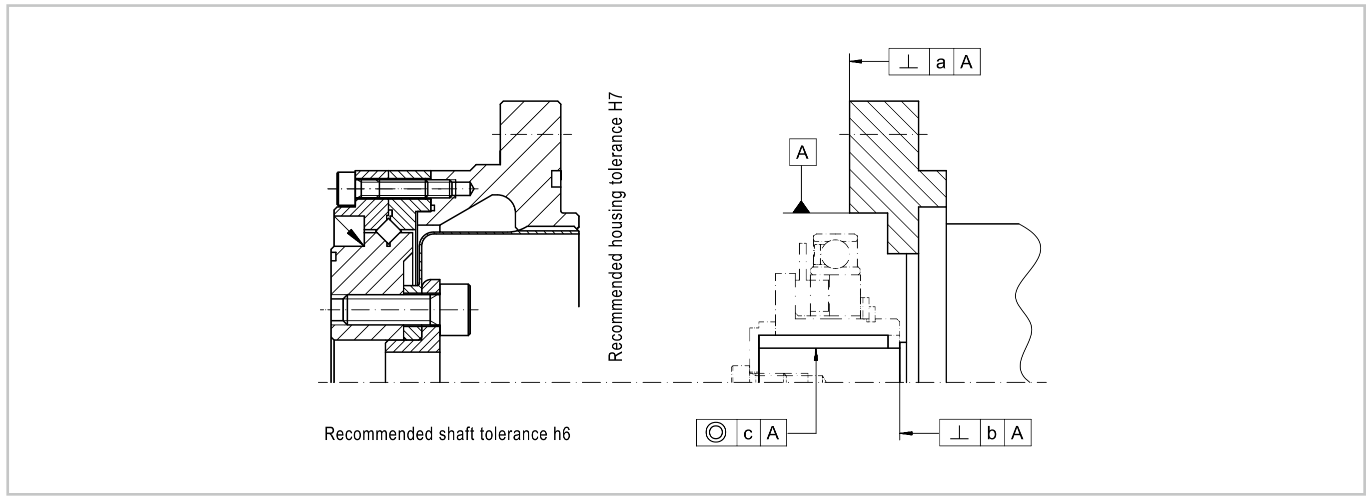


Table 2.3.15 **[mm]**

Symbol	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	0.032	0.032	0.032	0.032
	(0.008)	(0.010)	(0.010)	(0.012)	(0.012)	(0.012)	(0.013)	(0.015)	(0.015)
c	0.030	0.034	0.044	0.047	0.050	0.063	0.065	0.066	0.068
	(0.016)	(0.018)	(0.019)	(0.022)	(0.022)	(0.024)	(0.027)	(0.030)	(0.033)

The values in brackets are recommended tolerances for a Wave Generator without Oldham coupling. This coupling is used to compensate for eccentricity errors of the motor shaft and is installed in the standard gear. In case of a direct coupling of the Wave Generator on the motor shaft without Oldham coupling (option), the motor shaft tolerances should correspond to DIN 42955 R.

Adapter flange

The CPU-M Series Gears are designed as motor mounted gears. Please indicate the motor type to be adapted when ordering, therefore the Wave Generator can be manufactured to fit your motor. Depending on the size of the motor in relation to the gear, the most suitable adapter flange type should be selected, see Illustration 2.3.10 for an example.

Illustration 2.3.10

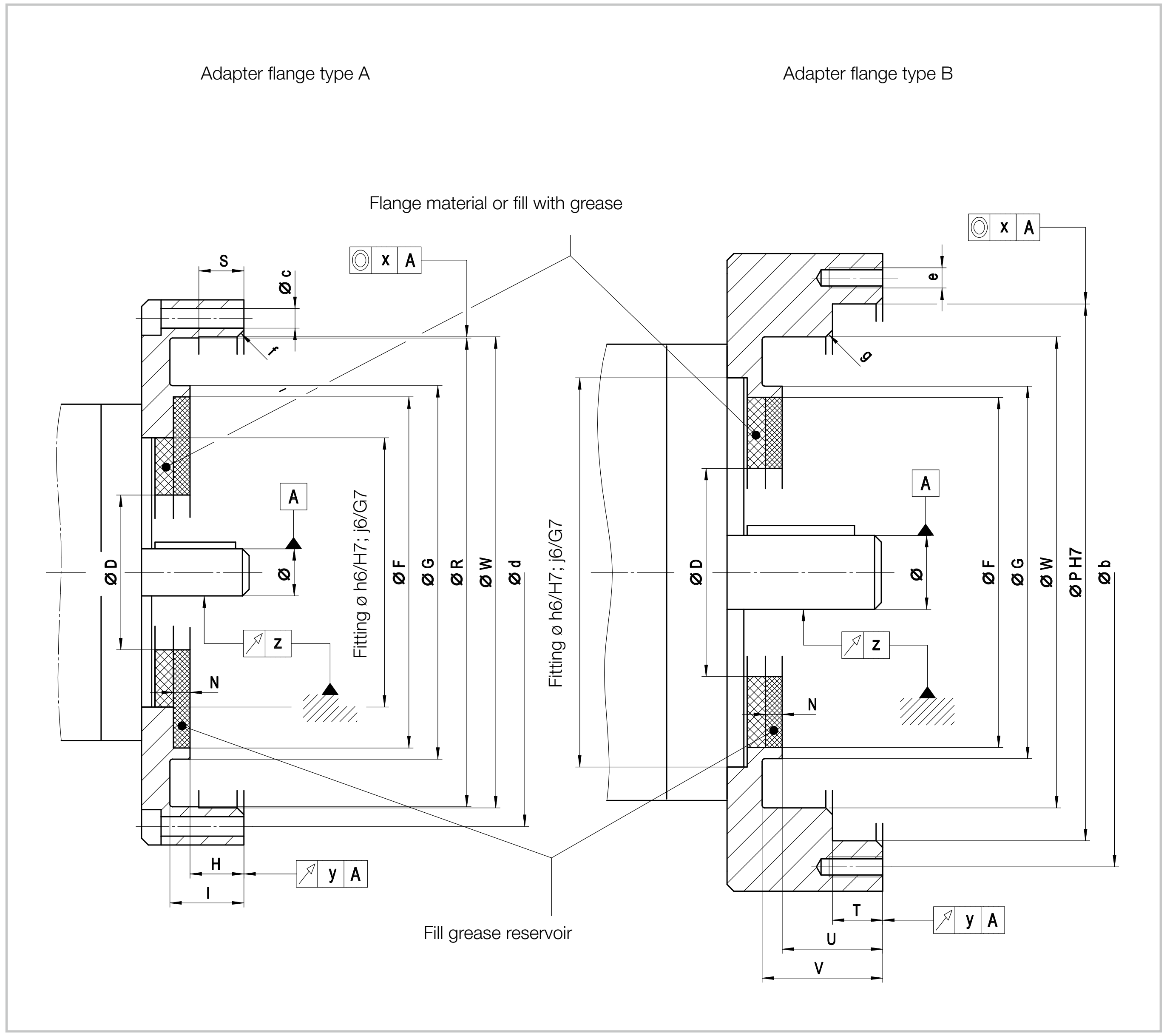


Table 2.3.16

Symbol	Size 14	17	20	25	32	40	45	50	58
Ø D	16	26	30	37	37	45	45	45	56
Ø F	36.5	47.0	53.0	66.0	86.0	106.0	120.0	131.0	154.0
Ø $G_{-0,1}$	37.5	48.0	55.5	69.0	90.5	110.0	125.0	139.0	160.0
$H^{+0,1}$	6.5	7.0	8.0	10.5	14.5	18.0	20.0	23.0	26.0
$I^{+0,1}$	9.5	10.0	11.0	14.5	19.5	24.0	28.0	31.0	36.0
N	1.0	1.5	1.5	1.5	1.5	2.0	3.0	4.0	4.0
ØP H7	60	72	82	96	125	154	175	190	217
Ø R	$50^{+0.027}$	$60^{+0.034}$	$70^{+0.036}$	$85^{+0.050}$	$110^{+0.055}$	$135^{+0.065}$	$155^{+0.070}$	$170^{+0.075}$	$195^{+0.091}$
S	2.5	3.0	3.0	5.0	6.5	11.0	12.0	16.0	19.0
$T^{+0,1}$	4.3	6.3	6.9	7.8	9.8	10.3	8.8	12.8	11.3
$U^{+0,1}$	10.5	13.0	14.6	18.0	24.0	28.0	28.5	35.5	37.0
$V^{+0,1}$	13.5	16.0	17.6	22.0	29.0	34.0	36.5	43.5	47.0
Ø $W^{+0,1}$	50.4	60.4	70.4	85.4	110.4	135.4	155.4	170.4	195.4
Ø b	68	78	88	105	135	165	190	206	234
Ø c	2.9	3.4	3.4	3.4	4.5	5.5	5.5	6.6	6.6
Ø d	55	66	76	91	118	144	164.5	180	206
e	M2.5	M2.5	M2.5	M3	M4	M5	M6	M6	M8
$f_{-0,1}$	1.0	1.3	1.3	1.3	1.3	2.0	2.0	2.0	2.0
$g_{-0,1}$	0.7	1.0	1.0	1.0	1.0	1.7	1.7	1.7	1.7
x	0.030	0.034	0.044	0.047	0.050	0.063	0.065	0.066	0.068
y	0.030	0.040	0.040	0.040	0.040	0.050	0.050	0.050	0.050
z	0.030	0.034	0.044	0.047	0.050	0.063	0.065	0.066	0.068
	(0.016)	(0.018)	(0.019)	(0.022)	(0.022)	(0.024)	(0.027)	(0.030)	(0.033)

All data given in the table are valid for adapter flanges mounted to the motor. The values in brackets are recommended tolerances for a Wave Generator without Oldham coupling. This coupling is used to compensate for eccentricity errors of the motor shaft and is installed in the standard gear. In case of a direct coupling of the Wave Generator on the motor shaft without Oldham coupling (option), the motor shaft tolerances should correspond to DIN 42955 R.

Assembly

We recommend the following assembly sequence.

Illustration 2.3.11 **Adapter flange type A**

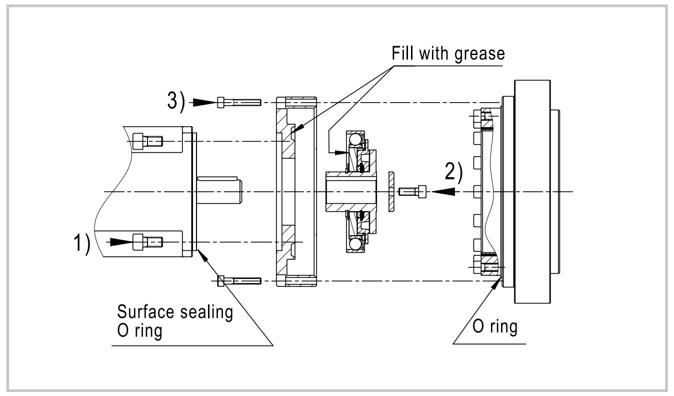


Illustration 2.3.12 **Adapter flange type B**

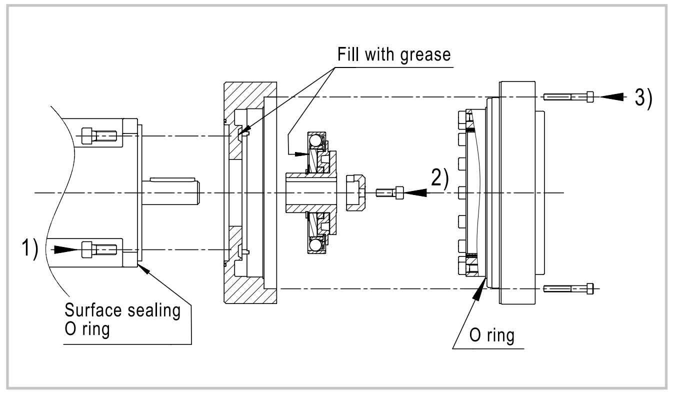
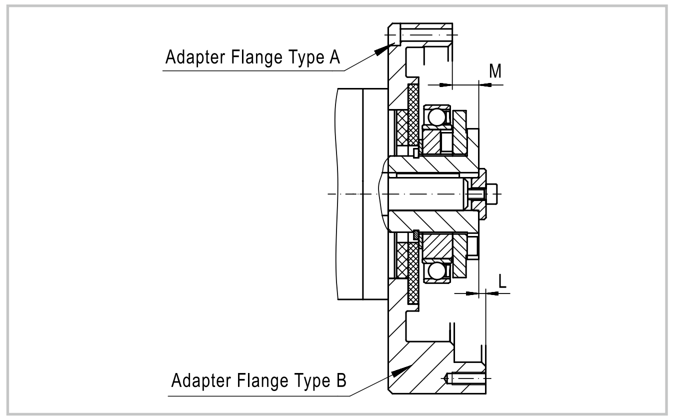
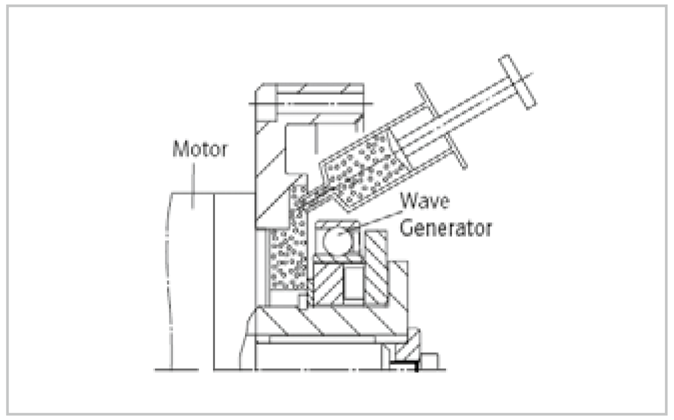


Illustration 2.3.13



The prescribed axial position of the Wave Generator, dimension M or L according to Illustration 2.3.13, is given in the customer confirmation drawing.

Illustration 2.3.14



Grease reservoir

When using the flange design recommended by Harmonic Drive SE, the gear can be used in all operating positions. We recommend placing an additional amount of grease in the grease reservoir between the Wave Generator and the end shield of the motor during assembly, see Illustration 2.3.14. This additional amount of grease is supplied in separate packaging.

Table 2.3.17

	[Unit]	Size								
		14	17	20	25	32	40	45	50	58
Standard grease quantity (included in gear component set on delivery)	ca. [g]	5.5	10	16	40	60	130	180	260	360
	ca. [cm³]	6	11	18	44	66	143	198	286	396
Recommended additional grease quantity for grease reservoir (supplied in separate packaging)	ca. [g]	2	3	4	6	14	27	54	90	108
	ca. [cm³]	2	3	4	7	16	30	60	100	120

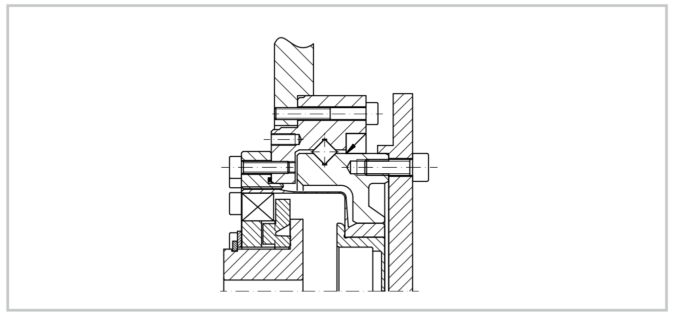
Table 2.3.18

Ordering code for grease	Available packages [kg]
Special grease Flexolub®-A1	1.0; 25

Adaption examples

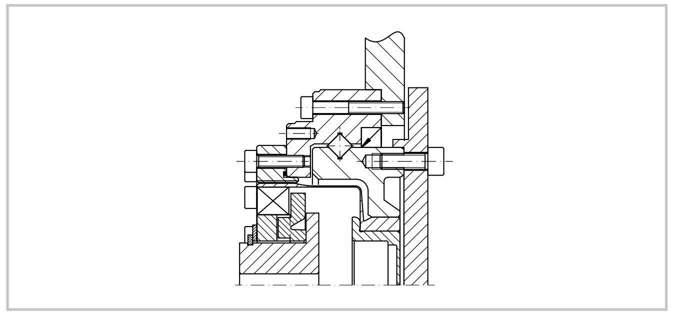
• Housing

Illustration 2.3.15



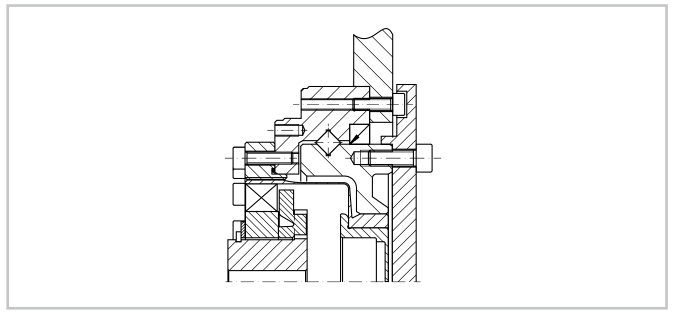
Use of the through holes

Illustration 2.3.16



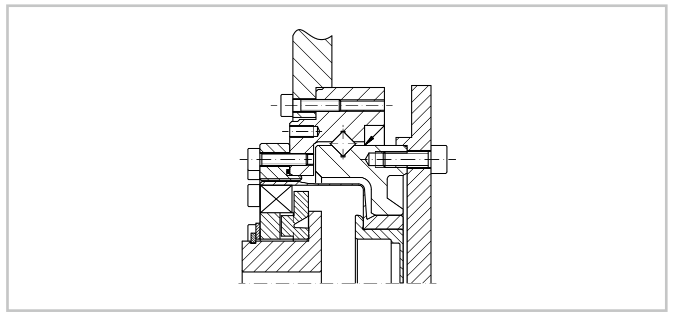
Use of the through holes

Illustration 2.3.17



Use of the threads

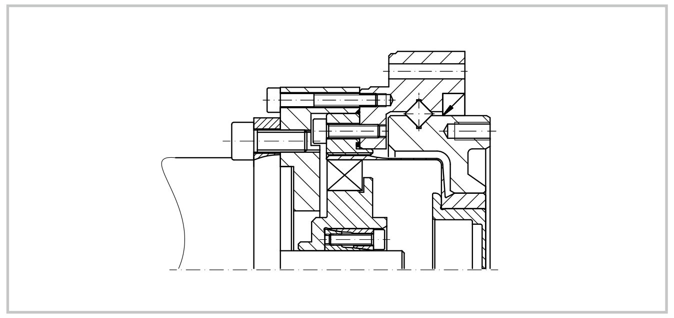
Illustration 2.3.18



Use of the threads

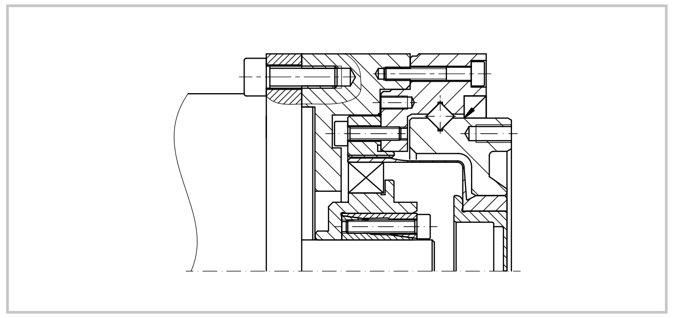
• Motor

Illustration 2.3.19



Small motor, flange type A

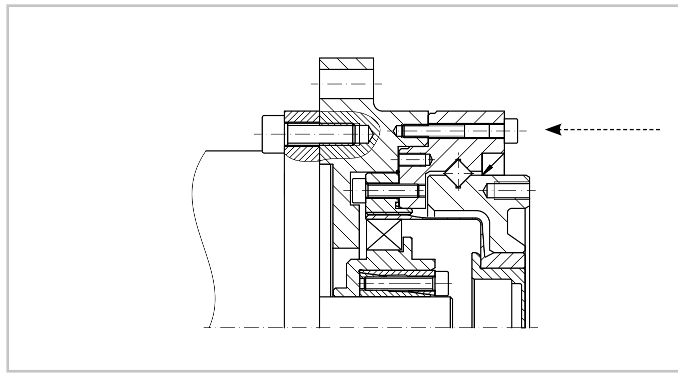
Illustration 2.3.20



Large motor, flange type B

• Individual adaptation for housing and motor

Illustration 2.3.21



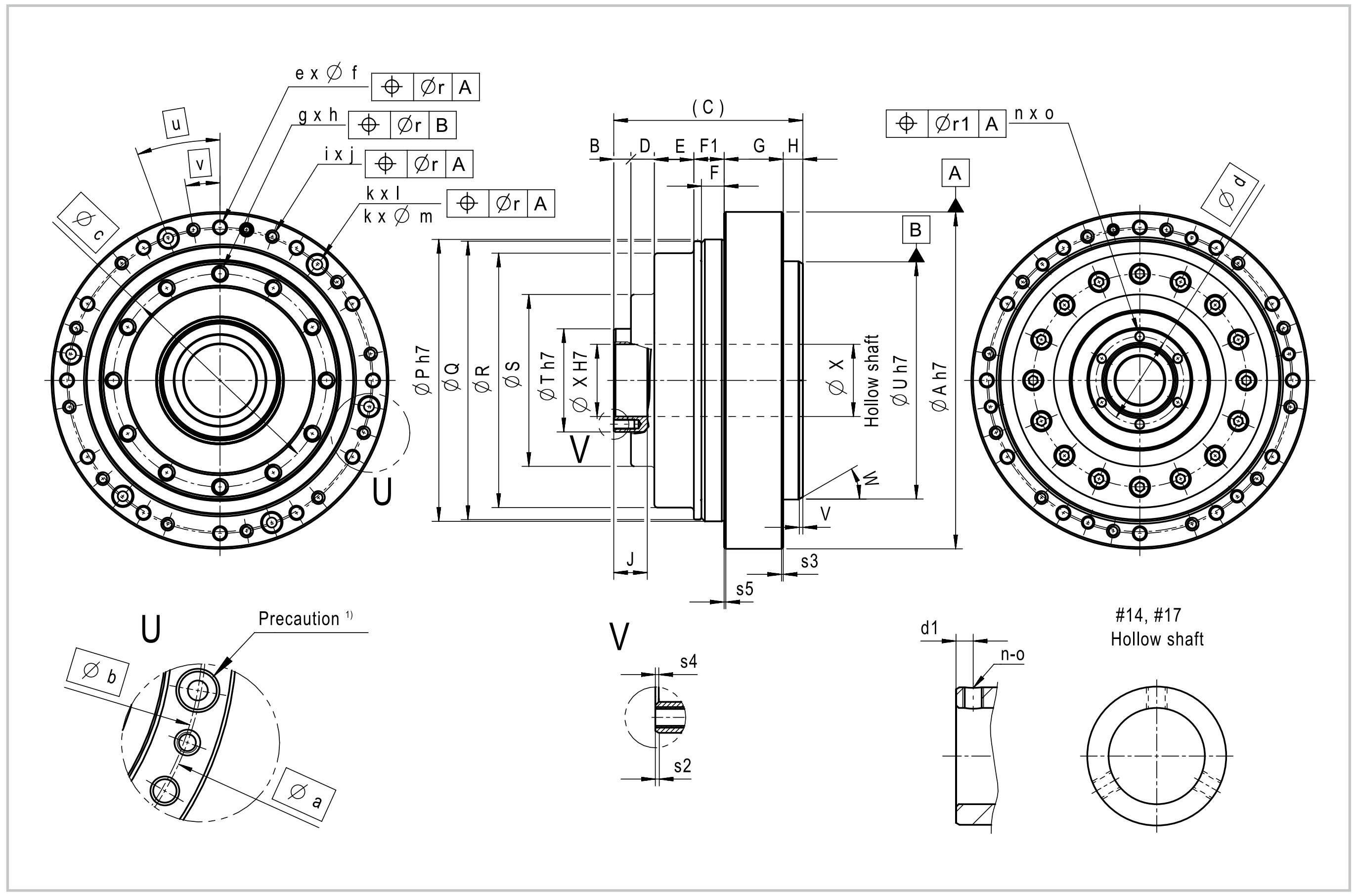
In this case, the through holes must be used, as shown here.
Do not use the countersunk holes!

Any motor, any flange type

Technical data CPU-H

• Dimensions

Illustration 2.3.22 **[mm]**



1) Countersunk hole only for motor adaptation, do not use for load!

Table 2.3.19 **CPU-H [mm]**

Symbol	Size 14	17	20	25	32	40	45	50	58
ØA h7	78	88	98	116	148	180	206	222	255
B	6.5	6.5	5.0	5.0	7.0	8.0	8.0	9.0	10.0
C	46.0	51.5	55.0	59.0	79.0	90.0	90.6	110.5	115.5
D	7.0	8.5	6.8	3.8	8.8	7.3	2.5	9.3	4.0
E	9.8	9.8	11.5	15.0	20.0	24.5	28.9	32.5	38.3
F	4.0	6.0	6.6	7.5	9.5	10.0	8.5	12.5	11.0
F1	5.7	8.2	8.8	9.7	12.7	13.7	12.2	16.7	15.2
G	12.0	13.5	17.2	19.0	24.0	29.0	32.0	35.0	41.0
H	5.0	5.0	5.7	6.5	6.5	7.5	7.0	8.0	7.0
J	10	10	10	12	10	14	15	15	15
ØP h7	60	72	82	96	125	154	175	190	217
ØQ	59.5	71.5	81.0	95.0	124.0	153.0	174.0	189.0	216.0
ØR	53	64	74	89	116	142	162	180	203
ØS	36	42	50	55	80	95	100	120	135
ØT h7	20	25	30	38	45	59	65	75	84
ØU h7	49	59	69	84	110	132	152	168	193
V	0.4	0.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0
W [°]	30	30	30	30	30	30	30	30	30
ØX H7	14	19	21	29	36	46	52	60	70
Øa	68	80	89	105	135	168	190	206	236
Øb	68	78	88	105	135	165	190	206	234
Øc	43	52	62	76	96	118	135	152	175
Ød	-	-	25.5	33.5	40.5	52.0	58.0	67.0	77.0
d1	2.5	2.5	-	-	-	-	-	-	-
e	8	12	12	12	12	12	12	12	12
Øf	3.4	3.4	3.4	4.5	5.5	6.6	9.0	9.0	11.0
g	12	12	12	12	12	12	12	12	12
h	M3x6	M4x8	M4x8	M5x10	M6x10	M8x14	M10x14	M10x16	M10x15
i	8	12	12	12	12	12	12	12	12
j	M3	M3	M3	M4	M5	M6	M8	M8	M10
k	4	6	6	6	6	6	6	6	6
l	Ø 5.5x3	Ø 5.5x3	Ø 5.5x3	Ø 6.5 x 3.4	Ø 8x4.4	Ø 10x6	Ø 11x6.8	Ø 11x6.4	Ø 15x9
Øm	2.9	2.9	2.9	3.4	4.5	5.5	6.6	6.6	9.0
n	3	3	6	6	6	6	6	6	8
o	M3	M3	M3x6	M3x6	M3x6	M4x8	M4x8	M4x8	M4x8
Ør	0.25	0.25	0.30	0.30	0.40	0.50	0.50	0.50	0.50
Ør1	-	-	0.25	0.25	0.25	0.25	0.25	0.25	0.25
s2	0.5x30°	0.5x30°	0.5x30°	0.5x30°	0.5x30°	0.5x30°	0.5x30°	0.5x30°	0.5x30°
s3	0.4x45°	0.4x45°	0.5x45°	0.5x45°	0.5x45°	0.5x45°	0.5x45°	0.5x45°	0.5x45°
s4	0.4x45°	0.4x45°	0.5x45°	0.5x45°	0.5x45°	0.5x45°	0.5x45°	0.5x45°	0.5x45°
s5	0.4x45°	0.4x45°	0.5x45°	0.5x45°	0.5x45°	0.5x45°	0.5x45°	0.5x45°	0.5x45°
u [°]	30	20	20	20	20	20	20	20	20
v [°]	15	10	10	8	10	10	10	10	10

CAD drawings for download: www.harmonicdrive.co.uk

• No load starting torque

Table 2.3.20

[Ncm]

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

• No load back driving torque

Table 2.3.21

[Nm]

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

• Input bearing

The input shaft of the CPU-H Gear is supported by two single row deep groove ball bearings. Illustration 2.3.44 shows the points of application of force of the radial and axial loads given in Table 2.3.22 and Illustration 2.3.24. Example: If the hollow shaft of a CPU-58-H Gear is preloaded with an axial load of 900 N, the max. permissible radial load is 1400 N, see Illustration 2.3.24.

The maximum values shown here apply to an average input speed of 2000 rpm and an average bearing life L_{10} = 7500 h.

Table 2.3.22

	Symbol [Unit]	Size 14	17	20	25	32	40	45	50	58
Distance	B [mm]	6.5	6.5	5.0	5.0	7.0	8.0	8.0	9.0	10.0
Maximum permissible radial load	F_r [N]	204	235	271	306	918	1113	1220	1812	2358

Illustration 2.3.23

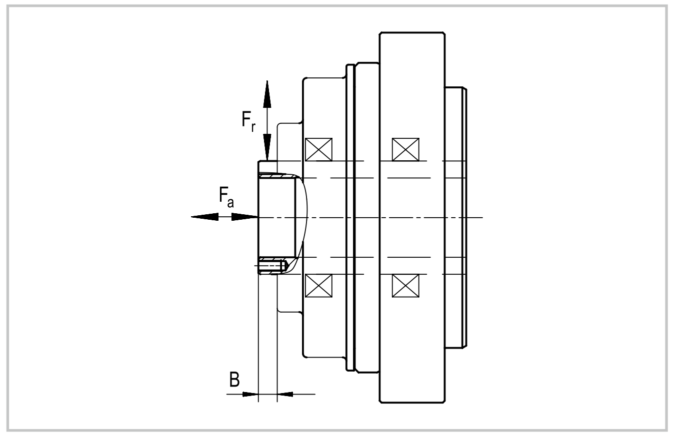
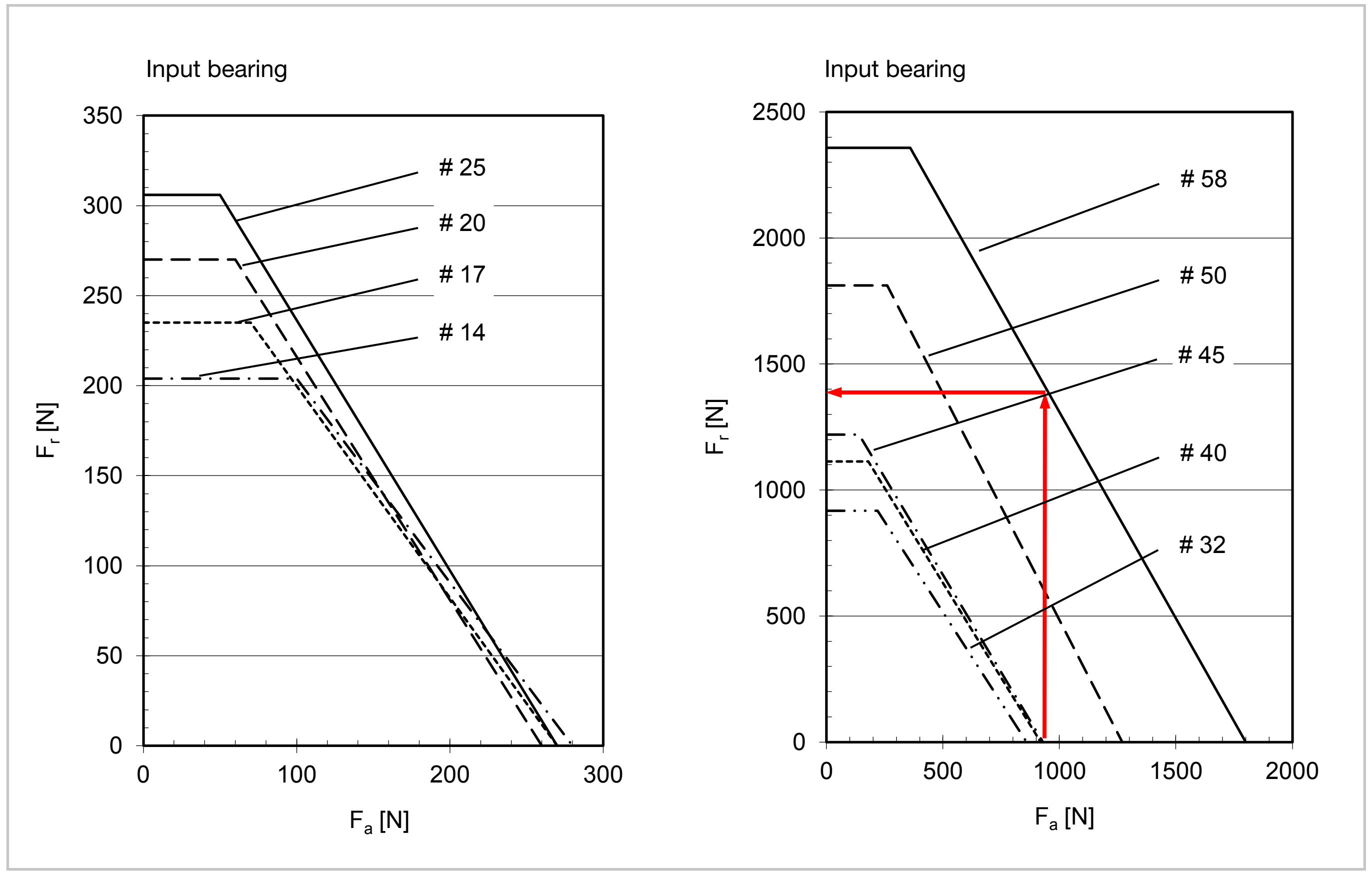


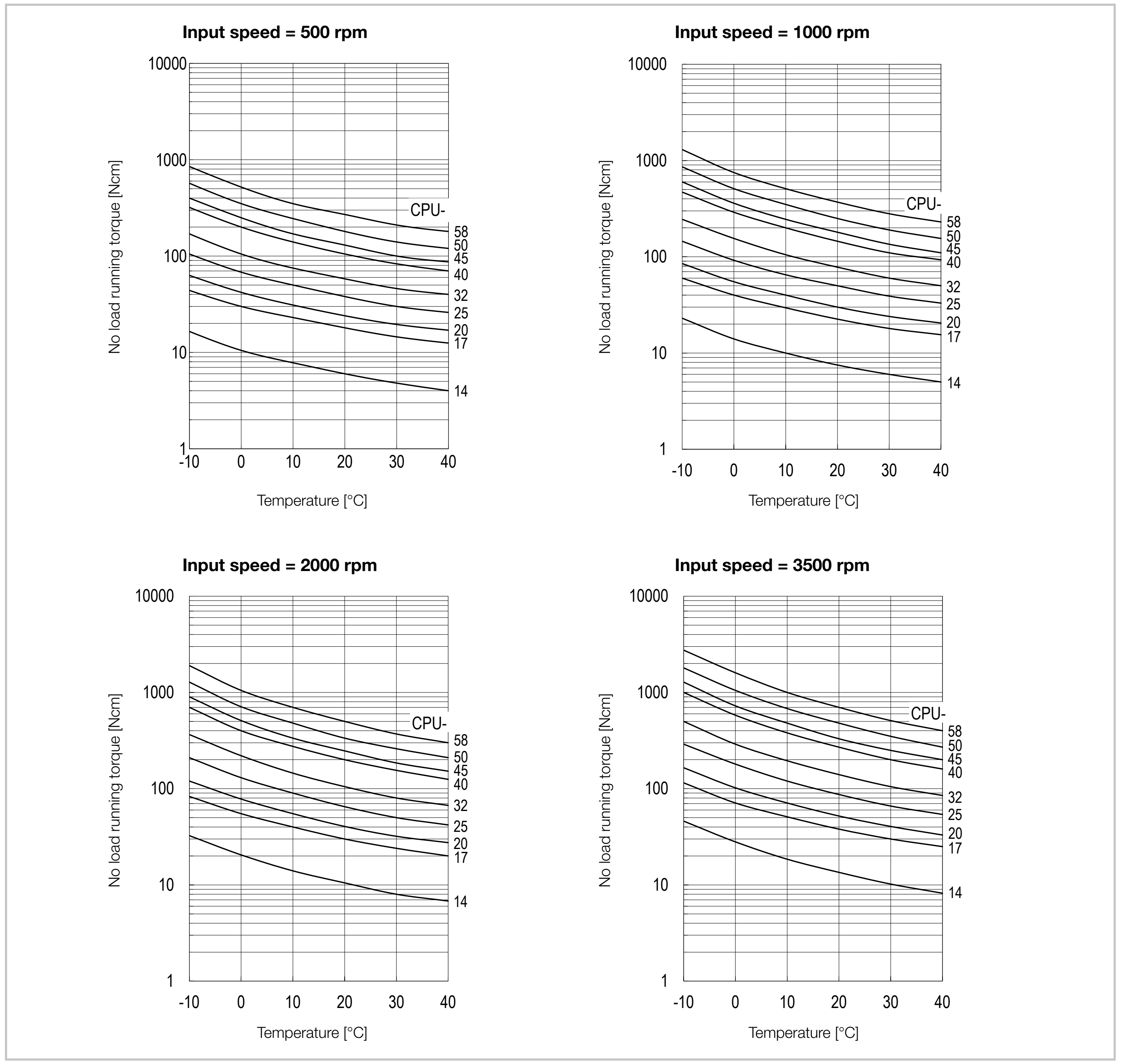
Illustration 2.3.24



No load running torque

The diagrams apply to Harmonic Drive® Flexolub®-A1.

Illustration 2.3.25



Compensation values for no load running torque

When using gears with ratios other than i=100 please add the compensation values from the table to the values taken from the curves.

Table 2.3.23

[Ncm]

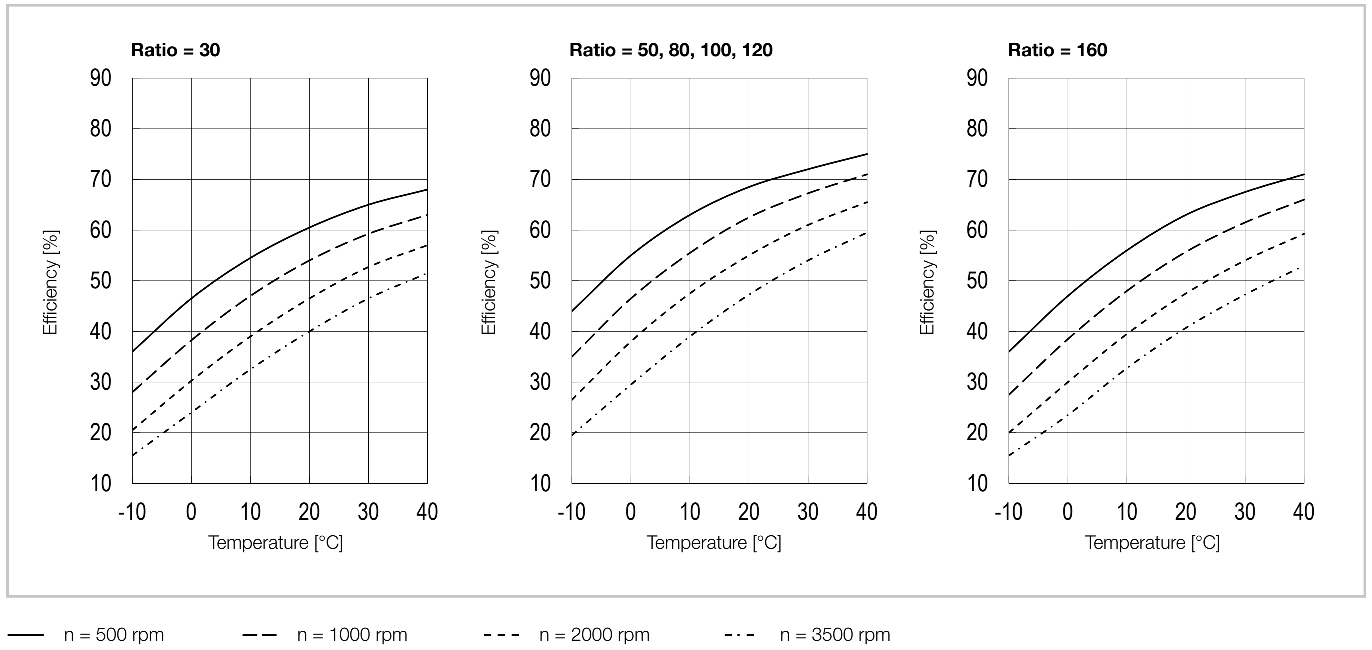
Ratio	Size								
	14	17	20	25	32	40	45	50	58
30	2.6	4.1	5.9	9.6	18.3	-	-	-	-
50	1.1	1.8	2.6	4.2	8.0	13.3	18.2	23.9	34.6
80	0.2	0.4	0.5	0.8	1.5	2.4	2.3	4.3	6.2
120	-	-0.2	-0.4	-0.6	-1.1	-1.7	-2.4	-3.1	-4.4
160	-	-	-0.8	-1.3	-2.5	-4.0	-5.5	-7.2	-10.3

Efficiency

Efficiency for grease lubrication at rated torque

The diagrams apply to Harmonic Drive® Grease Flexolub®-A1.

Illustration 2.3.26

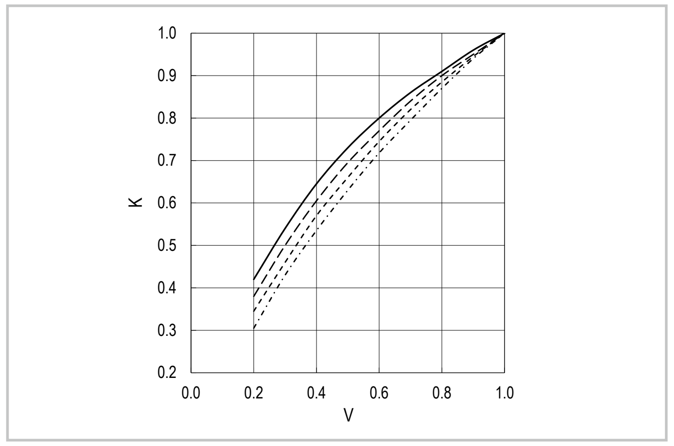


Efficiency calculation

The efficiency depends on the following parameters: Gear ratio, input speed, load torque, temperature, lubricant and lubricant quantity. If the load torque is lower than the rated torque, the efficiency will be lower than the efficiency than that indicated in the efficiency curves. The torque specific efficiency is determined by means of the the calculation factor K. For gears with a bearing mounted and sealed input shaft, the additional reduction in efficiency is taken into account by the correction value η_e.

Illustration 2.3.27

Calculation factor K



Calculation example:

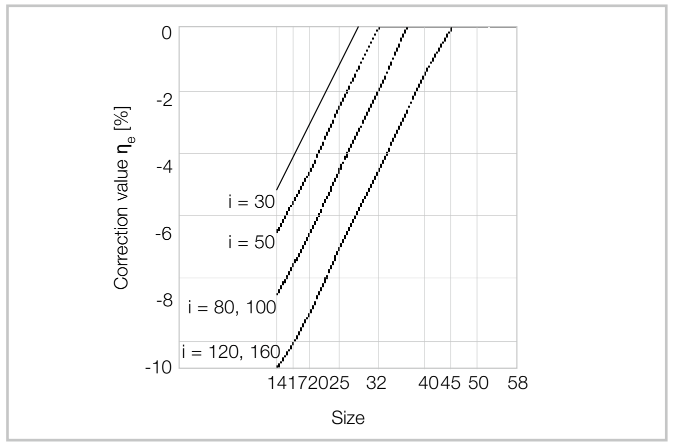
Product: CPU-25A-100-H

- Input speed: 1000 rpm
- (Average) load torque T_{av}: 60 Nm
- Rated torque T_N (catalogue reference): 67 Nm
- Grease lubrication with Harmonic Drive® Grease SK-1A
- lubricant temperature: 20 °C

1. Calculation of the torque factor
   $V = T_{av}/T_N = 60/67 = 0.9$. (For V>1 is K=1)
2. Reading the calculation factor K from diagram Illustration 2.3.27 K = 0.95
3. Reading the efficiency from the efficiency curve Illustration 2.3.26: η = 62 %
4. Reading the efficiency correction value from diagram Illustration 2.3.28: η_e= -4.5 %
5. Calculation of the load dependant efficiency
   $\eta_L = K \cdot (\eta + \eta_e) = 0.95 \cdot (62\ \% - 4.5\ \%) = 55\ \%$

Illustration 2.3.28

Correction value η_e

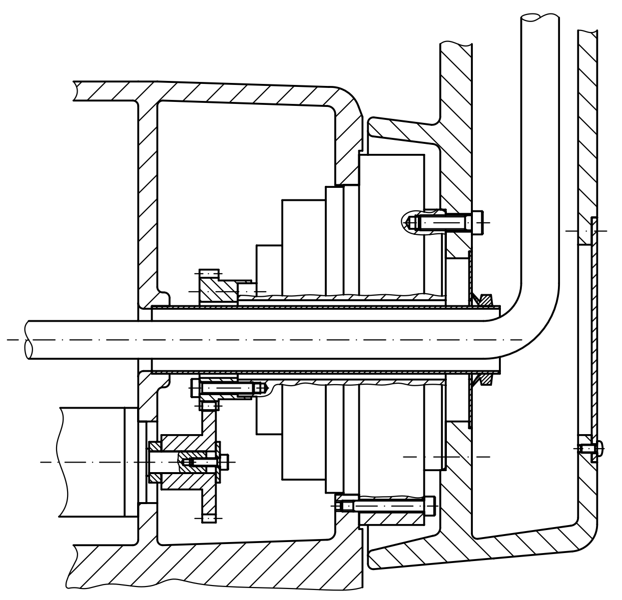


• Continous operation

The friction of the oil seals on the input can lead to an additional temperature increase in the hollow shaft gearboxes during operation. Therefore, a reduced "limit for average input speed" applies to these products. For continuous operation at rated speed, the max. operating times stated in Table 2.3.24 should not be exceeded.

Alternatively, a design according to Illustration 2.3.29 can be used. In this example, the radial oil seals on the input (high speed) have been removed. There are no restrictions on the duty cycle when using this design. The removal of one or both oil seals on the input should only be carried out if grease or base oil leakage is permitted or if this is excluded by the installation position.

Illustration 2.3.29



• Maximum permissible operating time for continuous operation

Table 2.3.24 **[min]**

Operation time	Size								
	14	17	20	25	32	40	45	50	58
At operation without load	90	90	90	60	45	40	35	30	20
At rated torque	60	60	60	45	35	30	25	20	15

The data given in Table 2.3.24 applies to:
- Ambient temperature: 25 °C
- Input speed: 2000 rpm
- Max. lubrication temperature: 80 °C
- Mounting of the gear on a plate with the following dimensions:
  Plate height and length: 330 mm
  Plate thickness: 15 mm for Size ≤ 32
  30 mm for Size ≥ 40
- Plate material: Steel
- An additional output flange is not mounted.

• Assembly of the input shaft CPU-H

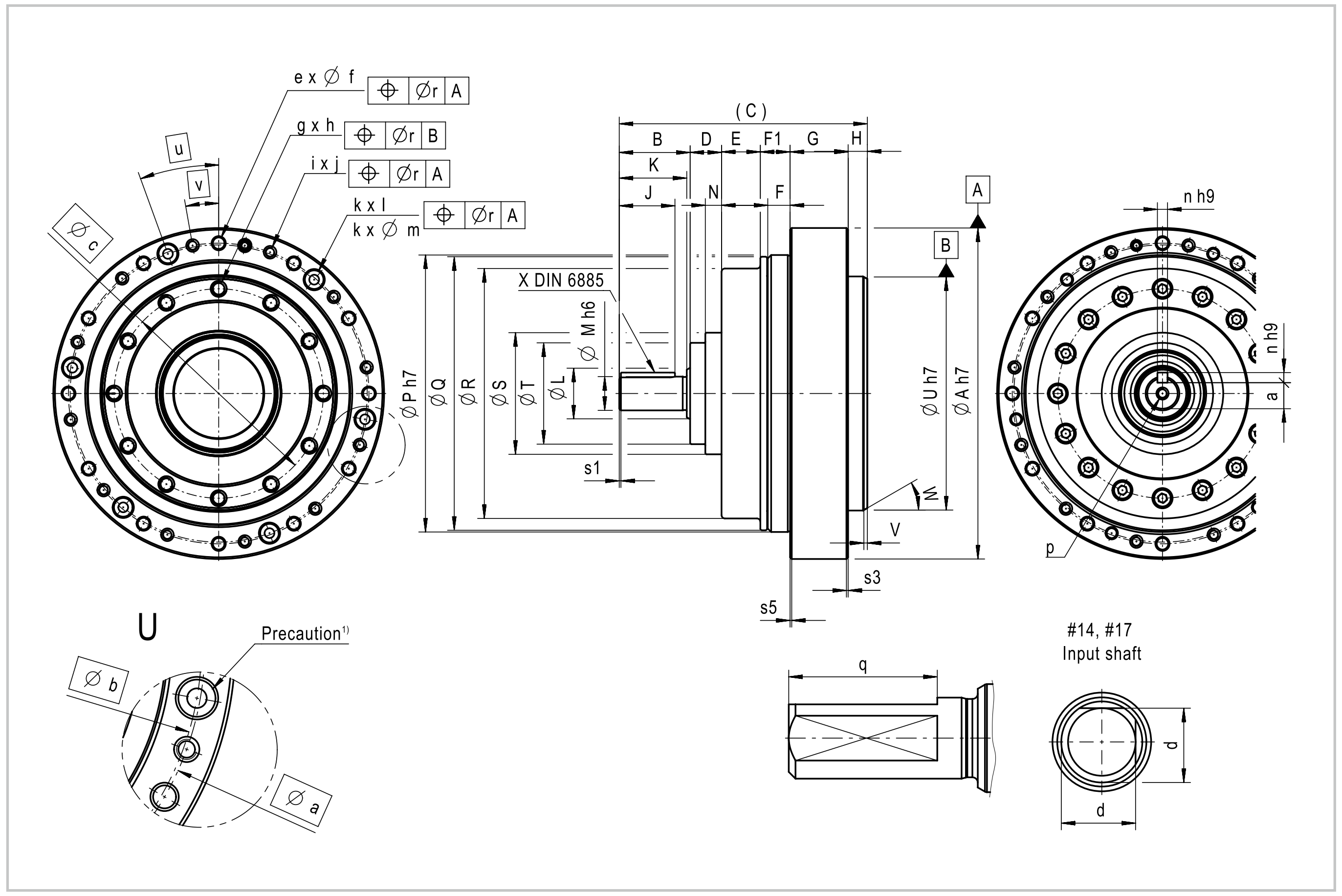
Table 2.3.25

	[Unit]	Size								
		14	17	20	25	32	40	45	50	58
Number of screws		3	3	6	6	6	6	6	6	8
Size of screws		M3	M3	M3	M3	M3	M4	M4	M4	M4
Screw tightening torque	[Nm]	2.30	2.30	2.30	2.30	2.30	5.29	5.29	5.29	5.29

Technical data CPU-S

• Dimensions

Illustration 2.3.30 [mm]



[1] Countersunk hole only for motor adaptation, do not use for load!

Table 2.3.26 **CPU-S [mm]**

	Size								
	14	17	20	25	32	40	45	50	58
ØA h7	78	88	98	116	148	180	206	222	255
B	15	17	21	26	26	31	31	36	37
C	55.0	61.5	73.5	86.5	100.5	117.5	124.0	138.5	150.0
D	7.5	8.0	9.3	10.3	11.3	11.8	12.9	10.3	11.5
E	9.8	9.8	11.5	15.0	20.0	24.5	28.9	32.5	38.3
F	4.0	6.0	6.6	7.5	9.5	10.0	8.5	12.5	11.0
F1	5.7	8.2	8.8	9.7	12.7	13.7	12.2	16.7	15.2
G	12.0	13.5	17.2	19.0	24.0	29.0	32.0	35.0	41.0
H	5.0	5.0	5.7	6.5	6.5	7.5	7.0	8.0	7.0
J	-	-	16.5	22.5	22.5	27.5	28.5	33.0	33.0
K	14	16	20	25	25	30	30	35	35
ØL	8	10	15	17	20	30	30	35	40
ØM h6	6	8	10	14	14	16	19	22	22
N	5.5	4.5	4.8	6.1	7.3	4.3	7.9	7.3	7.5
ØP h7	60	72	82	96	125	154	175	190	217
ØQ	59.5	71.5	81.0	95.0	124.0	153.0	174.0	189.0	216.0
ØR	53	64	74	89	116	142	162	180	203
ØS	24	28	36	42	52	65	72	86	92
ØT	20	22	30	34	43	57	60	70	68
ØU h7	49	59	69	84	110	132	152	168	193
V	0.4	0.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0
W [°]	30	30	30	30	30	30	30	30	30
X DIN 6885	-	-	A 3x3x16	A 5x5x22	A 5x5x22	A 5x5x25	A 6x6x28	A 6x6x32	A6x6x32
Øa	68	80	89	105	135	168	190	206	236
Øb	68	78	88	105	135	165	190	206	234
Øc	43	52	62	76	96	118	135	152	175
d	5.5	7.5	-	-	-	-	-	-	-
e	8	12	12	12	12	12	12	12	12
Øf	3.4	3.4	3.4	4.5	5.5	6.6	9.0	9.0	11.0
g	12	12	12	12	12	12	12	12	12
h	M3x6	M4x8	M4x8	M5x10	M6x10	M8x14	M10x14	M10x16	M10x15
i	8	12	12	12	12	12	12	12	12
j	M3	M3	M3	M4	M5	M6	M8	M8	M10
k	4	6	6	6	6	6	6	6	6
l	Ø5.5x3	Ø5.5x3	Ø5.5x3	Ø6.5x3.4	Ø8x4.4	Ø10x6	Ø11x6.8	Ø11x6.4	Ø15x9.0
Øm	2.9	2.9	2.9	3.4	4.5	5.5	6.6	6.6	9
n h9	-	-	3	5	5	5	6	6	6
o	-	-	$8.2^{0}_{-0.1}$	$11^{0}_{-0.1}$	$11^{0}_{-0.1}$	$13^{0}_{-0.1}$	$15.5^{0}_{-0.1}$	$18.5^{0}_{-0.1}$	$18.5^{0}_{-0.1}$
p	-	-	M3x6	M5x10	M5x10	M5x10	M6x12	M6x12	M6x12
q	11	12	-	-	-	-	-	-	-
Ør	0.25	0.25	0.30	0.30	0.40	0.50	0.50	0.50	0.50
s1	0.5x45 °	0.50x45 °	0.5x45 °	0.5x45 °	0.5x45 °	0.5x45 °	0.5x45 °	0.5x45 °	0.5x45 °
s3	0.4x45 °	0.40x45 °	0.5x45 °	0.5x45 °	0.5x45 °	0.5x45 °	0.5x45 °	0.5x45 °	0.5x45 °
s5	0.4x45 °	0.40x45 °	0.5x45 °	0.5x45 °	0.5x45 °	0.5x45 °	0.5x45 °	0.5x45 °	0.5x45 °
u [°]	30	20	20	20	20	20	20	20	20
v [°]	15	10	10	8	10	10	10	10	10

CAD drawings for download: www.harmonicdrive.co.uk

• No load starting torque

Table 2.3.27 **[Ncm]**

Ratio	Size 14	17	20	25	32	40	45	50	58
30	6.8	11.0	19.0	26.0	63.0	-	-	-	-
50	5.7	9.7	14.0	22.0	41.0	72.0	94.0	125.0	178.0
80	4.4	7.2	11.0	15.0	29.0	52.0	68.0	88.0	125.0
100	3.7	6.5	9.9	14.0	27.0	47.0	60.0	80.0	113.0
120	-	6.2	9.3	13.0	24.0	44.0	55.0	74.0	105.0
160	-	-	8.6	12.0	23.0	39.0	50.0	66.0	94.0

• No load back driving torque

Table 2.3.28 **[Nm]**

Ratio	Size 14	17	20	25	32	40	45	50	58
30	3.5	5.9	10.0	16.0	31.0	-	-	-	-
50	3.4	5.8	8.4	13.0	25.0	43.0	56.0	75.0	107.0
80	4.2	6.9	10.0	15.0	28.0	50.0	65.0	85.0	120.0
100	4.5	7.8	12.0	17.0	33.0	56.0	72.0	96.0	135.0
120	-	8.9	13.0	19.0	34.0	63.0	79.0	106.0	151.0
160	-	-	17.0	23.0	43.0	75.0	96.0	126.0	181.0

• Input bearing

The input shaft of the CPU-S Gear is supported by two single row deep groove ball bearings. Illustration 2.3.31 shows he points of application of force of the radial- and axial loads given in Table 2.3.29 and Illustration 2.3.32. Example: If the input shaft of a CPU-58-S Gear is preloaded with an axial load of 900 N, the max. permissible radial load is 1400 N, see Illustration 2.3.32.

The maximum values shown here apply to an average input speed of 2000 rpm and an average bearing life L_{10} = 7500 h.

Table 2.3.29

	Symbol [Unit]	Size 14	17	20	25	32	40	45	50	58
Distance	B [mm]	7	8	10	12.5	12.5	15	15	17.5	17.5
Maximum permissible radial load	F_r [N]	118	145	232	342	567	825	1264	1745	2027

Illustration 2.3.31

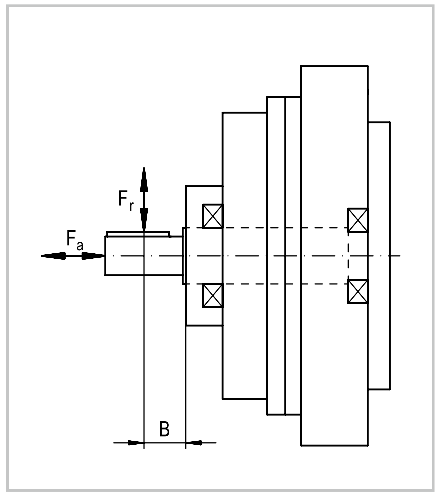
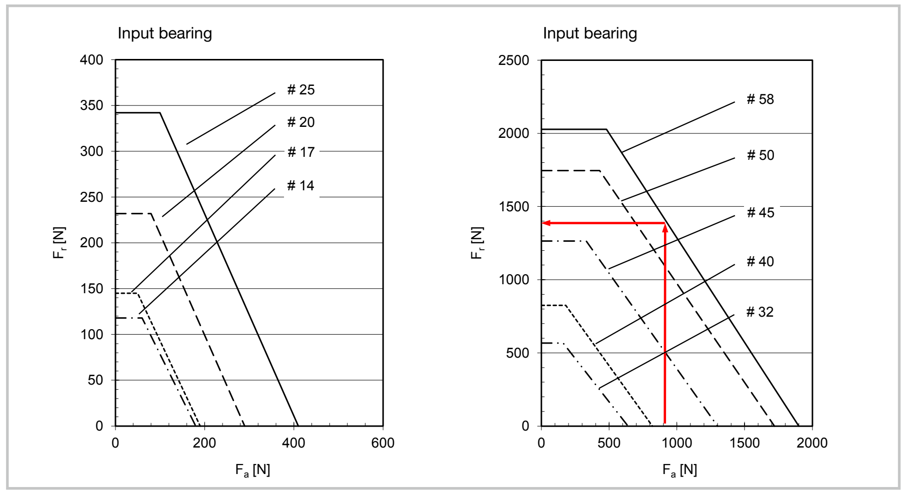


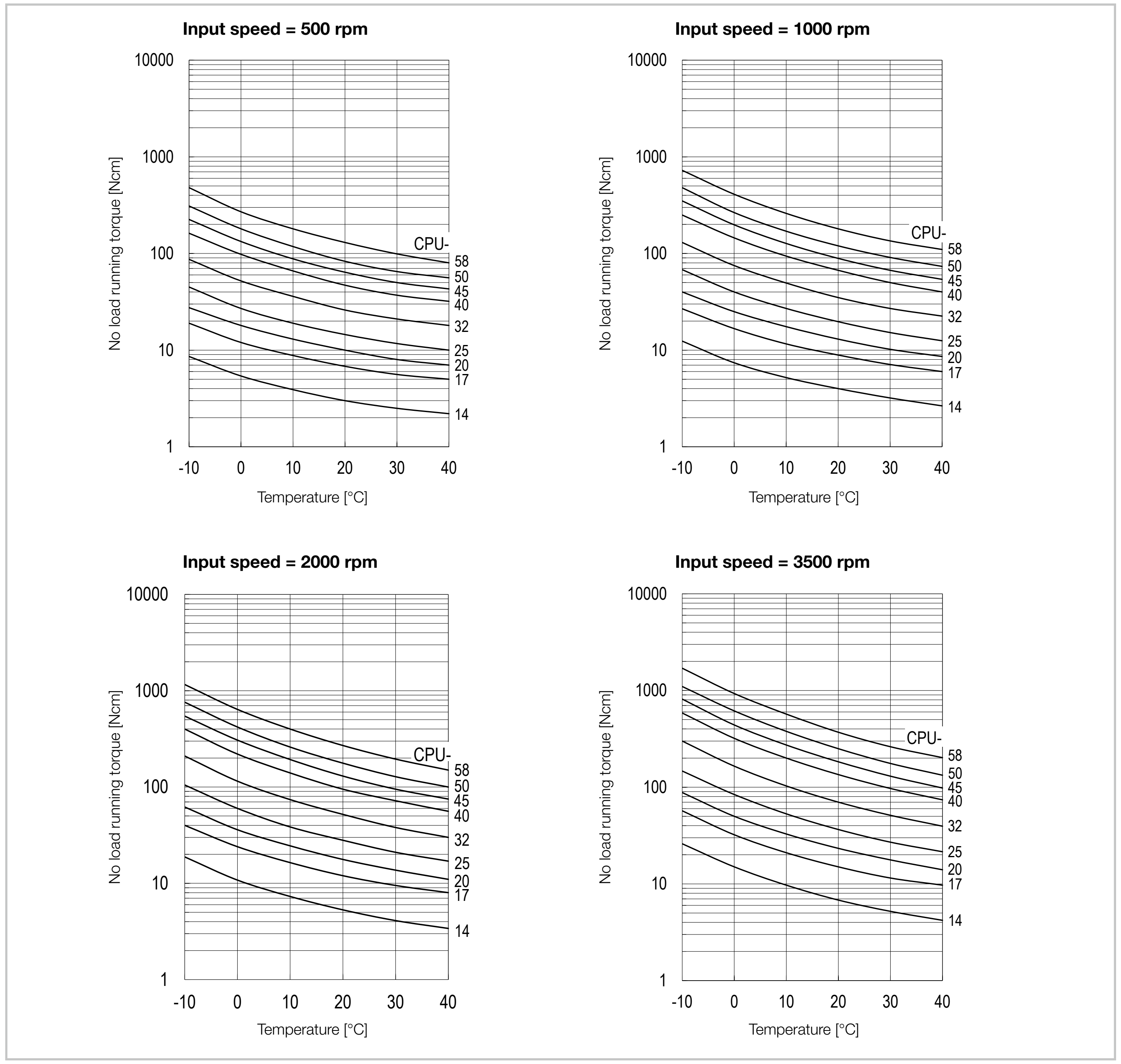
Illustration 2.3.32



• No load running torque

The diagrams apply to Harmonic Drive® Flexolub®-A1.

Illustration 2.3.33



Compensation values for no load running torque

When using gears with ratios other than i=100 please add the compensation values from the table to the values taken from the curves.

Table 2.3.30 **[Ncm]**

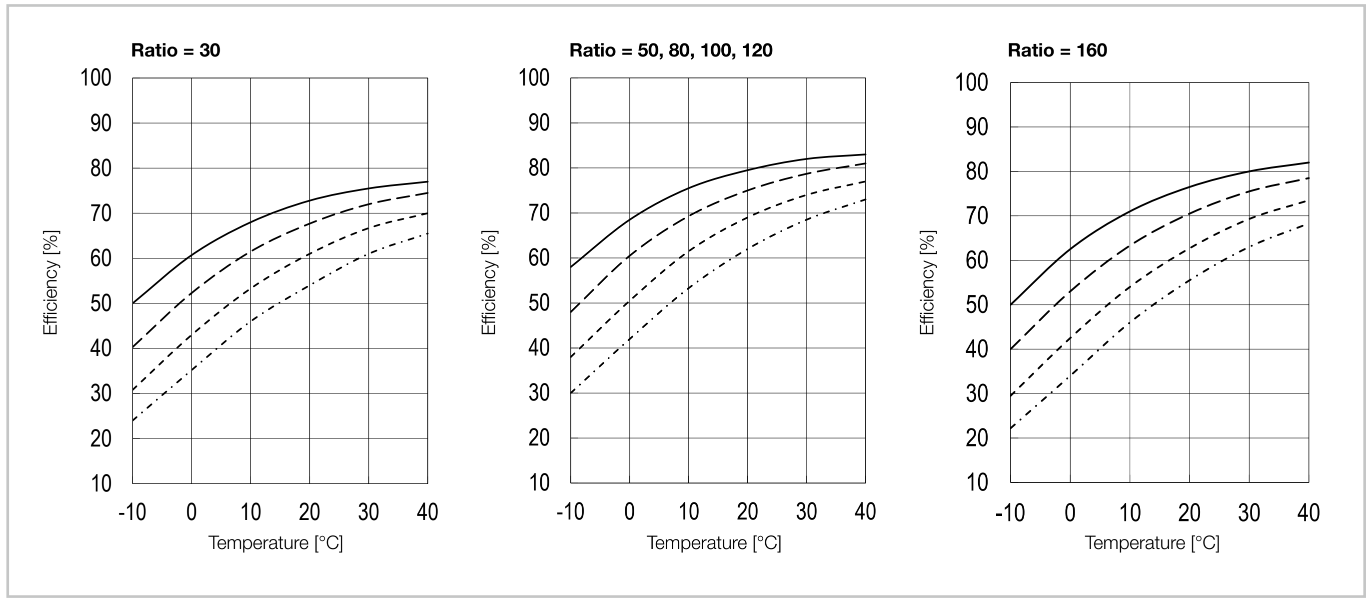
Ratio	Size 14	17	20	25	32	40	45	50	58
30	2.6	4.1	5.9	9.6	18.3	-	-	-	-
50	1.1	1.8	2.6	4.2	8.0	13.3	18.2	23.9	34.6
80	0.2	0.4	0.5	0.8	1.5	2.4	3.3	4.3	6.2
120	-	-0.2	-0.4	-0.6	-1.1	-1.7	-2.4	-3.1	-4.4
160	-	-	-0.8	-1.3	-2.5	-4.0	-5.5	-7.2	-10.3

• Efficiency

Efficiency for grease lubrication at rated torque

The diagrams apply to Harmonic Drive® Grease Flexolub®-A1.

Illustration 2.3.34



n = 500 rpm n = 1000 rpm n = 2000 rpm n = 3500 rpm

Efficiency calculation

The efficiency calculation of the CPU-S Gears is carried out according to the same procedure as for the CPU-H Gears.

Illustration 2.3.35 **Calculation factor K**

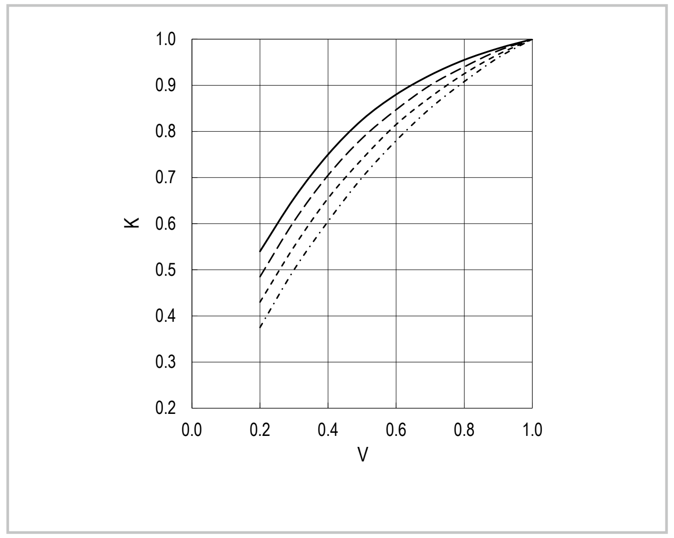
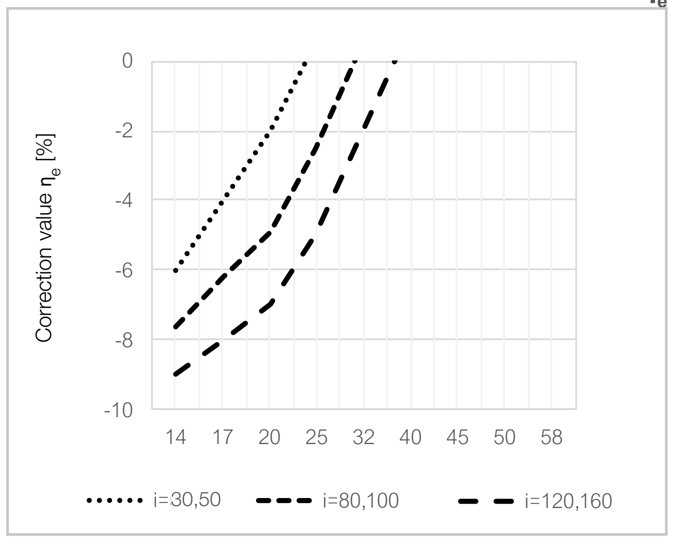


Illustration 2.3.36 **Correction value η_e**



• Materials and coatings used

Table 2.3.31

Version	CPU-M	CPU-H	CPU-S
Output bearing	Burnished steel[2]		
Circular Spline	Grey cast iron		
Flexspline	Bright steel		
Wave Generator (Hollow shaft by CPU-H)	Bright steel	Chemically nickel-plated steelv	Bright steel
Input shaft	x	x	Stainless steel
Housing flange	x	Chemically nickel-plated steelv	Chemically nickel-plated steelv
Adapter flange[1]	High-strength aluminium or steel, coating as per confirmation drawing	x	x
Screws	Coated against corrosion		

x not available in this version
[1] If supplied by Harmonic Drive SE
[2] no corrosion protection

Optional materials are available on request.

Lubrication

• Grease lubrication

The Gears with output bearing CPU-M/H/S are supplied fully greased. They are provided with lifetime grease lubrication at the factory. We recommend the use of the greases listed in Table 2.3.32. The output bearing is greased with Harmonic Drive® Grease 4BNo.2.

Table 2.3.32

Ratio	Harmonic Drive® Grease	14	17	20 ... 58
30 ... 160	Flexolub®-A1	O	O	O
	SK-1A	-	-	Δ
	SK-2	Δ	Δ	-
	4BNo.2	Δ	Δ	Δ

O Standard grease
□ Recommended for very high loads or very high demands on the service life of the grease
Δ Optional grease, please consult us

• Oil lubrication

Harmonic Drive® Gears with output bearing with oil lubrication are customised special designs. Lubrication and relubrication are determined individually. For more information, please refer to the chapter Engineering data.

Product description

Highest torque capacity and reinforced output bearing

The CSG-CPM/H/S Series gears with output bearing consist of a precise CSG-2A Gear Component Set and a tilt resistant output bearing. They are available as motor mounted gear, with hollow shaft or with input shaft.

In addition to the proven strain wave gear technology, CSG-CPM/H/S Series is also available in Triangle Technology. Setting new standards in torsional stiffness, transmission accuracy and dynamics

Features

- Highest torque capacity
- Outstanding, lifetime precision and zero backlash
- Longest lifetime
- Three versions for different mounting situations
- Large torque range
- Integrated tilt resistant cross roller bearing

CSG-CPM
Gears for direct motor mounting

CSG-CPH
Hollow shaft gear for feed through supply lines for further gear systems

CSG-CPS
Gear with input shaft to drive with belt pulley or spur gear

Ordering code

Table 2.4.1

Ordering code	CSG	-	20	-	100	-	CPM	-	SP
Series	CSG								
Size (corresponds to the pitch circle diameter of the Flexspline toothing in inches x 10)			14 17 20 25 32 40						
Ratio (in drive configuration: Circular Spline (CS) fixed, Wave Generator (WG) input, Flexspline (FS) output)					50 80 100 120 160				
Version									
Gear for motor mounting							CPM		
Closed hollow shaft gear with input bearing							CPH		
Gear with input shaft							CPS		
Customised design									
Standard design (field remains empty)									[ ]
Special design (on request)									SP

Please refer to the table of possible combinations.

Combinations

Table 2.4.2

CSG-CPM/H/S

		Size					
		14	17	20	25	32	40
Ratio	50	o	o	o	o	o	o
	80	o	o	o	o	o	o
	100	●	●	●	●	●	●
	120	-	o	o	o	o	o
	160	-	-	o	o	o	o

● available o on request - not available

The ratio i=30 is not available as CSG-CP. You will find an interface compatible alternative in the CPU Series (chapter 2.3).

Technical data

• Rating table

Table 2.4.3

Series	Size	Ratio	Limit for repeated peak torque	Limit for average torque	Rated torque at rated speed 2000 rpm	Limit for momentary peak torque	Max. input speed [rpm]	Limit for average input speed [rpm]	Moment of inertia [x10⁻⁴ kgm²]	Weight [kg]
			T_R [Nm]	T_A [Nm]	T_N [Nm]	T_M [Nm]	Grease lubrication	Grease lubrication	CPM CPH CPS	CPM CPH CPS
CSG	14	50	23	9	7	46	8500	3500[1] 3000[2]	0.033 0.091 0.025	0.54 0.67 0.64
	14	80	30	14	10	61				
	14	100	36	14	10	70				
CSG	17	50	44	34	21	91	7300	3500[1] 3000[2]	0.079 0.193 0.059	0.79 1.00 0.95
	17	80	56	35	29	113				
	17	100	70	51	31	143				
	17	120	70	51	31	112				
CSG	20	50	73	44	33	127	6500	3500[1] 3000[2]	0.193 0.404 0.173	1.30 1.55 1.49
	20	80	96	61	44	165				
	20	100	107	64	52	191				
	20	120	113	64	52	191				
	20	160	120	64	52	191				
CSG	25	50	127	72	51	242	5600	3500[1] 2575[2]	0.413 1.070 0.320	1.90 2.35 2.30
	25	80	178	113	82	332				
	25	100	204	140	87	369				
	25	120	217	140	87	395				
	25	160	229	140	87	408				
CSG	32	50	281	140	99	497	4800	3500[1] 1980[2]	1.69 2.85 1.20	3.95 5.00 4.60
	32	80	395	217	153	738				
	32	100	433	281	178	841				
	32	120	459	281	178	892				
	32	160	484	281	178	892				
CSG	40	50	523	255	178	892	4000	3000[1] 1300[2]	4.50 9.28 3.41	6.9 8.9 8.8
	40	80	675	369	268	1270				
	40	100	738	484	345	1400				
	40	120	802	586	382	1530				
	40	160	841	586	382	1530				

1) Valid for CSG-CPS and CSG-CPM.
2) Valid for CSG-CPH. Higher values on request.

You will find more information on this in the Engineering data chapter.

Accuracy

Table 2.4.4 **[arcmin]**

			Size							
			14 ... 17			20 ... 32			40	
Ratio			30	50	≥ 80	30	50	≥ 80	50	≥ 80
Transmission accuracy	CSG-CPH, CSG-CPS		< 2.0	< 1.2	< 1.0	< 1.5	< 1.0	< 0.8	< 0.7	< 0.5
	CSG-CPM	Wave Generator with Oldham coupling								
		Solid Wave Generator [1]	< 2.0	< 1.5		< 1.5	< 1.0			
Hysteresis loss			< 3	< 2	< 1	< 3	< 2	< 1	< 2	< 1
Lost motion			< 1							
Repeatability			< ±0.1							

1) Higher accuracy on request

• Torsional stiffness

Table 2.4.5

	Symbol [Unit]	Size 14	17	20	25	32	40
Limit torques	T_1 [Nm]	0.2	3.9	7.0	14	29	54
	T_2 [Nm]	6.9	12.0	25	48	108	196
i = 50	K_3 [x 10⁴ Nm/rad]	0.57	1.30	2.30	4.40	9.80	18
	K_2 [x 10⁴ Nm/rad]	0.47	1.10	1.80	3.40	7.80	14
	K_1 [x 10⁴ Nm/rad]	0.34	0.81	1.30	2.50	5.40	10
i ≥ 80	K_3 [x 10⁴ Nm/rad]	0.71	1.60	2.90	5.70	12.00	23
	K_2 [x 10⁴ Nm/rad]	0.61	1.40	2.50	5.00	11.00	20
	K_1 [x 10⁴ Nm/rad]	0.47	1.00	1.60	3.10	6.70	13

Output bearing

• Rating table

Table 2.4.6

	Symbol [Unit]	Size 14	17	20	25	32	40
Bearing type[1]		C	C	C	C	C	C
Pitch circle diameter	d_p [m]	0.0465	0.0590	0.0700	0.0880	0.1140	0.1340
Distance[2]	R [m]	0.014	0.014	0.016	0.018	0.020	0.026
Dynamic load rating	C [N]	8250	10700	21000	21800	34500	43300
Static load rating	C_0 [N]	11400	14800	27000	35800	59000	81600
Permissible dynamic tilting moment[3,4]	M [Nm]	73	114	172	254	578	886
Permissible static tilting moment[4]	M_0 [Nm]	155	276	603	1050	2242	3645
Tilting moment stiffness[5]	K_B [Nm/arcmin]	23	40	70	114	350	522
Permissible axial load[4]	F_a [N]	2030	2286	4486	5298	9357	10361
Permissible radial load[4]	F_r [N]	1360	1532	3006	3550	6269	6942

1) Bearing type C = Crossed roller bearing; F = Four point contact bearing
2) Distance between the centre of the rolling bearing and the screw mounting surface on the output side, see chapter Gear dimensioning.
3) These values are valid for moving gears. They are not based on the equation for lifetime of the output bearing but on the maximum allowable deflection of the Harmonic Drive® Gear Component Set. The values indicated in the table must not be exceeded even if the lifetime equation of the bearing permits higher values.
4) These data are valid for M: $F_a = 0$, $F_r = 0$ I F_a: $M = 0$, $F_r = 0$ I F_r: $M = 0$, $F_a = 0$
5) The value of tilting moment stiffness is the average value (± 20 %).

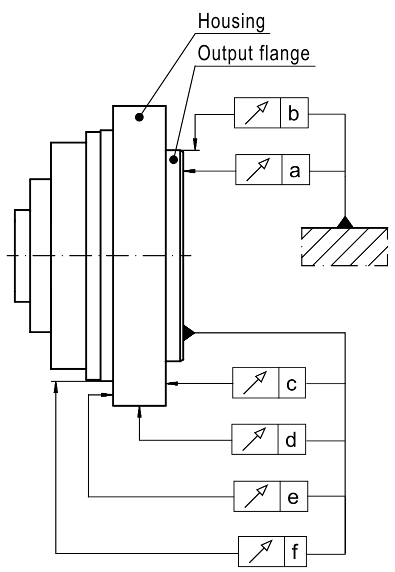
• Output bearing and housing tolerances

Data applies to rotating output flange.

Table 2.4.7 **[mm]**

Symbol	Size 14	17	20	25	32	40
a (axial runout)	0.010	0.010	0.010	0.010	0.012	0.012
b (radial runout)	0.010	0.010	0.010	0.010	0.010	0.010
c	0.010	0.010	0.010	0.010	0.012	0.012
d	0.010	0.010	0.010	0.010	0.010	0.010
e	0.020	0.020	0.020	0.020	0.020	0.020
f	0.015	0.015	0.015	0.015	0.015	0.015

Illustration 2.4.1



Assembly

• Screw connection

Screw connection on the output side

Table 2.4.8

	[Unit]	Size 14	17	20	25	32	40
Number of screws		12	12	12	12	12	12
Size of screws		M3	M4	M4	M5	M6	M8
Pitch circle diameter	[mm]	43	52	62	76	96	118
Screw tightening torque	[Nm]	2.3	5.1	5.1	10.0	17.4	42.2
Torque transmitting capacity	[Nm]	85	188	228	463	847	1964

12.9 quality screws, friction coefficient μ = 0.15

Screw connection on the housing side

Table 2.4.9

	[Unit]	Size 14	17	20	25	32	40
Number of screws		8	12	12	12	12	12
Size of screws		M3	M3	M3	M4	M5	M6
Pitch circle diameter	[mm]	68	80	89	105	135	168
Screw tightening torque	[Nm]	2.3	2.3	2.3	5.1	10.0	17.4
Torque transmitting capacity	[Nm]	89	158	177	378	805	1482

12.9 quality screws, friction coefficient μ = 0.15

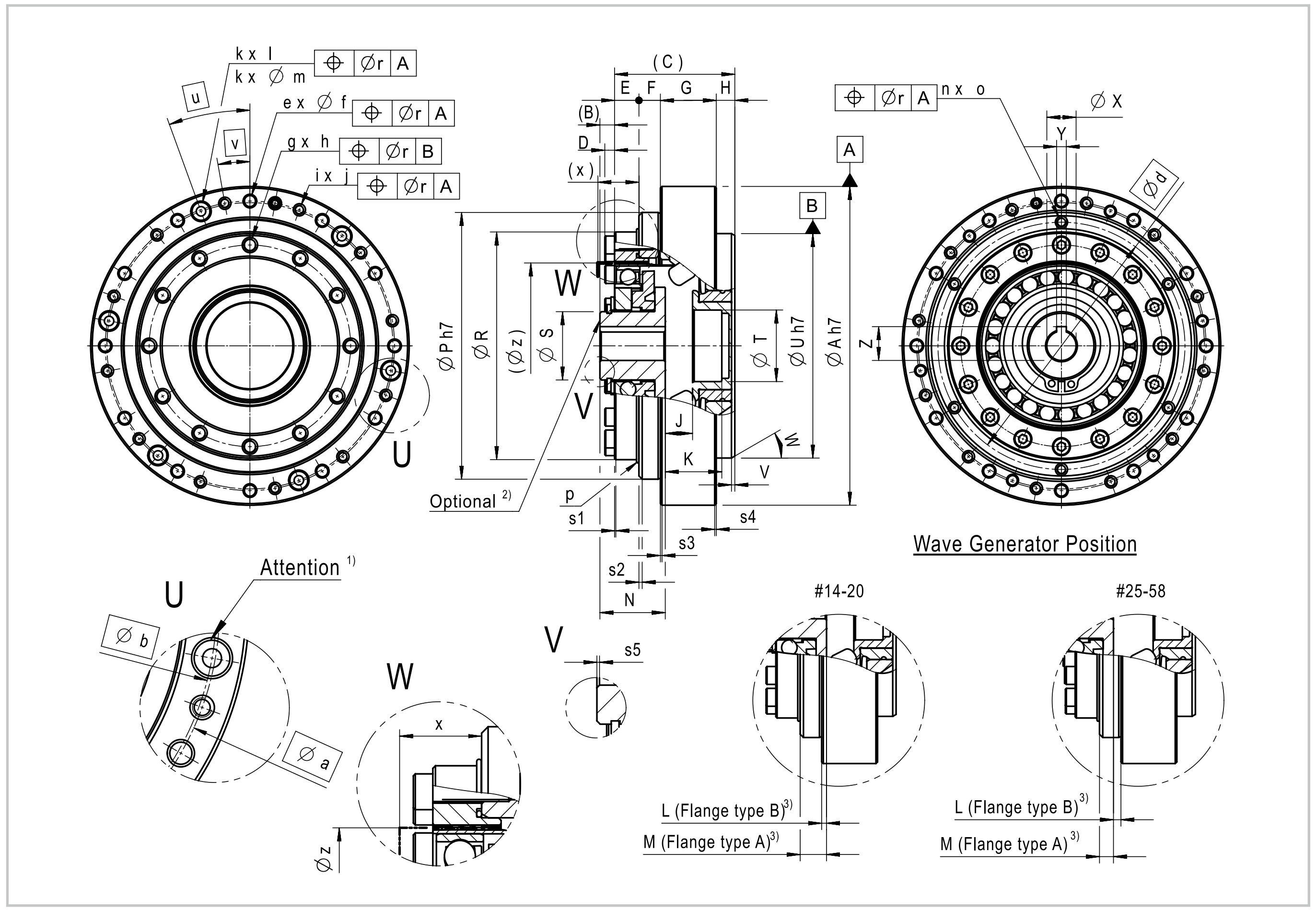


Technical data CSG-CPM

• Dimensions

Illustration 2.4.2

CSG-CPM [mm]



1) Countersunk hole only for motor adaptation, do not use for load!
2) Hub without keyway or with other diameter see chapter "Engineering data".
3) Explanations see Illustration 2.4.10

Table 2.4.10

CSG-CPM [mm]

Symbol		Size 14	17	20	25	32	40
ØA h7		78	88	98	116	148	180
B		5.00	6.00	4.5	3.00	2.00	2.00
C		27.0	31.0	37.0	43.0	54.0	63.5
D		3	3	3	4	5	6
E		6.0	6.5	7.5	10.0	14.0	17.0
F		4.0	6.0	6.6	7.5	9.5	10.0
G		12.0	13.5	17.2	19.0	24.0	29.0
H		5.0	5.0	5.7	6.5	6.5	7.5
J		6.7	8.0	8.4	10.8	14.8	16.5
K		12.2	15.5	17.4	21.8	29.8	33.5
L		$3.5^{+0.4}_{0}$	$2.2^{+0.4}_{0}$	$2.9^{+0.4}_{0}$	$1.1^{0}_{-0.5}$	$1.9^{0}_{-0.6}$	$0.7^{0}_{-0.6}$
M		$7.5^{+0.4}_{0}$	$8.2^{+0.4}_{0}$	$9.5^{+0.4}_{0}$	$8.6^{+0.5}_{0}$	$7.6^{+0.6}_{0}$	$10.7^{+0.6}_{0}$
N		$17.6^{0}_{-0.1}$	$20.7^{0}_{-0.1}$	$21.5^{0}_{-0.1}$	$21.6^{0}_{-0.1}$	$23.6^{0}_{-0.1}$	$29.7^{-0.1}_{0}$
Ø P h7		60	72	82	96	125	154
Ø R		$50^{0,01}_{-0,015}$	$60^{0.01}_{-0.02}$	$70^{0.01}_{-0.02}$	$85^{0.01}_{-0.025}$	$110^{0.01}_{-0.025}$	$135^{0.01}_{-0.03}$
Ø S		14	18	21	26	26	32
Ø T		16	19	22	26	37	42
Ø U h7		49	59	69	84	110	132
V		0.4	0.4	1.0	1.0	1.0	1.0
W [°]		30	30	30	30	30	30
ØX H7		6	8	9	11	14	14
Y JS9		-	-	3	4	5	5
Z		-	-	$10.4^{+0.1}_{0}$	$12.8^{+0.1}_{0}$	$16.3^{+0.1}_{0}$	$16.3^{+0.1}_{0}$
Ø a		68	80	89	105	135	168
Ø b		68	78	88	105	135	165
Ø c		43	52	62	76	96	118
Ø d		55.0	66.0	76.0	91.0	118.0	144.0
e		8	12	12	12	12	12
Ø f		3.4	3.4	3.4	4.5	5.5	6.6
g		12	12	12	12	12	12
h		M3 x 6	M4 x 8	M4 x 8	M5 x 10	M6 x 10	M8 x 14
i		8	12	12	12	12	12
j		M3	M3	M3	M4	M5	M6
k		4	6	6	6	6	6
l		Ø 5.5 x 3.0	Ø 5.5 x 3.0	Ø 5.5 x 3.0	Ø 6.5 x 3.4	Ø 8 x 4.4	Ø 10 x 6.0
Ø m		2.9	2.9	2.9	3.4	4.5	5.5
n		6	6	6	6	6	6
o		M2.5 x 5	M3 x 6	M3 x 6	M3 x 6	M4 x 8	M5 x 10
p (o-Ring)		49.9 x 0.80	59.28 x 0.78	69 x 1.00	83 x 1.00	108 x 1.00	133 x 1.50
Ø r		0.25	0.25	0.3	0.3	0.4	0.5
s1		0.4 x 45 °	0.4 x 45 °	0.4 x 45 °	0.4 x 45 °	0.4 x 45 °	0.4 x 45 °
s2		0.8 x 45 °	0.8 x 45 °	1.0 x 45 °	1.0 x 45 °	1.0 x 45 °	1.0 x 45 °
s3		0.4 x 45 °	0.4 x 45 °	0.5 x 45 °	0.5 x 45 °	0.5 x 45 °	0.5 x 45 °
s4		0.4 x 45 °	0.4 x 45 °	0.5 x 45 °	0.5 x 45 °	0.5 x 45 °	0.5 x 45 °
s5		0.5 x 45 °	0.5 x 45 °	0.4 x 45 °	0.4 x 45 °	0.4 x 45 °	0.4 x 45 °
u [°]		30	20	20	20	20	20
v [°]		15	10	10	8	10	10
Minimum housing clearance	x	7.0	7.5	9.0	11.5	15.5	19.0
	Ø z	38	45	53	66	86	106

CAD drawings for download: www.harmonicdrive.co.uk

Details Wave Generator

Illustration 2.4.3

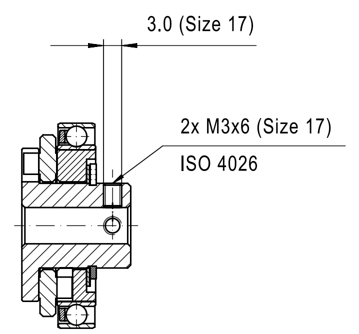
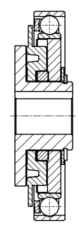
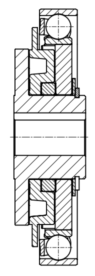


Illustration 2.4.4



Wave Generator
for CSG-CPM sizes 20, 25, 32

Illustration 2.4.5



Wave Generator
for CSG-CPM sizes 40

• No load starting torque

Table 2.4.11 **[Ncm]**

Ratio	Size					
	14	17	20	25	32	40
50	4.1	6.1	7.8	15.0	31.0	55.0
80	2.8	4.0	4.9	9.2	19.0	35.0
100	2.5	3.4	4.3	8.0	18.0	31.0
120	-	3.1	3.8	7.3	15.0	28.0
160	-	-	3.3	6.3	14.0	24.0

• No load back driving torque

Table 2.4.12 **[Nm]**

Ratio	Size					
	14	17	20	25	32	40
50	1.6	3.0	4.7	9.0	18.0	33.0
80	1.6	3.0	4.8	9.1	19.0	33.0
100	1.8	3.3	5.1	9.8	20.0	36.0
120	-	3.5	5.5	11.0	22.0	39.0
160	-	-	6.4	13.0	26.0	46.0

• Accuracy of the Oldham coupling

Harmonic Drive® Gears are zero backlash. If an Oldham coupling is used, a small backlash in the range of a few seconds of arc occurs outside the tooth engagement, see Table 2.4.13. This small amount of backlash does not occur with a Solid Wave Generator.

Table 2.4.13 **CSG-CPM [arcsec]**

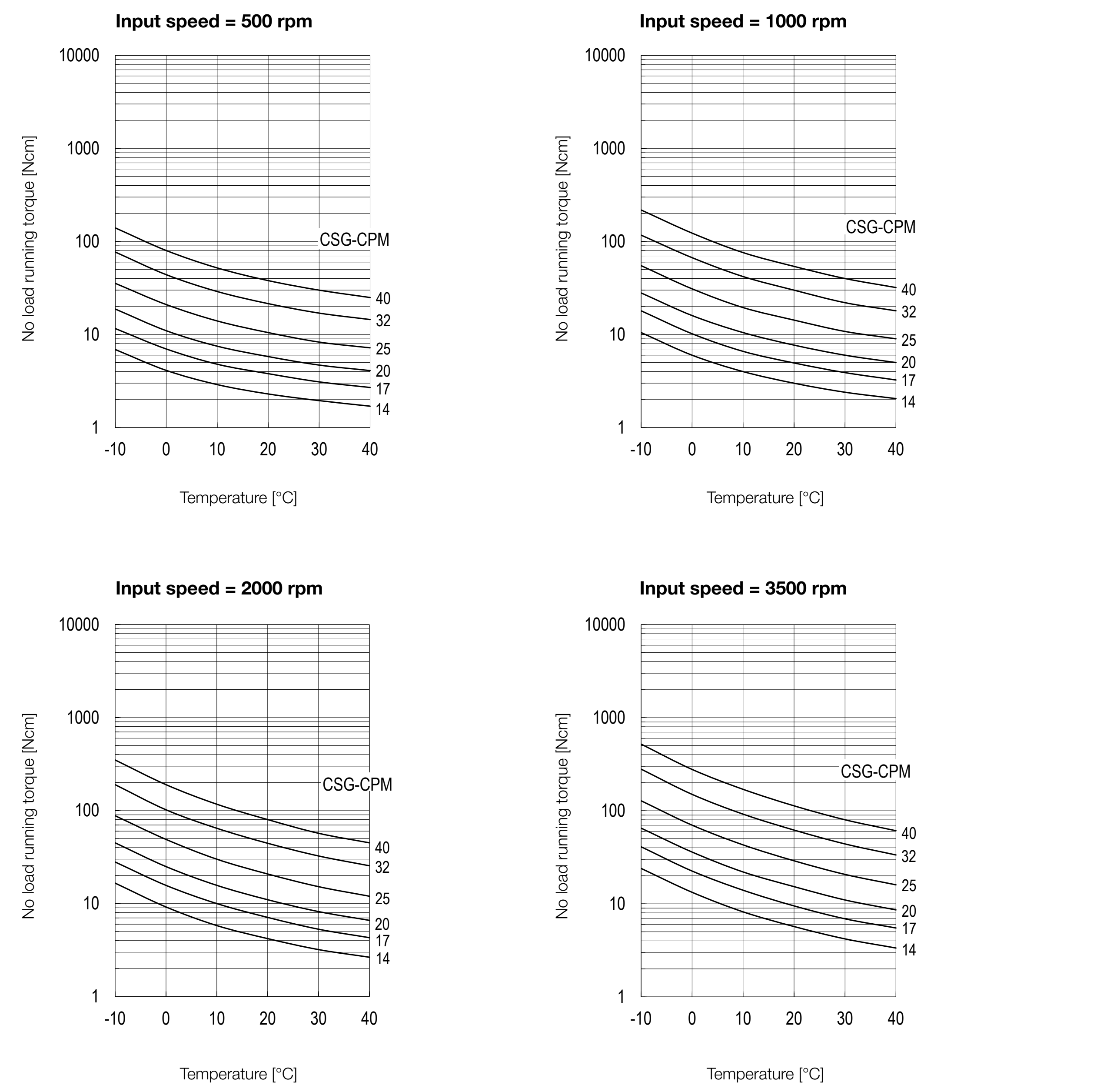
Ratio	Size					
	14	17	20	25	32	40
50	36	20	17	17	14	14
80	23	13	11	11	9	9
100	18	10	9	9	7	7
120	-	8	8	8	6	6
160	-	-	6	6	5	5

You will find more information on this in the Engineering data chapter.

• No load running torque

The diagrams apply to Harmonic Drive® grease 4BNo.2.

Illustration 2.4.6



Compensation values for no load running torque

When using gears with ratios other than i = 100 please add the compensation values from the table to the values taken from the curves.

Table 2.4.14 **[Ncm]**

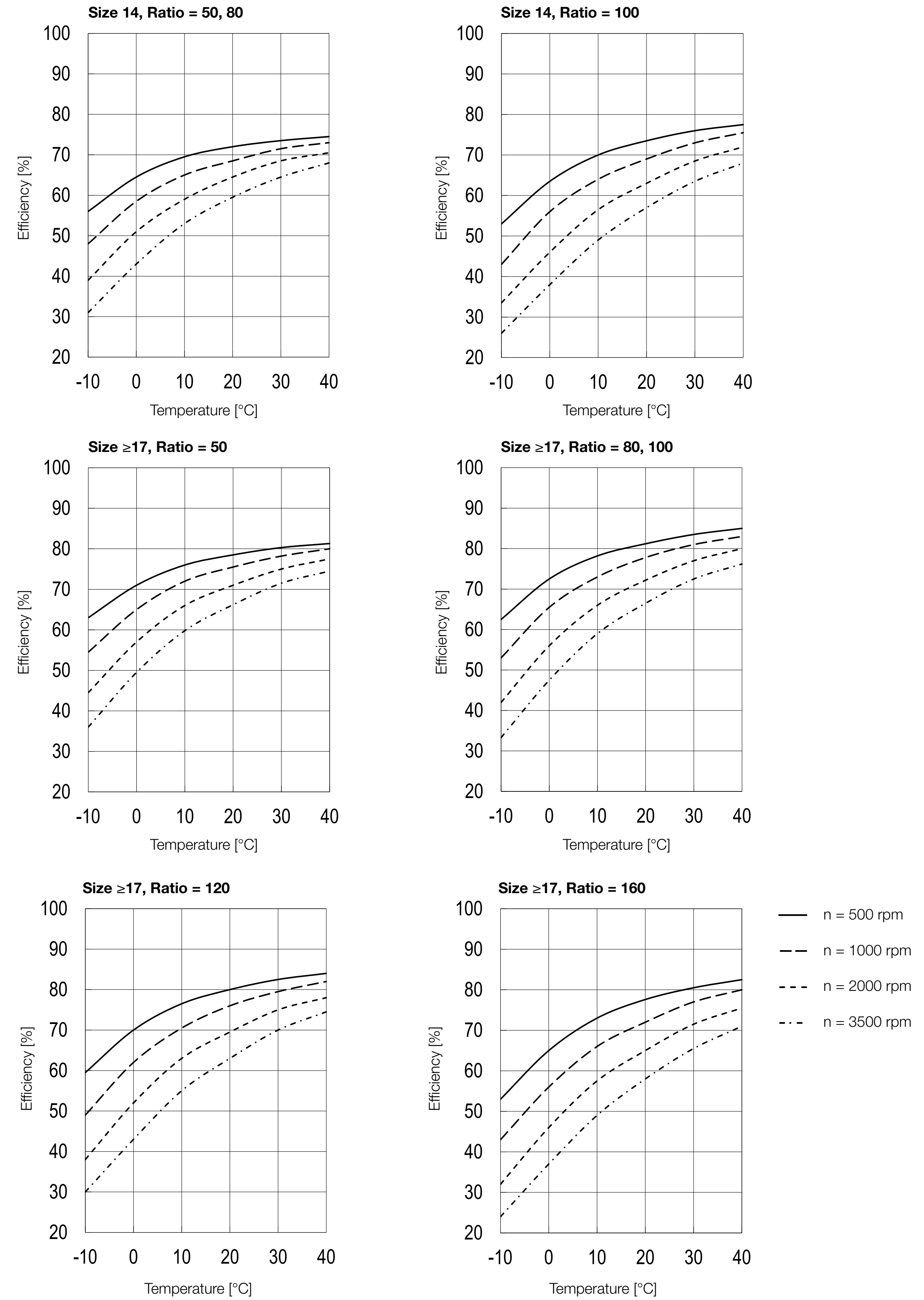
Ratio	Size					
	14	17	20	25	32	40
50	1.1	1.6	2.3	3.8	7.1	12.0
80	0.2	0.3	0.5	0.7	1.3	2.1
120	-	-0.2	-0.3	-0.5	-0.9	-1.5
160	-	-	-0.8	-1.2	-2.2	-3.5

- Efficiency

Efficiency for grease lubrication at rated torque

The diagrams apply to Harmonic Drive® grease 4BNo.2.

Illustration 2.4.7



You will find more information on this in the Engineering data chapter.

Efficiency calculation

The efficiency depends on the following parameters: Gear ratio, input speed, load torque, temperature, lubricant and lubricant quantity. If the load torque is lower than the rated torque, the efficiency will be lower than the efficiency indicated in the efficiency curves. The torque specific efficiency is determined by means of the calculation factor K.

Calculation example

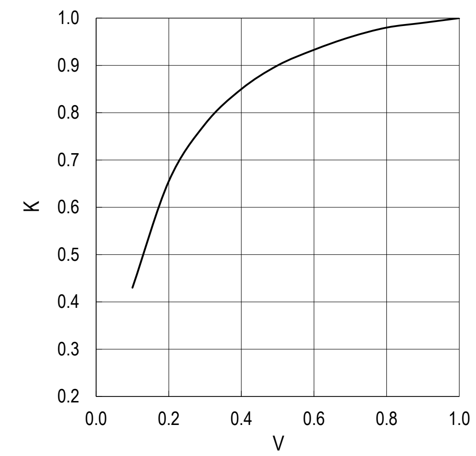
CSG-20-80-CPM

- Input speed: 1000 rpm
- (Average) load torque T_{av}: 30 Nm
- Rated torque T_N (catalogue reference): 44 Nm
- Grease lubrication with Harmonic Drive® Grease lubricant temperature: 20 °C.

1. Calculation of the torque factor $V = T_{av}/T_N = 30/44 = 0.68$ (For V>1 is K=1)
2. Reading the calculation factor K from Illustration 2.4.8: K = 0.94
3. Reading the efficiency from the efficiency curve Illustration 2.4.7: η = 78 %
4. Calculation of the load dependant efficiency $\eta_L = 78\ \% \cdot 0.94 = 73\ \%$

Illustration 2.4.8

Calculation factor K



Assembly tolerances

We recommend to consider the tolerances below when assembling:

Illustration 2.4.9

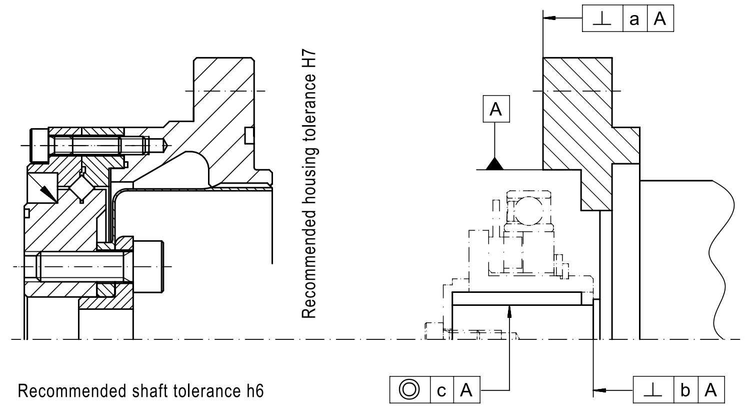


Table 2.4.15 [mm]

Symbol	Size 14	17	20	25	32	40
a	0.011	0.015	0.017	0.024	0.026	0.026
b	0.017	0.020	0.020	0.024	0.024	0.032
	(0.008)	(0.010)	(0.010)	(0.012)	(0.012)	(0.012)
c	0.030	0.034	0.044	0.047	0.050	0.063
	(0.016)	(0.018)	(0.019)	(0.022)	(0.022)	(0.024)

The values in brackets are recommended tolerances for a Wave Generator without Oldham coupling. This coupling is used to compensate for eccentricity errors of the motor shaft and is installed in the standard gear. In case of a direct coupling of the Wave Generator on the motor shaft without Oldham coupling (option), the motor shaft tolerances should correspond to DIN 42955 R.

Adapter flange

The CSG-CPM Series Gears are designed as motor mounted gears. Please indicate the motor type to be adapted when ordering, therefore the Wave Generator can be manufactured to fit your motor. Depending on the size of the motor in relation to the gear, the most suitable adapter flange type should be selected, see Illustration 2.4.10 for an example.

Illustration 2.4.10

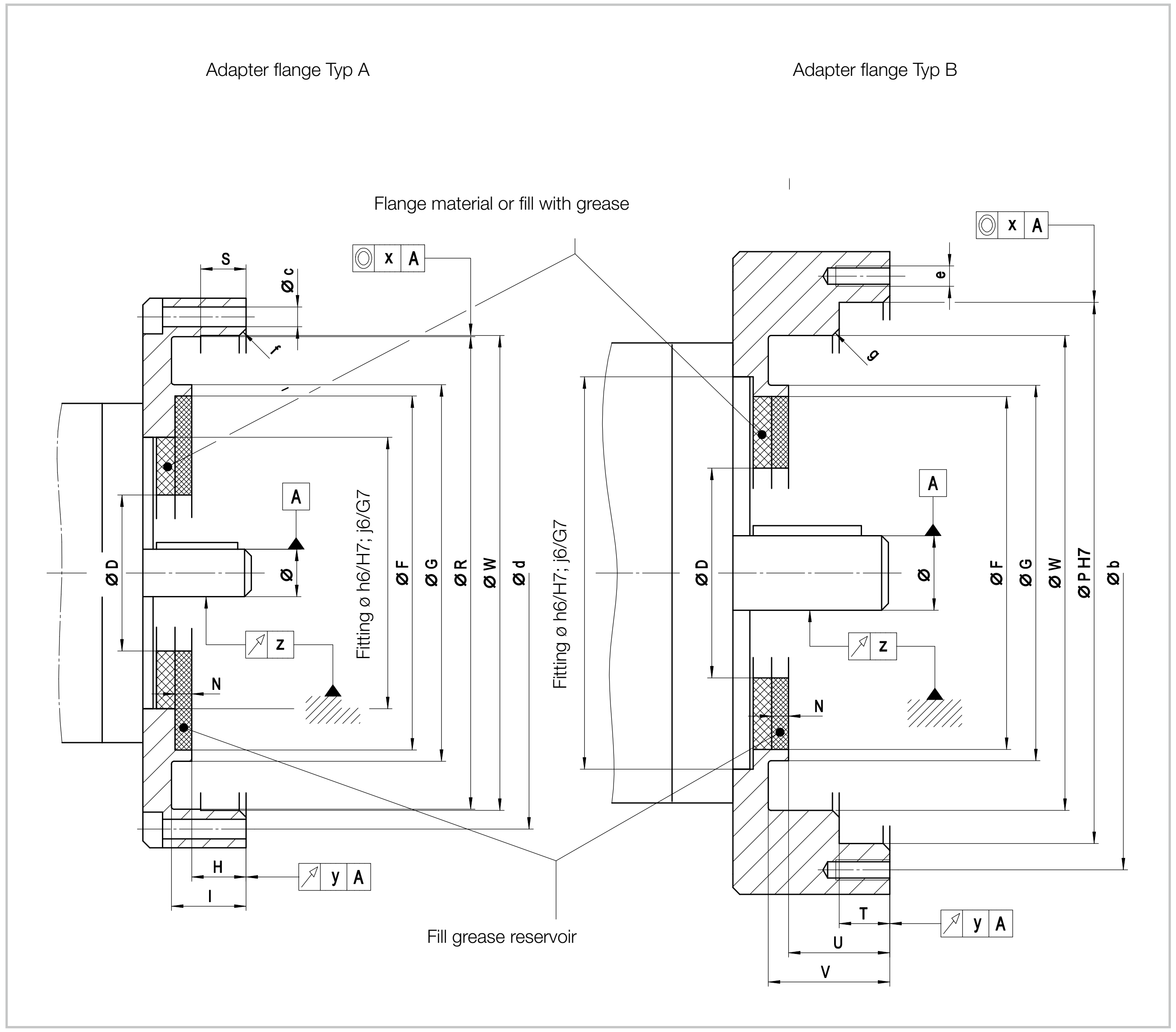


Table 2.4.16

Symbol	Size 14	17	20	25	32	40
Ø D	16	26	30	37	37	45
Ø F	36.5	47.0	53.0	66.0	86.0	106.0
Ø $G_{-0,1}$	37.5	48.0	55.5	69.0	90.5	110.0
$H^{+0,1}$	6.5	7.0	8.0	10.5	14.5	18.0
$I^{+0,1}$	9.5	10.0	11.0	14.5	19.5	24.0
N	1.0	1.5	1.5	1.5	1.5	2.0
ØP H7	60	72	82	96	125	154
Ø R	$50^{+0.027}$	$60^{+0.034}$	$70^{+0.036}$	$85^{+0.050}$	$110^{+0.055}$	$135^{+0.065}$
S	2.5	3.0	3.0	5.0	6.5	11.0
$T^{+0,1}$	4.3	6.3	6.9	7.8	9.8	10.3
$U^{+0,1}$	10.5	13.0	14.6	18.0	24.0	28.0
$V^{+0,1}$	13.5	16.0	17.6	22.0	29.0	34.0
Ø $W^{+0,1}$	50.4	60.4	70.4	85.4	110.4	135.4
Ø b	68	78	88	105	135	165
Ø c	2.9	3.4	3.4	3.4	4.5	5.5
Ø d	55	66	76	91	118	144
e	M2.5	M2.5	M2.5	M3	M4	M5
$f_{-0,1}$	1.0	1.3	1.3	1.3	1.3	2.0
$g_{-0,1}$	0.7	1.0	1.0	1.0	1.0	1.7
x	0.030	0.034	0.044	0.047	0.050	0.063
y	0.030	0.040	0.040	0.040	0.040	0.050
z	0.030	0.034	0.044	0.047	0.050	0.063
	(0.016)	(0.018)	(0.019)	(0.022)	(0.022)	(0.024)

All data given in the table are valid for adapter flanges mounted to the motor. The values in brackets are recommended tolerances for a Wave Generator without Oldham coupling. This coupling is used to compensate for eccentricity errors of the motor shaft and is installed in the standard gear. In case of a direct coupling of the Wave Generator on the motor shaft without Oldham coupling (option), the motor shaft tolerances should correspond to DIN 42955 R.

Assembly

We recommend the following assembly sequence.

Illustration 2.4.11

Adapter flange Typ A

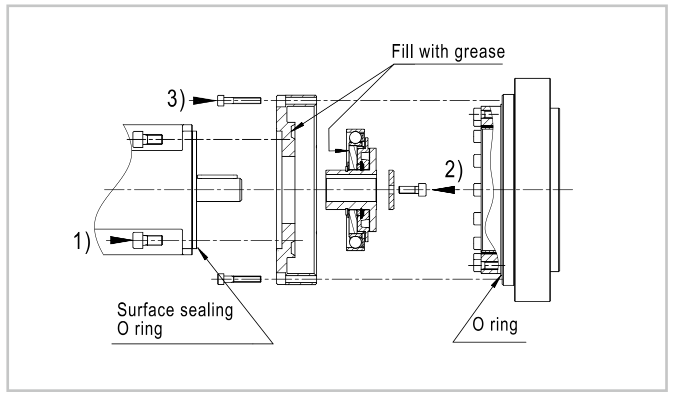


Illustration 2.4.12

Adapter flange Typ B

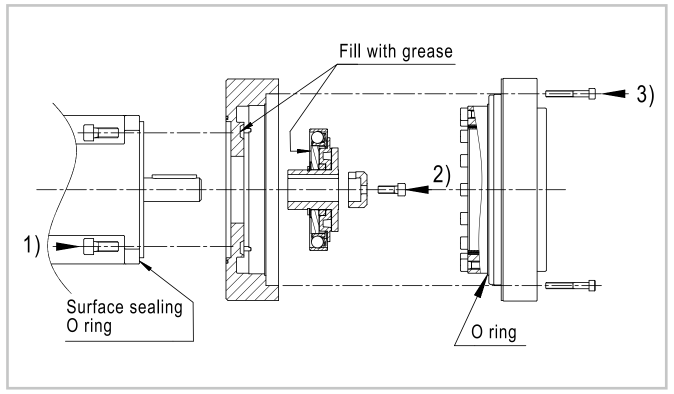
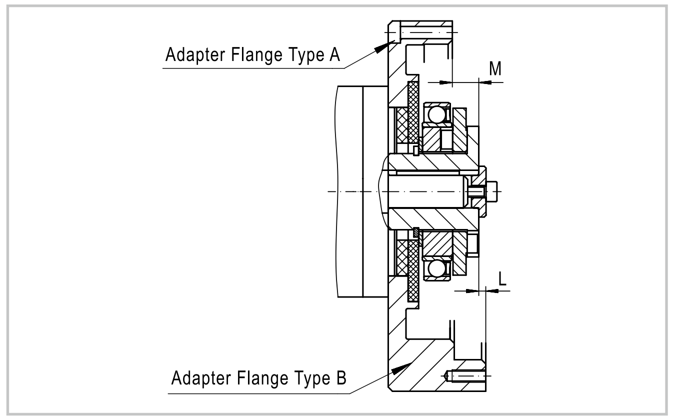
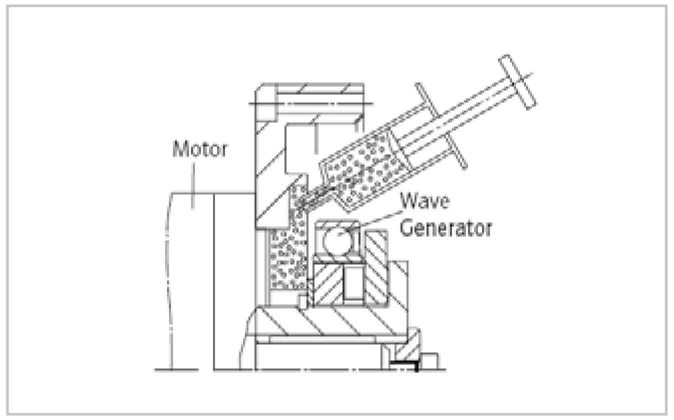


Illustration 2.4.13



The prescribed axial position of the Wave Generator, dimension M or L according to Illustration 2.4.13, is given in the customer confirmation drawing.

Illustration 2.4.14



Grease reservoir

When using the flange design recommended by Harmonic Drive SE, the gear can be used in all operating positions. We recommend placing an additional amount of grease in the grease reservoir between the Wave Generator and the end shield of the motor during assembly, see Illustration 2.4.14. This additional amount of grease is supplied in separate packaging.

Table 2.4.17

	[Unit]	Size					
		14	17	20	25	32	40
Standard grease quantity (included in gear component set on delivery)	ca. [g]	5.5	10	16	40	60	130
	ca. [cm³]	6	11	18	44	66	143
Recommended additional grease quantity for grease reservoir (supplied in separate packaging)	ca. [g]	2	3	4	6	14	27
	ca. [cm³]	2	3	4	7	16	30

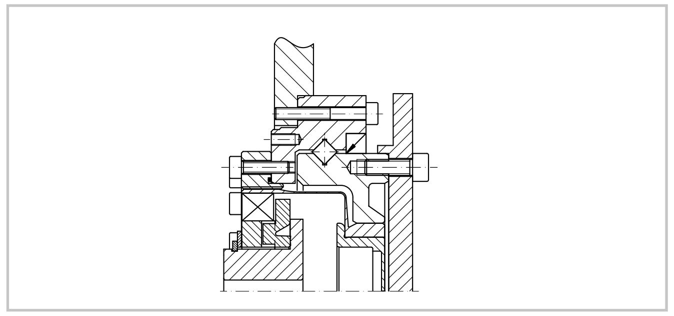
Table 2.4.18

Ordering code for grease	Available packages [kg]
Special grease 4BNo.2	1.0; 25

Adaption examples

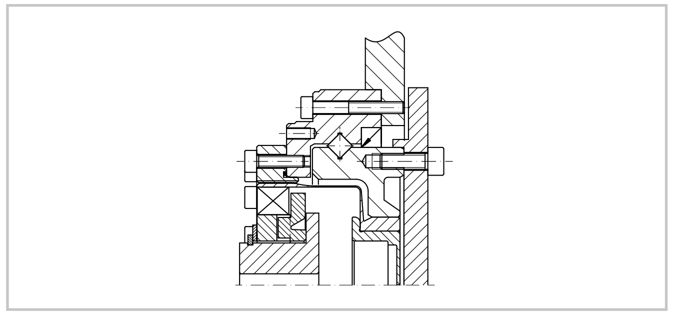
• Housing

Illustration 2.4.15



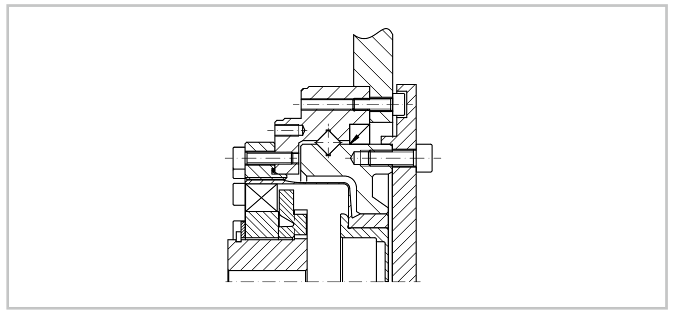
Use of the through holes

Illustration 2.4.16



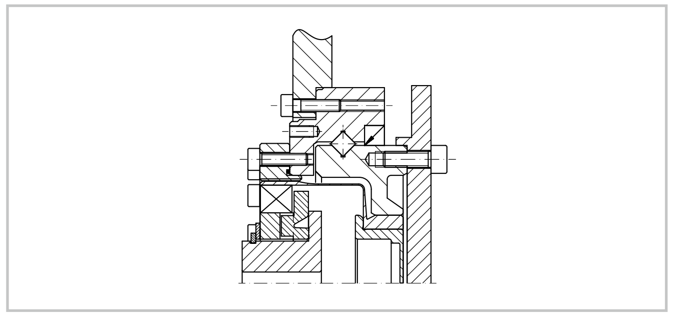
Use of the through holes

Illustration 2.4.17



Use of the threads

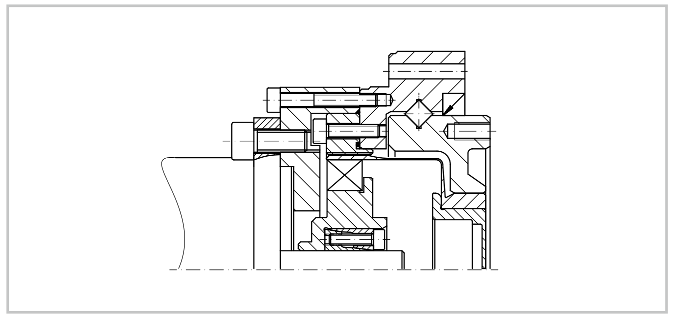
Illustration 2.4.18



Use of the threads

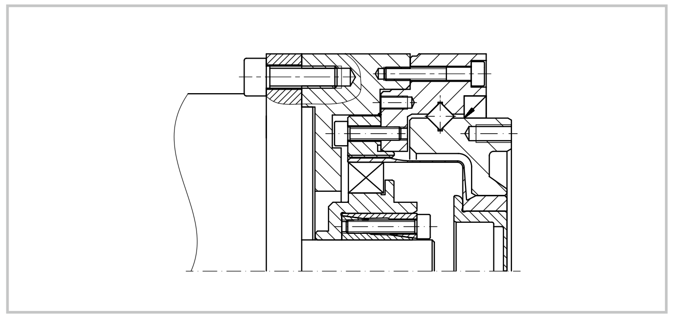
• Motor

Illustration 2.4.19



Small motor, flange type A

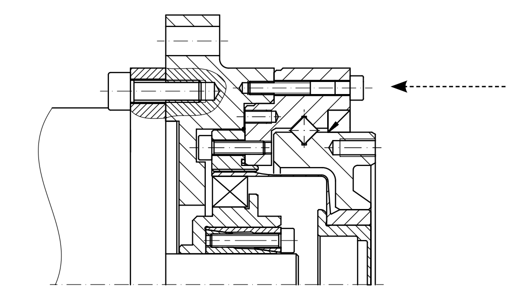
Illustration 2.4.20



Large motor, flange type B

• Individual adaptation for housing and motor

Illustration 2.4.21



In this case, the through holes must be used, as shown here.
Do not use the countersunk holes!

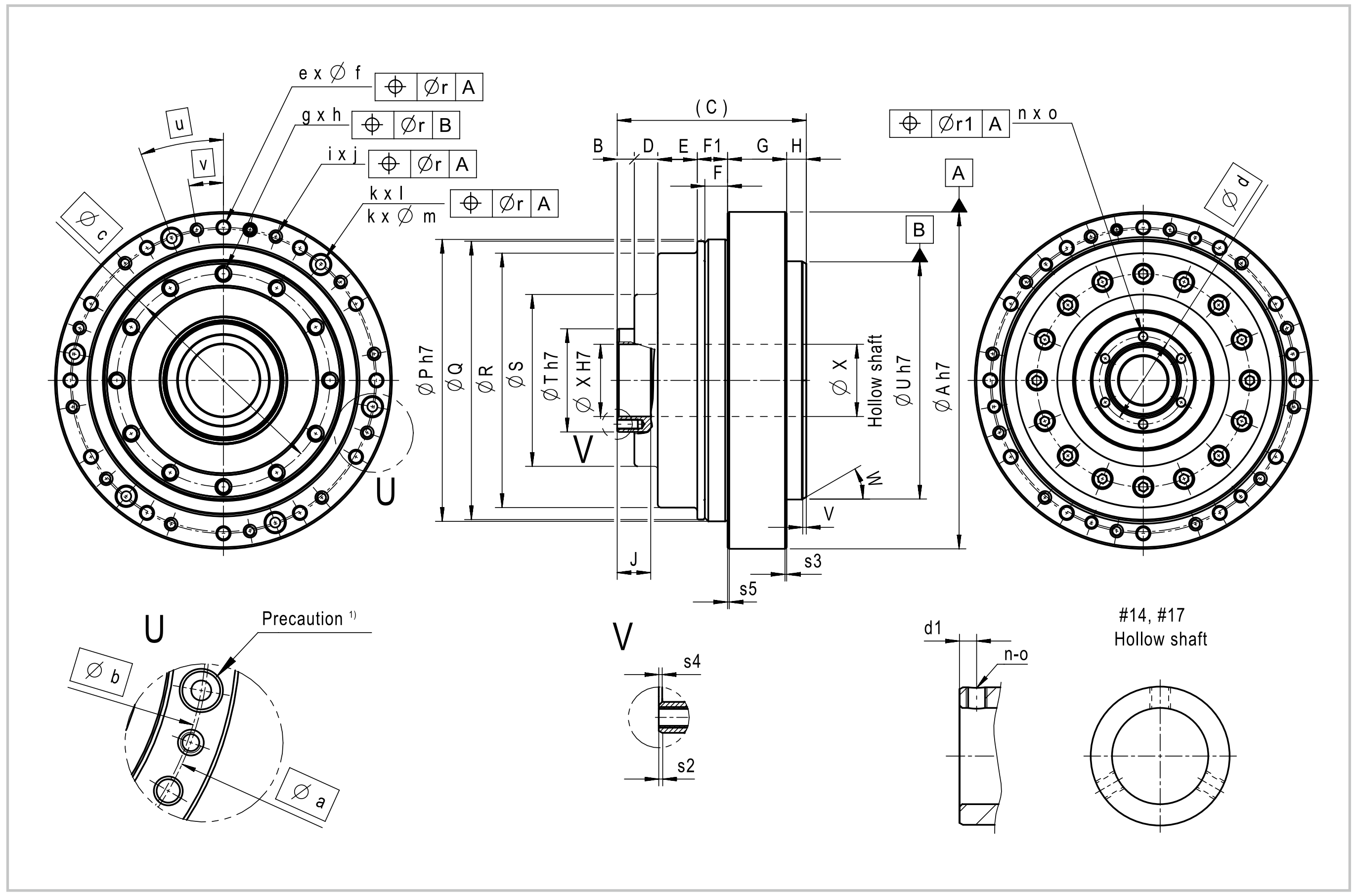
Any motor, any flange type

Technical data CSG-CPH

• Dimensions

Illustration 2.4.22

CSG-CPH [mm]



[1] Countersunk hole only for motor adaptation, do not use for load!

Table 2.4.19

CSG-CPH [mm]

Symbol	Size 14	17	20	25	32	40
ØA h7	78	88	98	116	148	180
B	6.5	6.5	5.0	5.0	7.0	8.0
C	46.0	51.5	55.0	59.0	79.0	90.0
D	7.0	8.5	6.8	3.8	8.8	7.3
E	9.8	9.8	11.5	15.0	20.0	24.5
F	4.0	6.0	6.6	7.5	9.5	10.0
F1	5.7	8.2	8.8	9.7	12.7	13.7
G	12.0	13.5	17.2	19.0	24.0	29.0
H	5.0	5.0	5.7	6.5	6.5	7.5
J	10	10	10	12	10	14
ØP h7	60	72	82	96	125	154
ØQ	59.5	71.5	81.0	95.0	124.0	153.0
ØR	53	64	74	89	116	142
ØS	36	42	50	55	80	95
ØT h7	20	25	30	38	45	59
ØU h7	49	59	69	84	110	132
V	0.4	0.4	1.0	1.0	1.0	1.0
W [°]	30	30	30	30	30	30
ØX H7	14	19	21	29	36	46
Øa	68	80	89	105	135	168
Øb	68	78	88	105	135	165
Øc	43	52	62	76	96	118
Ød	-	-	25.5	33.5	40.5	52.0
d1	2.5	2.5	-	-	-	-
e	8	12	12	12	12	12
Øf	3.4	3.4	3.4	4.5	5.5	6.6
g	12	12	12	12	12	12
h	M3x6	M4x8	M4x8	M5x10	M6x10	M8x14
i	8	12	12	12	12	12
j	M3	M3	M3	M4	M5	M6
k	4	6	6	6	6	6
l	Ø 5.5x3	Ø 5.5x3	Ø 5.5x3	Ø 6.5 x 3.4	Ø 8x4.4	Ø 10x6
Øm	2.9	2.9	2.9	3.4	4.5	5.5
n	3	3	6	6	6	6
o	M3	M3	M3x6	M3x6	M3x6	M4x8
Ør	0.25	0.25	0.30	0.30	0.40	0.50
Ør1	-	-	0.25	0.25	0.25	0.25
s2	0.5x30°	0.5x30°	0.5x30°	0.5x30°	0.5x30°	0.5x30°
s3	0.4x45°	0.4x45°	0.5x45°	0.5x45°	0.5x45°	0.5x45°
s4	0.4x45°	0.4x45°	0.5x45°	0.5x45°	0.5x45°	0.5x45°
s5	0.4x45°	0.4x45°	0.5x45°	0.5x45°	0.5x45°	0.5x45°
u [°]	30	20	20	20	20	20
v [°]	15	10	10	8	10	10

CAD drawings for download: www.harmonicdrive.co.uk

• No load starting torque

Table 2.4.20 **[Ncm]**

Ratio	Size					
	14	17	20	25	32	40
50	8.8	27	36	56	85	136
80	7.5	25	33	50	74	117
100	6.9	24	32	49	72	112
120	-	24	31	48	68	110
160	-	-	31	47	67	105

• No load back driving torque

Table 2.4.21 **[Nm]**

Ratio	Size					
	14	17	20	25	32	40
50	5.3	16	22	34	51	82
80	7.2	24	31	48	70	112
100	8.2	29	38	59	86	134
120	-	34	45	69	97	158
160	-	-	59	90	128	201

• Input bearing

The hollow shaft of the CSG-CPH Gear is supported by two single row deep groove ball bearings. Illustration 2.4.23 shows the points of application of force of the radial and axial loads given in Table 2.4.22 and Illustration 2.4.24. Example: If the hollow shaft of a CSG-40-CPH Gear is preloaded with an axial load of 600 N the max. permissible radial load is 500 N, see Illustration 2.4.24.

The maximum values shown here apply to an average input speed of 2000 rpm and an average bearing life L_{10} = 10.000 h.

Table 2.4.22

	Symbol [Unit]	Size					
		14	17	20	25	32	40
Distance	B [mm]	6.5	6.5	5.0	5.0	7.0	8.0
Maximum permissible radial load	F_r [N]	204	235	271	306	918	1113

Illustration 2.4.23

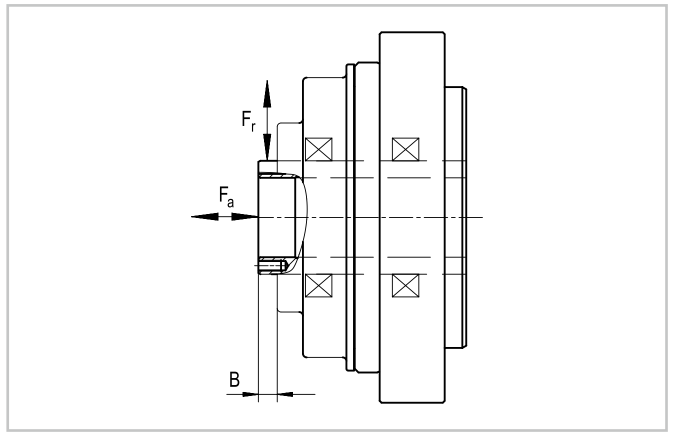
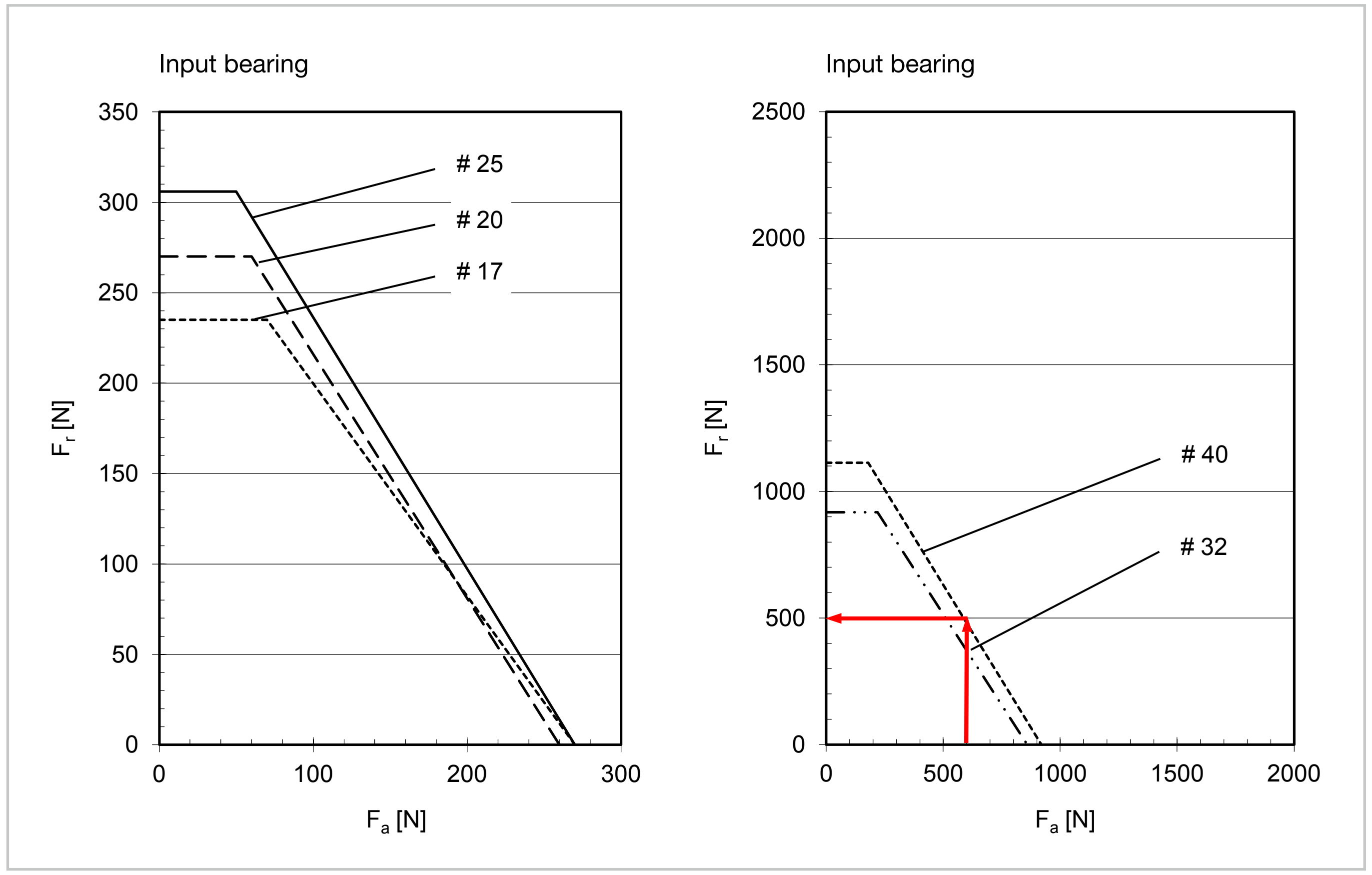


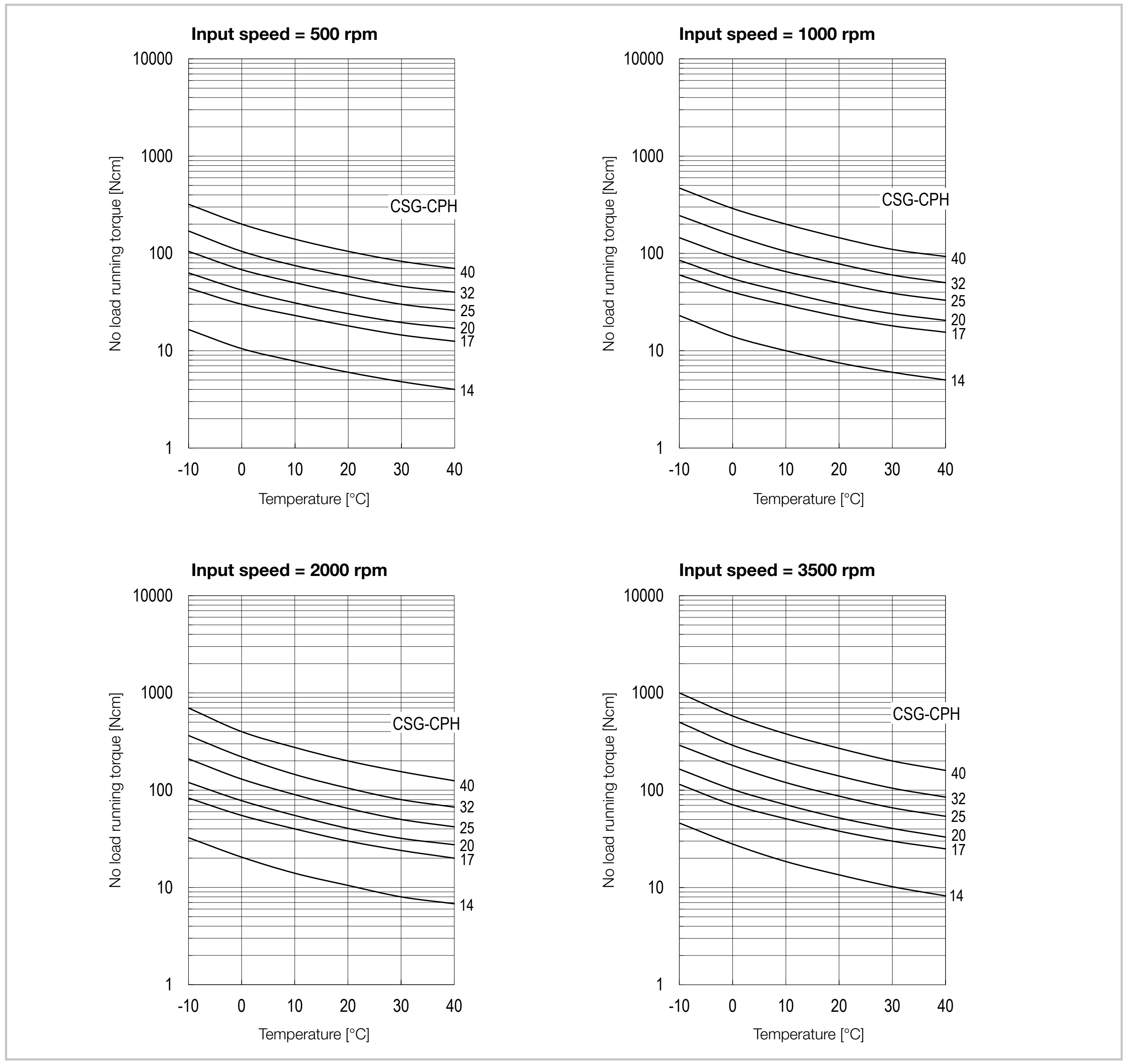
Illustration 2.4.24



No load running torque

The diagrams apply to Harmonic Drive® grease 4BNo.2.

Illustration 2.4.25



Compensation values for no load running torque

When using gears with ratios other than i=100 please add the compensation values from the table to the values taken from the curves.

Table 2.4.23 **[Ncm]**

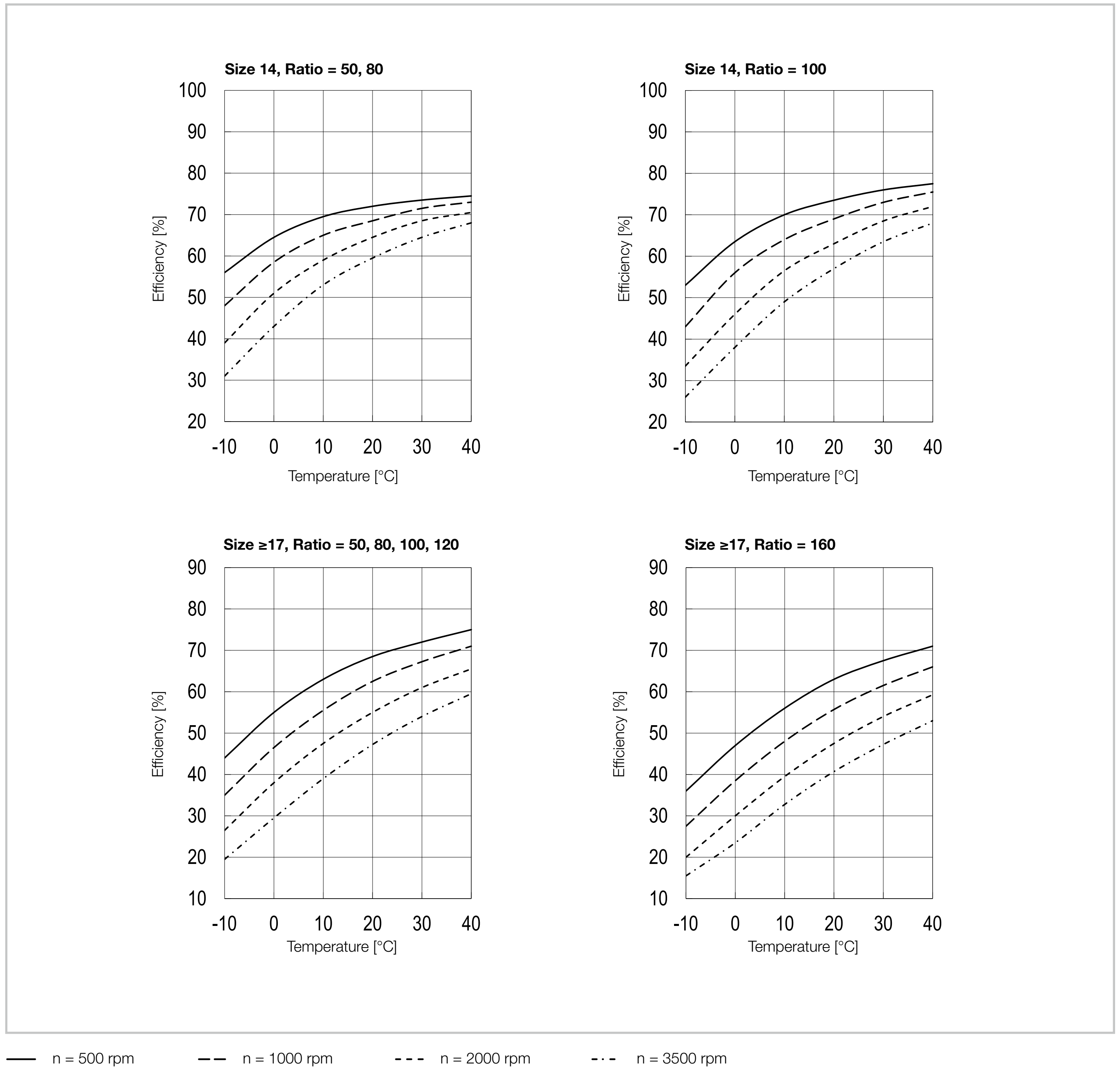
Ratio	Size					
	14	17	20	25	32	40
30	2.6	4.1	5.9	9.6	18.3	-
50	1.1	1.8	2.6	4.2	8.0	13.3
80	0.2	0.4	0.5	0.8	1.5	2.4
120	-	-0.2	-0.4	-0.6	-1.1	-1.7
160	-	-	-0.8	-1.3	-2.5	-4.0

Efficiency

Efficiency for grease lubrication at rated torque

The diagrams apply to Harmonic Drive® Grease 4BNo.2.

Illustration 2.4.26



Efficiency calculation

The efficiency depends on the following parameters: Gear ratio, input speed, load torque, temperature, lubricant and lubricant quantity. If the load torque is lower than the rated torque, the efficiency will be lower than the efficiency than that indicated in the efficiency curves. The torque specific efficiency is determined by means of the the calculation factor K. For gears with a bearing mounted and sealed input shaft, the additional reduction in efficiency is taken into account by the correction value η_e.

Calculation example:

CSG-25-100-CPH

- Input speed: 1000 rpm
- (Average) load torque T_{av}: 75 Nm
- Rated torque T_N (catalogue reference): 87 Nm
- Grease lubrication with Harmonic Drive® Grease 4BNo.2
- lubricant temperature: 20 °C

1. Calculation of the torque factor
   $V = T_{av}/T_N = 75/87 = 0.86$. (For V>1 is K=1)
2. Reading the calculation factor K from Illustration 2.4.27 K = 0.95
3. Reading the efficiency from the efficiency curve Illustration 2.4.26: η = 62 %
4. Reading the efficiency correction value from Illustration 2.4.28: η_e= -4.5 %
5. Calculation of the load dependant efficiency
   $\eta_L = K \cdot (\eta + \eta_e) = 0.95 \cdot (62\ \% - 4.5\ \%) = 55\ \%$

Illustration 2.4.27

Calculation factor K

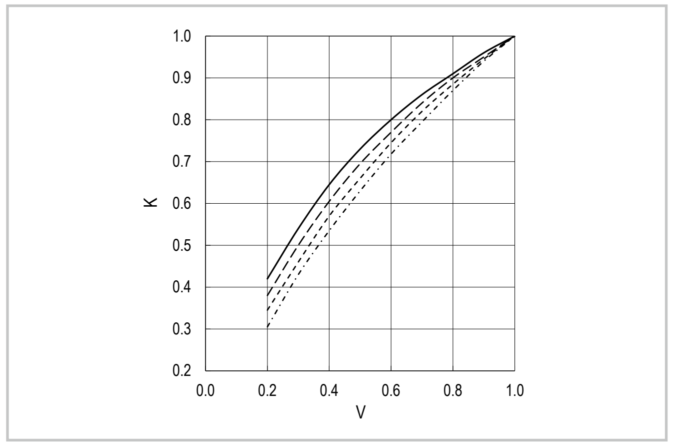
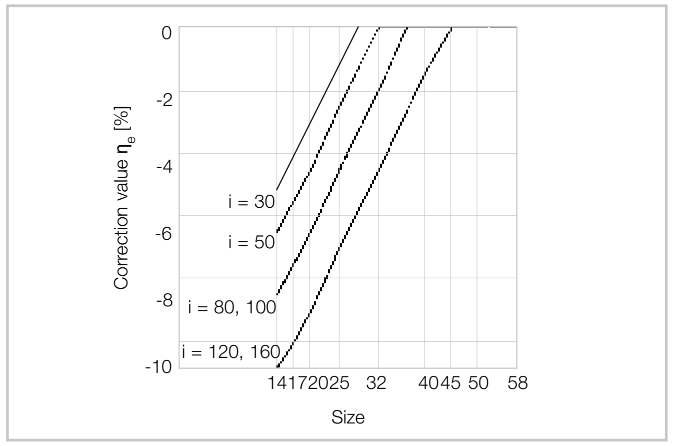


Illustration 2.4.28

Correction value η_e

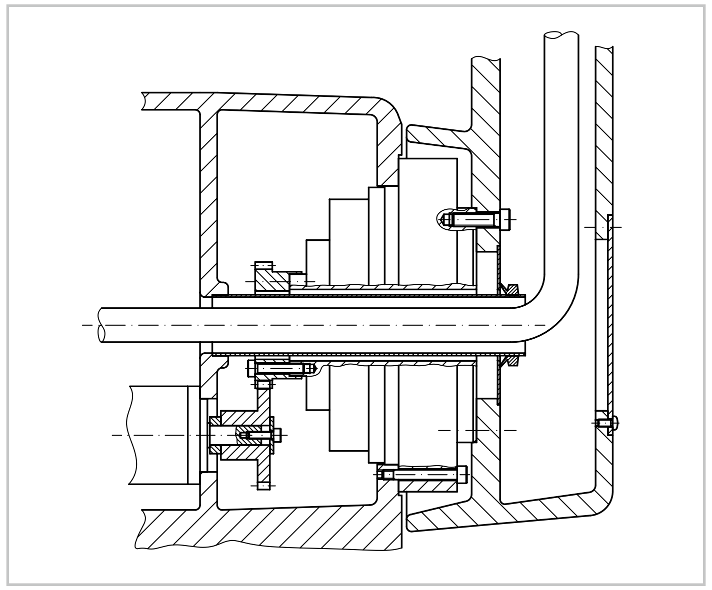


• Continous operation

The friction of the oil seals on the input can lead to an additional temperature increase in the hollow shaft gearboxes during operation. Therefore, a reduced "limit for average input speed" applies to these products. For continuous operation at rated speed, the max. operating times stated in Table 2.4.24 should not be exceeded.

Alternatively, a design according to Illustration 2.4.29 can be used. In this example, the radial oil seals on the input (high speed) have been removed. There are no restrictions on the duty cycle when using this design. The removal of one or both oil seals on the input should only be carried out if grease or base oil leakage is permitted or if this is excluded by the installation position.

Illustration 2.4.29



• Maximum permissible operating time for continuous operation

Table 2.4.24 **[min]**

Operation time	Size 14	17	20	25	32	40
At operation without load	90	90	90	60	45	40
At rated torque	60	60	60	45	35	30

The data given in Table 2.4.24 applies to:
- Ambient temperature: 25 °C
- Input speed: 2000 rpm
- Max. lubrication temperature: 80 °C
- Mounting of the gear on a plate with the following dimensions:
  Plate height and length: 330 mm
  Plate thickness: 15 mm for Size ≤ 32
  30 mm for Size ≥ 40
- Plate material: Steel
- An additional output flange is not mounted.

• Assembly of the input shaft CSG-CPH

Table 2.4.25

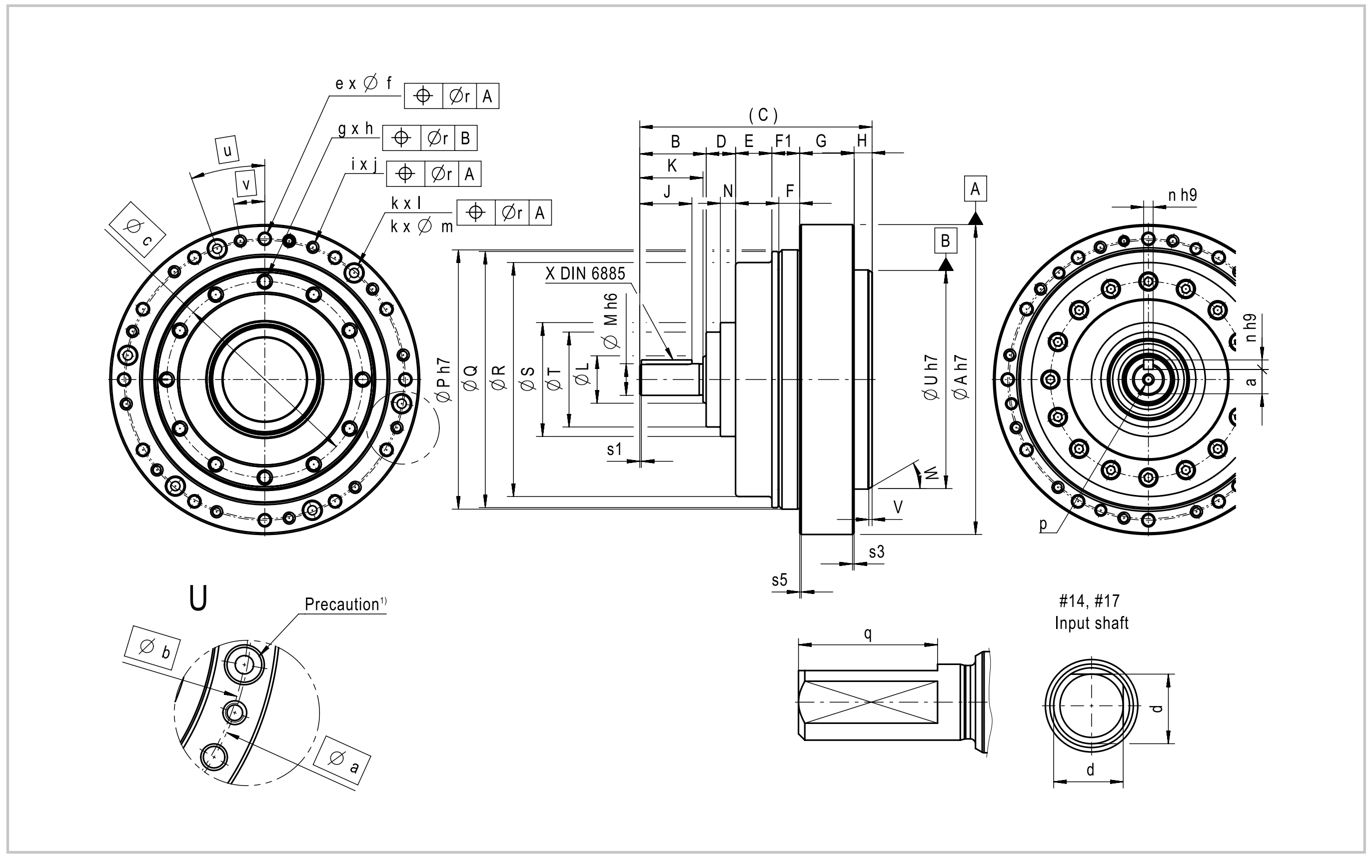
	[Unit]	Size 14	17	20	25	32	40
Number of screws		3	3	6	6	6	6
Size of screws		M3	M3	M3	M3	M3	M4
Screw tightening torque	[Nm]	2.30	2.30	2.30	2.30	2.30	5.29

Technical data CSG-CPS

- ## Dimensions

Illustration 2.4.30

CSG-CPS [mm]



1) Countersunk hole only for motor adaptation, do not use for load!

Table 2.4.26

CSG-CPS [mm]

Symbol	Size 14	17	20	25	32	40
ØA h7	78	88	98	116	148	180
B	15	17	21	26	26	31
C	55.0	61.5	73.5	86.5	100.5	117.5
D	7.5	8.0	9.3	10.3	11.3	11.8
E	9.8	9.8	11.5	15.0	20.0	24.5
F	4.0	6.0	6.6	7.5	9.5	10.0
F1	5.7	8.2	8.8	9.7	12.7	13.7
G	12.0	13.5	17.2	19.0	24.0	29.0
H	5.0	5.0	5.7	6.5	6.5	7.5
J	-	-	16.5	22.5	22.5	27.5
K	14	16	20	25	25	30
ØL	8	10	15	17	20	30
ØM h6	6	8	10	14	14	16
N	5.5	4.5	4.8	6.1	7.3	4.3
ØP h7	60	72	82	96	125	154
ØQ	59.5	71.5	81.0	95.0	124.0	153.0
ØR	53	64	74	89	116	142
ØS	24	28	36	42	52	65
ØT	20	22	30	34	43	57
ØU h7	49	59	69	84	110	132
V	0.4	0.4	1.0	1.0	1.0	1.0
W [°]	30	30	30	30	30	30
X DIN 6885	-	-	A 3x3x16	A 5x5x22	A 5x5x22	A 5x5x25
Øa	68	80	89	105	135	168
Øb	68	78	88	105	135	165
Øc	43	52	62	76	96	118
d	5.5	7.5	-	-	-	-
e	8	12	12	12	12	12
Øf	3.4	3.4	3.4	4.5	5.5	6.6
g	12	12	12	12	12	12
h	M3x6	M4x8	M4x8	M5x10	M6x10	M8x14
i	8	12	12	12	12	12
j	M3	M3	M3	M4	M5	M6
k	4	6	6	6	6	6
l	Ø5.5x3	Ø5.5x3	Ø5.5x3	Ø6.5x3.4	Ø8x4.4	Ø10x6
Øm	2.9	2.9	2.9	3.4	4.5	5.5
n h9	-	-	3	5	5	5
o	-	-	$8.2^{0}_{-0.1}$	$11^{0}_{-0.1}$	$11^{0}_{-0.1}$	$13^{0}_{-0.1}$
p	-	-	M3x6	M5x10	M5x10	M5x10
q	11	12	-	-	-	-
Ør	0.25	0.25	0.30	0.30	0.40	0.50
s1	0.5x45 °	0.50x45 °	0.5x45 °	0.5x45 °	0.5x45 °	0.5x45 °
s3	0.4x45 °	0.40x45 °	0.5x45 °	0.5x45 °	0.5x45 °	0.5x45 °
s5	0.4x45 °	0.40x45 °	0.5x45 °	0.5x45 °	0.5x45 °	0.5x45 °
u [°]	30	20	20	20	20	20
v [°]	15	10	10	8	10	10

CAD drawings for download: www.harmonicdrive.co.uk

• No load starting torque

Table 2.4.27 **[Ncm]**

Ratio	Size					
	14	17	20	25	32	40
50	5.7	9.7	14.0	22.0	41.0	72.0
80	4.4	7.2	11.0	15.0	29.0	52.0
100	3.7	6.5	9.9	14.0	27.0	47.0
120	-	6.2	9.3	13.0	24.0	44.0
160	-	-	8.6	12.0	23.0	39.0

• No load back driving torque

Table 2.4.28 **[Nm]**

Ratio	Size					
	14	17	20	25	32	40
50	3.4	5.8	8.4	13.0	25.0	43.0
80	4.2	6.9	10.0	15.0	28.0	50.0
100	4.5	7.8	12.0	17.0	33.0	56.0
120	-	8.9	13.0	19.0	34.0	63.0
160	-	-	17.0	23.0	43.0	75.0

• Input bearing

The input shaft of the CSG-CPS Gear is supported by two single row deep groove ball bearings. Illustration 2.4.31 shows he points of application of force of the radial and axial loads given in Table 2.4.29 and Illustration 2.4.32. Example: If the input shaft of a CSG-40-CPS Gear is preloaded with an axial load of 500 N, the max. permissible radial load is 430 N, see Illustration 2.4.32.

The maximum values shown here apply to an average input speed of 2000 rpm and an average bearing life L_{10} = 10.000 h.

Table 2.4.29

	Symbol [Unit]	Size					
		14	17	20	25	32	40
Distance	B [mm]	7	8	10	12,5	12,5	15
Maximum permissible radial load	F_r [N]	118	145	232	342	567	825

Illustration 2.4.31

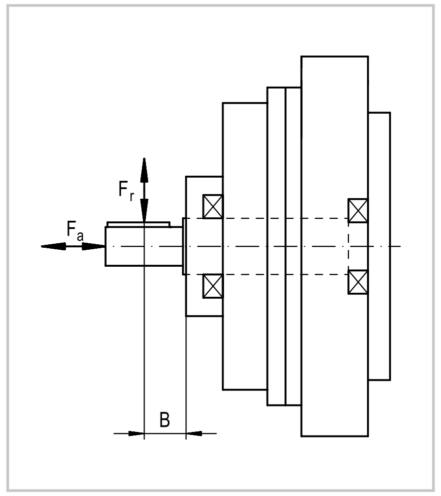
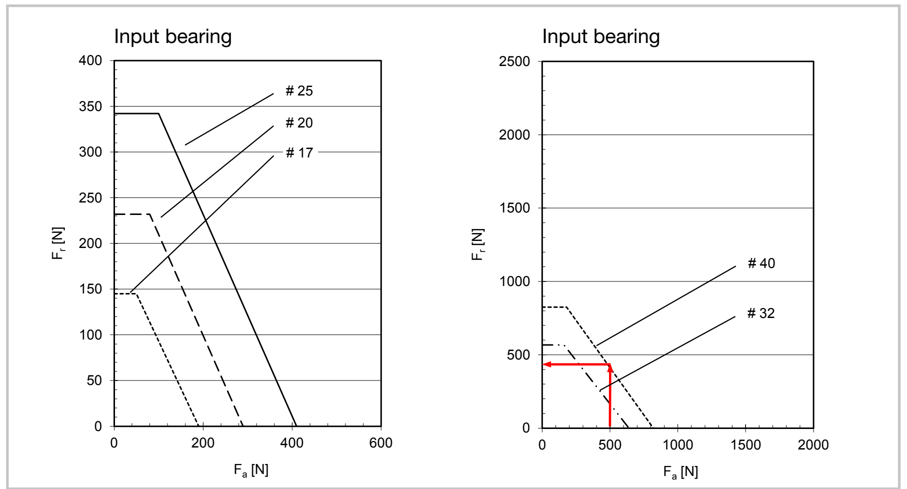


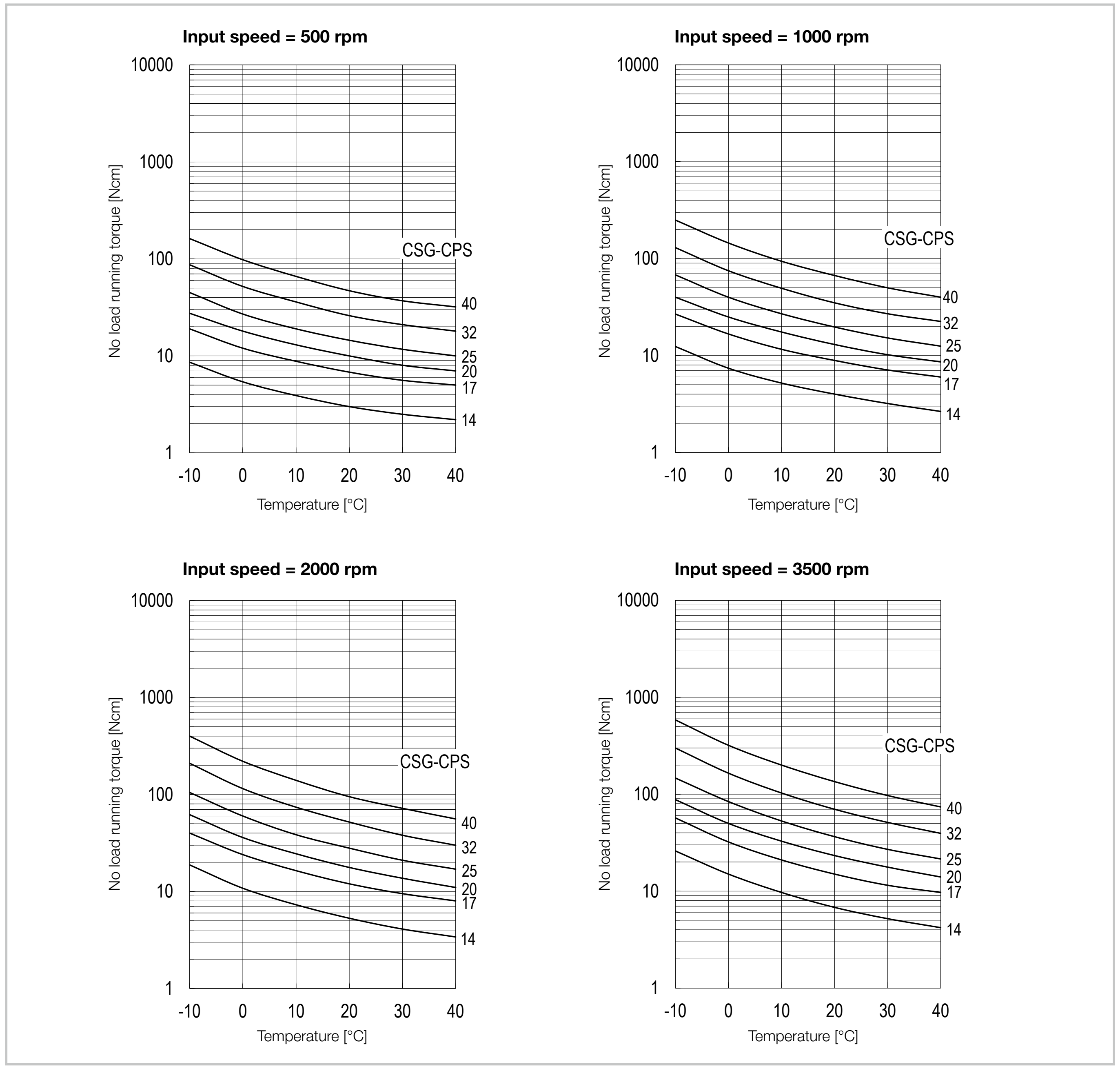
Illustration 2.4.32



• No load running torque

The diagrams apply to Harmonic Drive® grease 4BNo.2.

Illustration 2.4.33



Compensation values for no load running torque

When using gears with ratios other than i=100 please add the compensation values from the table to the values taken from the curves.

Table 2.4.30 **[Ncm]**

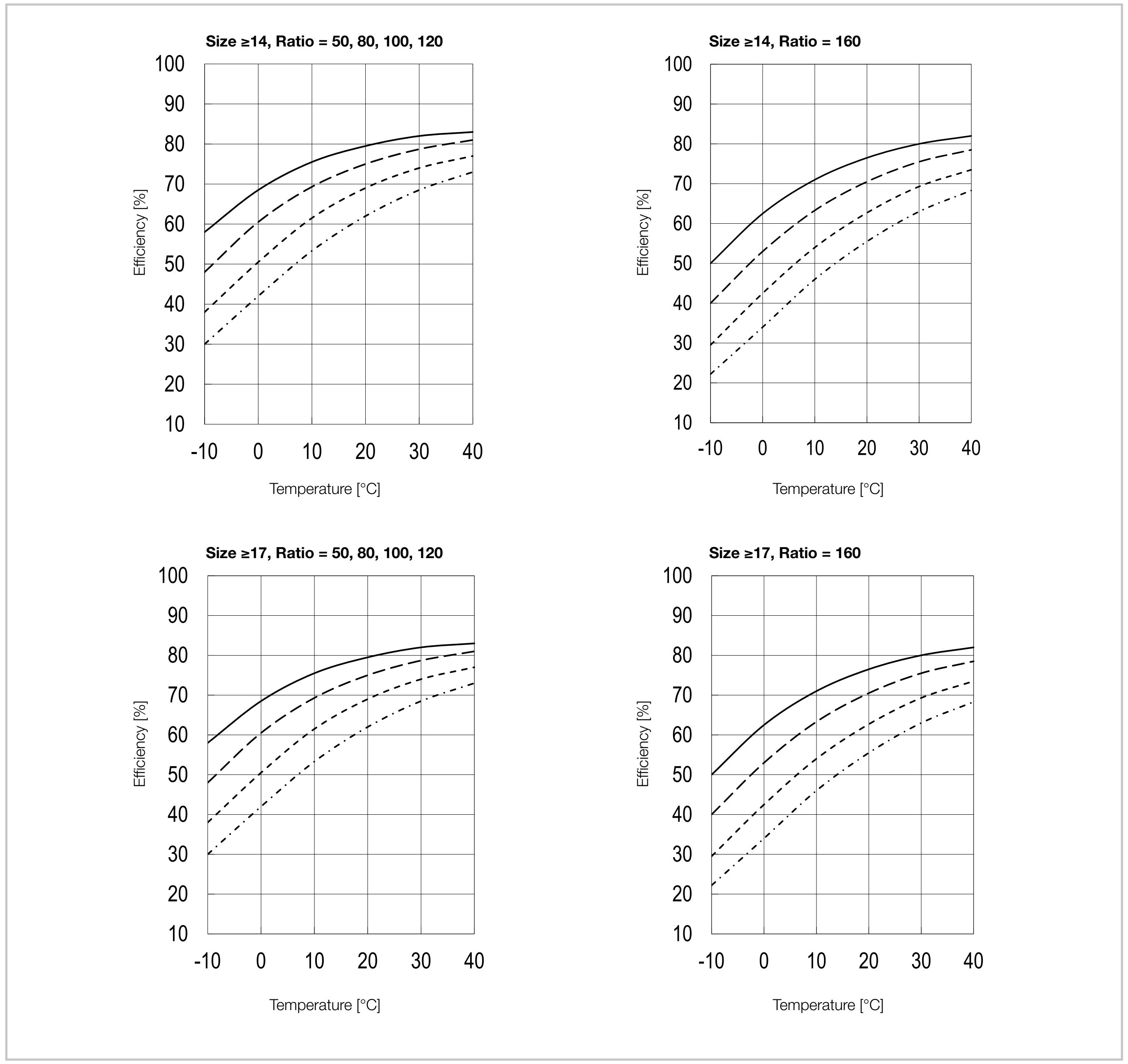
Ratio	Size					
	14	17	20	25	32	40
50	1.1	1.8	2.6	4.2	8.0	13.3
80	0.2	0.4	0.5	0.8	1.5	2.4
120	-	-0.2	-0.4	-0.6	-1.1	-1.7
160	-	-	-0.8	-1.3	-2.5	-4.0

Efficiency

Efficiency for grease lubrication at rated torque

The diagrams apply to Harmonic Drive® Grease 4BNo.2.

Illustration 2.4.34



n = 500 rpm n = 1000 rpm n = 2000 rpm n = 3500 rpm

Efficiency calculation

The efficiency calculation of the CSG-CPS Gears is carried out according to the same procedure as for the CSG-CPH Gears.

Illustration 2.4.35 **Calculation factor K**

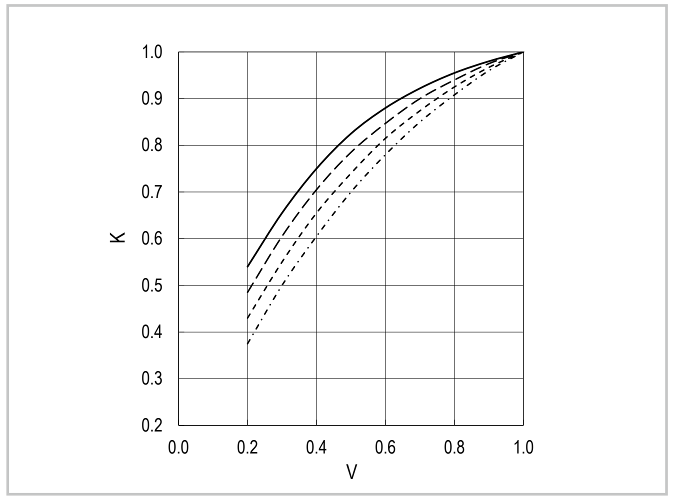
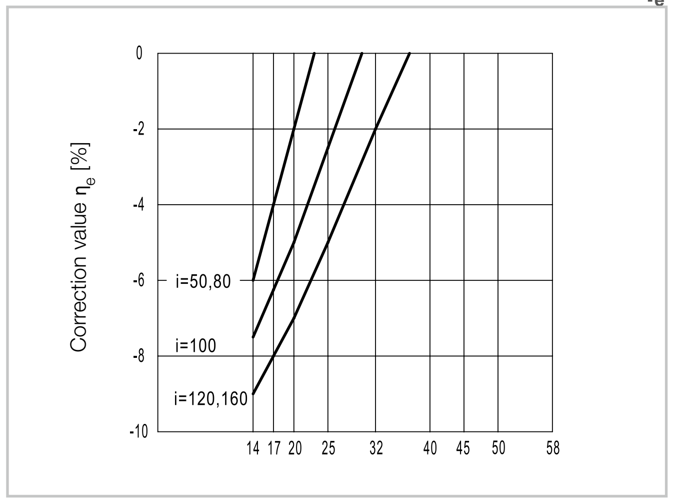


Illustration 2.4.36 **Correction value η_e**



Materials and coatings used

Table 2.4.31

Version	CSG-CPM	CSG-CPH	CSG-CPS
Abtriebslager	Bright steel		
Circular Spline	Grey cast iron		
Flexspline	Bright steel		
Wave Generator (Hollow shaft by CSG-CPH)	Bright steel	Bright steel	Bright steel
Input shaft	x	x	Stainless steel
Housing flange	x	Bright steel	Bright steel
Adapter flange[1]	High-strength bright aluminium oder steel	x	x
Screws	No corrosion protection		

x not available in this version
[1] If supplied by Harmonic Drive SE
[2] no corrosion protection

Optional materials and coatings are available on request from Harmonic Drive SE.

Lubrication

• Grease lubrication

The Gears with output bearing CSG-CPM/H/S are supplied fully greased. They are provided with lifetime grease lubrication at the factory. We recommend the use of the greases listed in Table 2.4.32. The output bearing is greased with Harmonic Drive® Grease 4BNo.2.

Table 2.4.32

Ratio	Harmonic Drive® Grease	Size		
		14	17	20 ... 40
50 ... 160	Flexolub®-A1	-	-	-
	SK-1A	-	-	Δ
	SK-2	Δ	Δ	-
	4BNo.2	O	O	O

O Standard grease
☐ Recommended for very high loads or very high demands on the service life of the grease
Δ Optional grease, please consult us

• Oil lubrication

Harmonic Drive® Gears with output bearing with oil lubrication are customised special designs. Lubrication and relubrication are determined individually. For more information, please refer to the chapter Engineering data.

Product description

Compact and lightweight precision gear

The CSD-2UH/-2UF Series Gears consist of a short mounting CSD Gear Component Set and a tilt resistant output bearing. They are characterised by a short design, lowest weight and excellent corrosion protection.

Features

- Shortest construction
- Lowest weight
- Integrated tilt resistant output bearing
- Optional hollow shaft
- Direct motor attachment possible

CSD-2UH

Gear for direct motor mounting with small outer diameter

CSD-2UF

Short Hollow shaft gear with integrated output bearing with highest load capacity

Ordering code

Table 2.5.1

Ordering code	CSD	-	25	-	100	-	2UH	-	SP
Series	CSD								
Size/Product generation (corresponds to the pitch circle diameter of the Flexspline toothing in inches x 10)			14 17 20 25 32 40 50						
Ratio (in drive configuration: Circular Spline (CS) fixed, Wave Generator (WG) input, Flexspline (FS) output)					50 80 100 120 160				
Version Gear for direct motor mounting with small outer diameter Short hollow shaft gear with integrated output bearing							2UH 2UF		
Customised design Standard design (field remains empty) Special design (on request)									[ ] SP

Please refer to the table of possible combinations.

Combinations

Table 2.5.2 **CSD-2UH**

		Size						
		14	17	20	25	32	40	50
Ratio	50	•	•	•	•	•	•	•
	80	•	•	•	•	•	•	•
	100	•	•	•	•	•	•	•
	120	-	•	•	•	•	•	•
	160	-	-	•	•	•	•	•

Table 2.5.3 **CSD-2UF**

		Size					
		14	17	20	25	32	40
Ratio	50	•	•	•	•	•	•
	80	•	•	•	•	•	•
	100	•	•	•	•	•	•
	120	-	•	•	•	•	•
	160	-	-	•	•	•	•

• available o on request - not available

Technical data

• Rating table

Table 2.5.4

Size	Ratio	Limit for repeated peak torque	Limit for average torque	Rated torque at rated speed 2000 rpm	Limit for momentary peak torque	Max. input speed	Limit for average input speed	Moment of inertia	Weight	
	i	T_R [Nm]	T_A [Nm]	T_N [Nm]	T_M [Nm]	[rpm]	[rpm]	[kgm²]	[kg] 2UH	2UF
14	50	12.0	4.8	3.7	24.0	8500	3500	0.021×10^{-4}	0.35	0.50
	80	16.0	7.7	5.4	35.0					
	100	19.0	7.7	5.4	35.0					
17	50	23	18	11	48	7300	3500	0.054×10^{-4}	0.46	0.66
	80	29	19	15	61					
	100	37	27	16	71					
	120	37	27	16	71					
20	50	39	24	17	69	6500	3500	0.090×10^{-4}	0.65	0.94
	80	51	33	24	89					
	100	57	34	28	95					
	120	60	34	28	95					
	160	64	34	28	95					
25	50	69	38	27	127	5600	3500	0.282×10^{-4}	1.20	1.70
	80	96	60	44	179					
	100	110	75	47	184					
	120	117	75	47	204					
	160	123	75	47	204					
32	50	151	75	53	268	4800	3500	1.090×10^{-4}	2.40	3.30
	80	213	117	83	398					
	100	233	151	96	420					
	120	247	151	96	445					
	160	261	151	96	445					
40	50	281	137	96	480	4000	3000	2.850×10^{-4}	3.60	5.70
	80	364	198	144	686					
	100	398	260	185	700					
	120	432	315	205	765					
	160	453	316	206	765					
50[1)]	50	500	247	172	1000	3500	2500	8.610×10^{-4}	6.90	-
	80	659	363	260	1300					
	100	686	466	329	1440					
	120	756	569	370	1565					
	160	823	590	370	1715					

[1)] Only available for version CSD-2UH

You will find more information on this in the Engineering data chapter.

Illustration 2.5.1 **CSD-2UH**

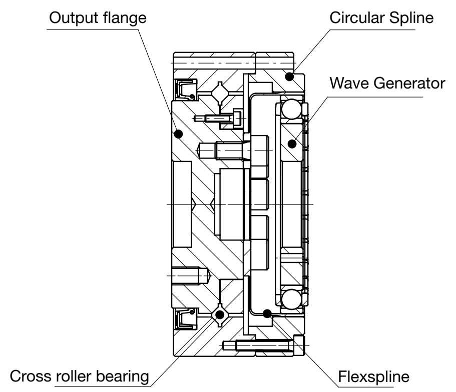
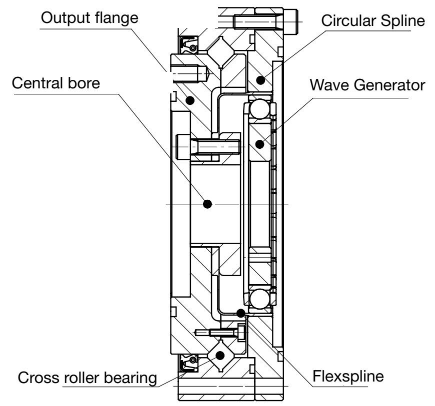


Illustration 2.5.2 **CSD-2UF**



• Dimensions

Illustration 2.5.3 **CSD-2UH [mm]**

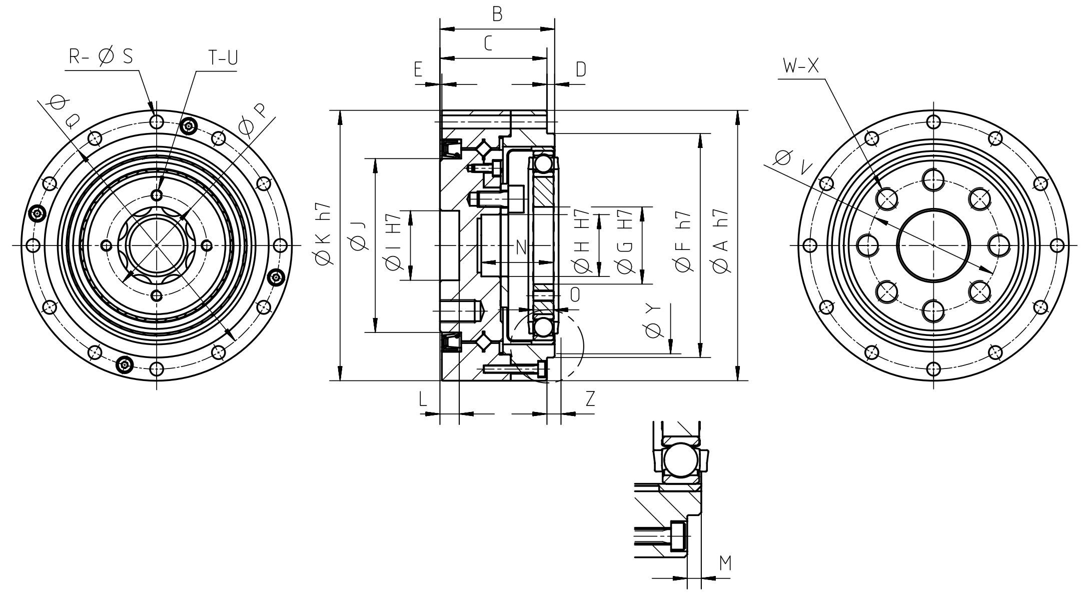


Table 2.5.5 **CSD-2UH [mm]**

	Size						
	14	17	20	25	32	40	50
ØA h7	55	62	70	85	112	126	157
B	25.0	26.5	29.7	37.1	43.0	51.7	62.5
C	23.0	24.5	27.7	34.1	40.0	47.7	58.5
D	2	2	2	3	3	4	4
E	0.5	0.5	0.5	0.5	1.0	1.0	1.0
ØF h7	42.5	49.5	58.0	73.0	96.0	108.5	136.0
ØG H7	11	15	20	24	32	40	50
ØH H7	11	11	16	20	30	32	44
ØI H7	12	14	18	24	32	36	48
ØJ	31	38	45	58	78	90	112
ØK h7	55	62	70	85	112	126	157
L	5.0	5.0	5.0	5.5	5.5	6.0	7.0
M	$1.7^{0}_{-0.2}$	$1.7^{0}_{-0.2}$	$1.7^{0}_{-0.2}$	$2.6^{0}_{-0.2}$	$2.5^{0}_{-0.2}$	$3.4^{0}_{-0.2}$	$3.2^{0}_{-0.2}$
N	14.8	16.3	18.8	23.7	30.6	36.5	44.3
O	$4.0^{0}_{-0.1}$	$5.0^{0}_{-0.1}$	$5.2^{0}_{-0.1}$	$6.3^{0}_{-0.1}$	$8.6^{0}_{-0.1}$	$10.3^{0}_{-0.1}$	$12.7^{0}_{-0.1}$
ØP (PCD)	17	21	26	30	40	50	60
ØQ (PCD)	49.0	56.0	64.0	79.0	104.0	117.5	147.0
R	6	10	12	18	18	18	22
ØS	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
ØV (PCD)	25	27	34	42	57	72	88
W	10	8	8	8	10	10	10
X	M3x7	M5x8	M6x9	M8x12	M8x12	M10x15	M12x18
ØY	38	45	53	66	86	106	133
Z	3.0	3.0	3.5	4.5	5.0	6.5	7.5

CAD drawings for download: www.harmonicdrive.co.uk

Illustration 2.5.4

CSD-2UF [mm]

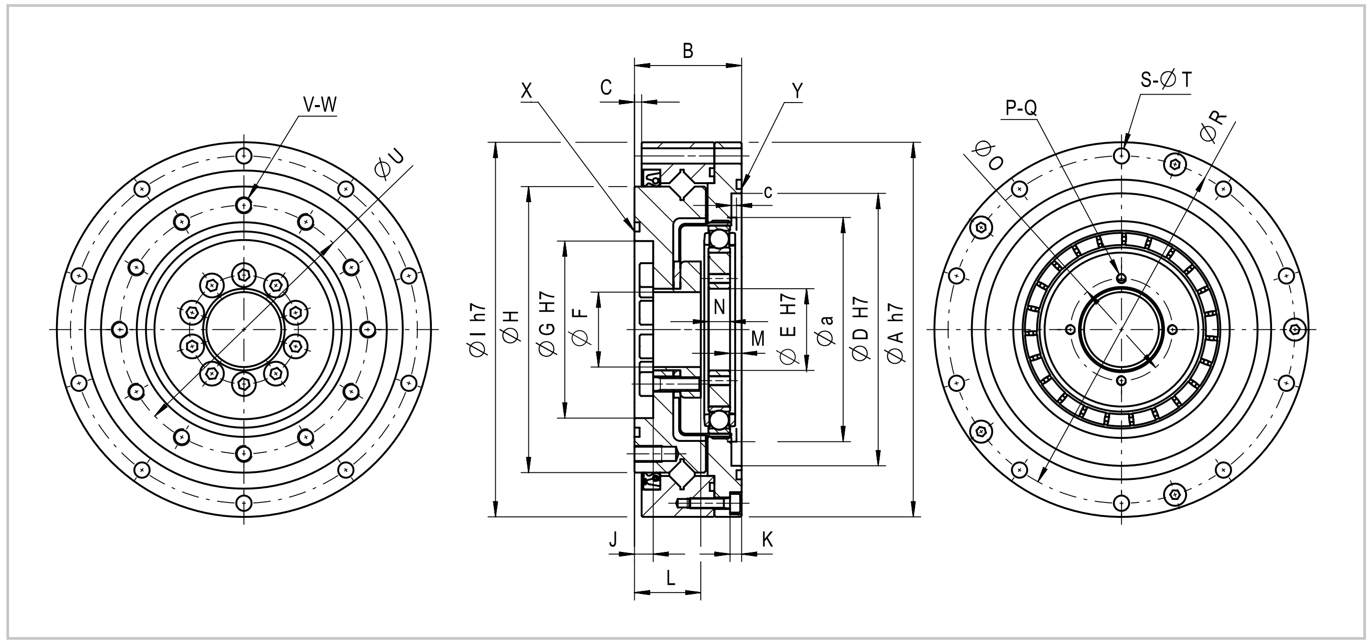


Table 2.5.6

CSD-2UF [mm]

	Size					
	14	17	20	25	32	40
ØA h7	70	80	90	110	142	170
B	22.0	22.7	26.8	31.5	37.0	45.0
C	0.5	0.5	2.3	2.1	2.8	6.5
ØD H7	48	56	64	80	106	132
ØE H7	11	15	20	24	32	40
ØF	9	9	18	22	29	37
ØG H7	30	34	40	52	70	80
ØH	49	59	69	84	110	132
ØI h7	70	80	90	110	142	170
J	4.9	5.4	4.8	5.5	6.0	7.0
K	2.5	2.5	2.5	3.0	3.0	3.0
L	12.9	13.4	16.8	19.5	22.0	27.0
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	$4.0^{0}_{-0.1}$	$5.0^{0}_{-0.1}$	$5.2^{0}_{-0.1}$	$6.3^{0}_{-0.1}$	$8.6^{0}_{-0.1}$	$10.3^{0}_{-0.1}$
ØO (PCD)	17	21	26	30	40	50
P	4	4	4	4	4	4
Q	M3	M3	M3	M3	M4	M5
ØR (PCD)	64	74	84	102	132	158
S	6	8	8	10	10	10
ØT	3.4	3.4	3.4	4.5	5.5	6.6
ØU (PCD)	42	50	60	73	96	116
V	8	10	8	8	8	12
W	M3x5	M3x6	M4x8	M5x8	M6x10	M6x10
X	34.5x0.8	38.0x1.2	S48	S60	S80	S100
Y	49.0x1.5	59.4x1.2	S70	S85	S115	S140
Øa	38	45	53	66	86	106
c	1.0	1.0	1.5	1.5	2.0	2.5

CAD drawings for download: www.harmonicdrive.co.uk

Accuracy

Table 2.5.7

[arcmin]

	Size					
	14		17		20 ... 50	
Ratio	50	>50	50	>50	50	>50
Transmission accuracy	<1.5		<1.5		<1.0	
Hysteresis loss	<2.5	<2.0	<2.0	<1.0	<2.0	<1.0

Torsional stiffness

Table 2.5.8

	Symbol [Unit]	Size						
		14	17	20	25	32	40	50
Limit torques	T_1 [Nm]	2.0	3.9	7.0	14.0	29.0	54.0	108.0
	T_2 [Nm]	6.9	12.0	25.0	48.0	108.0	196.0	382.0
i = 50	K_3 [x 10^4 Nm/rad]	0.47	1.20	2.00	3.70	8.40	15.00	30.00
	K_2 [x 10^4 Nm/rad]	0.37	0.88	1.30	2.70	6.10	11.00	21.00
	K_1 [x 10^4 Nm/rad]	0.29	0.67	1.10	2.00	4.70	8.80	17.00
i > 50	K_3 [x 10^4 Nm/rad]	0.61	1.30	2.50	4.70	11.00	20.00	37.00
	K_2 [x 10^4 Nm/rad]	0.44	0.94	1.70	3.70	7.80	14.00	29.00
	K_1 [x 10^4 Nm/rad]	0.40	0.84	1.30	2.70	6.10	11.00	21.00

No load starting torque

Table 2.5.9

CSD-2UH [Ncm]

Ratio	Size						
	14	17	20	25	32	40	50
50	4.4	6.7	8.9	16.0	32.0	55.0	102.0
80	3.2	4.4	5.7	10.0	22.0	36.0	68.0
100	2.8	3.8	5.1	9.1	20.0	32.0	60.0
120	-	3.6	4.5	8.2	17.0	29.0	56.0
160	-	-	3.9	7.2	15.0	26.0	47.0

Table 2.5.10

CSD-2UF [Ncm]

Ratio	Size					
	14	17	20	25	32	40
50	5.3	7.5	9.7	17.0	34.0	58.0
80	3.8	4.9	6.2	11.0	23.0	37.0
100	3.2	4.2	5.5	9.6	21.0	33.0
120	-	4.0	4.8	8.6	18.0	30.0
160	-	-	4.1	7.4	16.0	27.0

You will find more information on this in the Engineering data chapter.

• No load back driving torque

Table 2.5.11 **CSD-2UH [Nm]**

Ratio	Size 14	17	20	25	32	40	50
50	2.9	4.3	5.2	9.5	19.0	33.0	61.0
80	2.9	4.1	5.7	10.0	21.0	35.0	66.0
100	3.5	4.6	6.0	11.0	23.0	38.0	71.0
120	-	5.1	6.4	12.0	24.0	41.0	78.0
160	-	-	7.4	13.0	30.0	48.0	89.0

Table 2.5.12 **CSD-2UF [Nm]**

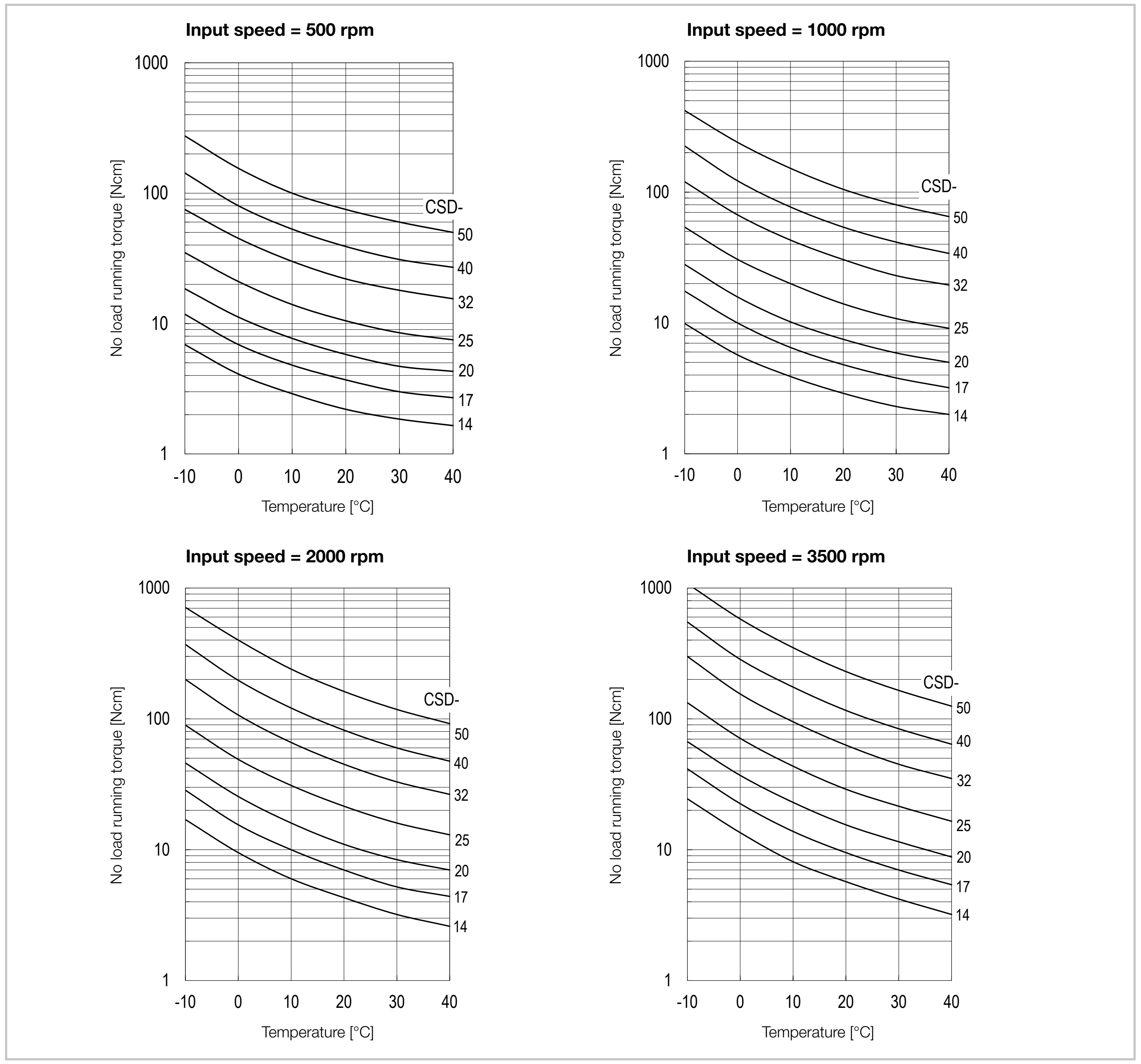
Ratio	Size 14	17	20	25	32	40
50	3.3	4.7	5.6	10.0	20.0	34.0
80	3.3	4.5	6.1	10.0	22.0	36.0
100	3.9	5.0	6.4	11.0	24.0	39.0
120	-	5.6	6.8	12.0	25.0	42.0
160	-	-	7.8	14.0	31.0	49.0

You will find more information on this in the Engineering data chapter.

• No load running torque

The diagrams apply to Harmonic Drive® Grease SK-2 (size 14, 17) and SK-1A (size ≥ 20).

Illustration 2.5.5 **CSD-2UH**



Compensation values for no load running torque

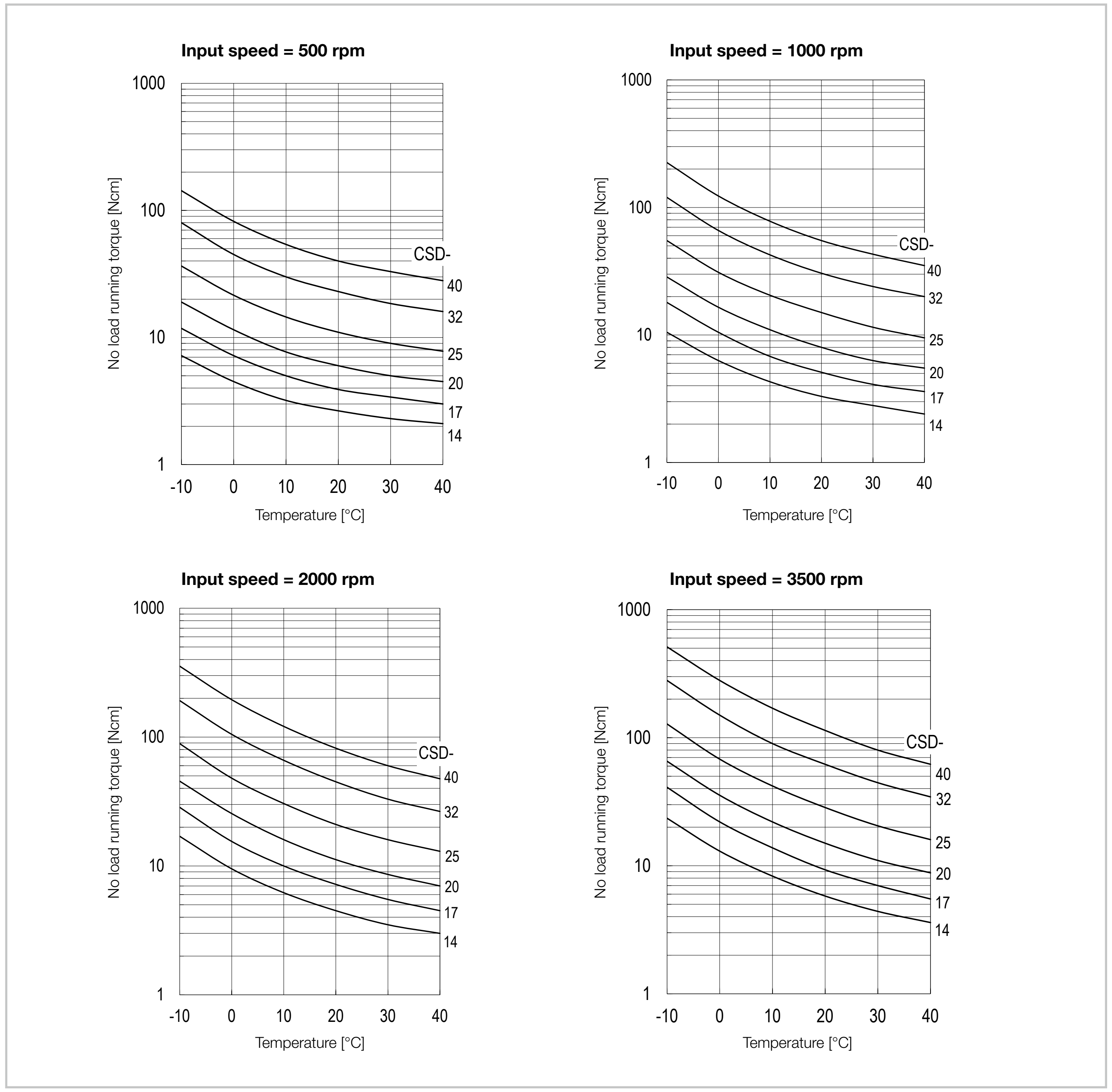
When using gears with ratios other than i=100 please apply the compensation values for the table to the values taken from the curves.

Table 2.5.13 **[Ncm]**

		Size 14	17	20	25	32	40	50
2UH	50	0.93	1.5	2.3	3.8	7.3	12	22
	80	0.2	0.3	0.4	0.7	1.3	2.1	3.8
	120	-	-0.2	-0.3	-0.5	-0.9	-1.5	-2.7
	160	-	-	-0.7	-1.2	-2.2	-3.6	-6.4
2UF	50	1.4	1.8	2.6	4.3	8.2	14	-
	80	0.3	0.4	0.5	0.8	1.5	2.5	-
	120	-	-0.3	-0.4	-0.6	-1.1	-1.8	-
	160	-	-	-0.84	-1.3	-2.5	-4.2	-

Illustration 2.5.6

CSD-2UF



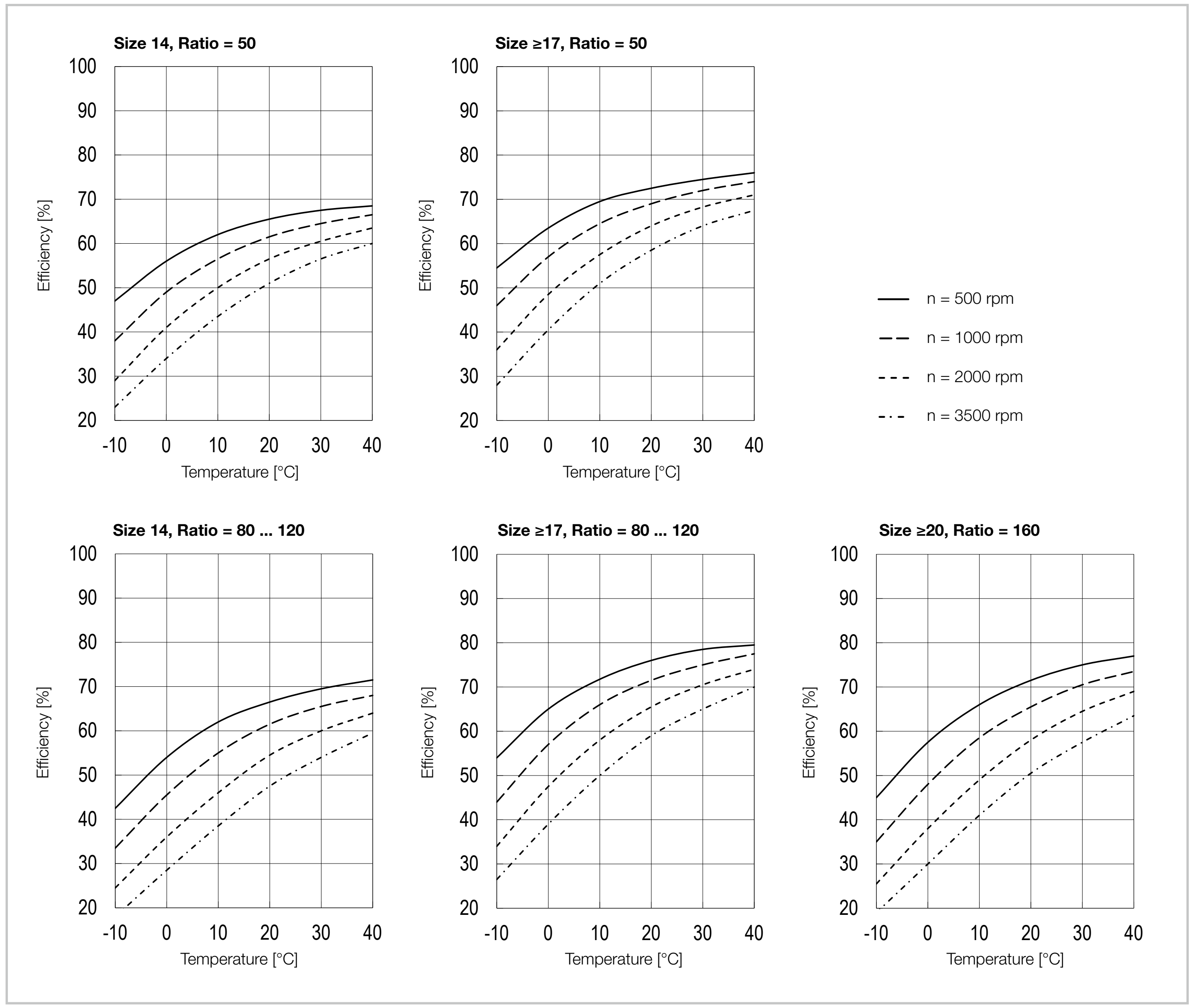
- Efficiency

Efficiency for grease lubrication at rated torque

The diagrams apply to Harmonic Drive® Grease SK-2 (size 14, 17) and SK-1A (size ≥20).

Illustration 2.5.7

CSD-2UH



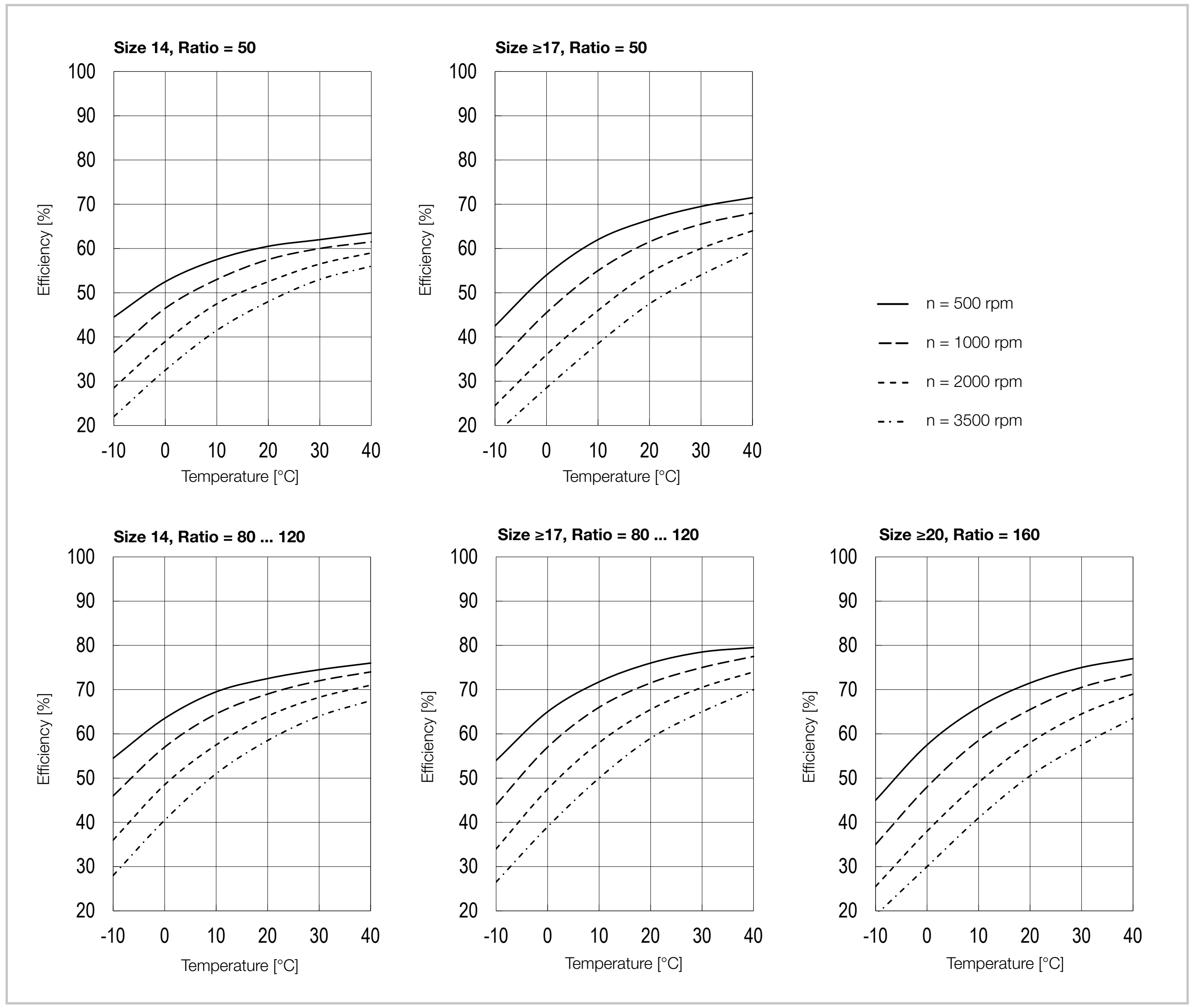
You will find more information on this in the Engineering data chapter.

Efficiency for grease lubrication at rated torque

The diagrams apply to Harmonic Drive® Gease SK-2 (size 14, 17) and SK-1A (size ≥20).

Illustration 2.5.8

CSD-2UF



You will find more information on this in the Engineering data chapter.

Efficiency calculation

The efficiency depends on the following parameters: Gear ratio, input speed, load torque, temperature, lubricant and lubricant quantity. If the load torque is lower than the rated torque, the efficiency will be lower than the efficiency indicated in the efficiency curves. The torque specific efficiency is determined by means of the calculation factor K.

Calculation example:

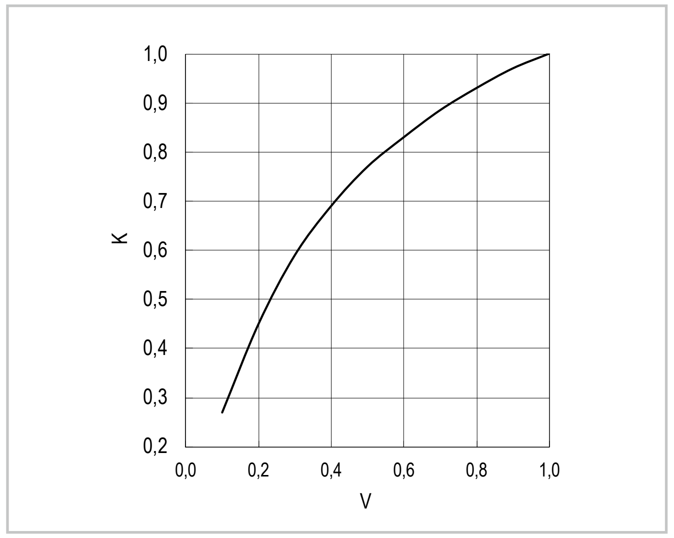
Product: CSD-20-80-2UH

- Input speed: 1000 rpm
- (Average) load torque T_{av}: 20 Nm
- Rated torque T_N (catalogue reference): 24 Nm
- Grease lubrication with Harmonic Drive® Grease SK-1A, lubricant temperature: 20 °C.

1. Calculation of the torque factor
   $V = T_{av}/T_N = 20/24 = 0.83$ (For V > 1 is K = 1)
2. Reading the calculation factor K from diagram Illustration 2.5.9: K = 0.93
3. Reading the efficiency from the efficiency curve Illustration 2.5.7: η = 72 %
4. Calculation of the load dependant efficiency
   $\eta_L = 72\ \% \cdot 0.93 = 67\ \%$

Illustration 2.5.9

Calculation factor K



Correction value for Efficiency

When using input side support bearings and radial shaft seals, the following correction values for the efficiency must be taken into account.

Table 2.5.14

CSD-2UH [%]

		Size						
		14	17	20	25	32	40	50
Ratio	50	0	3.0	2.4	-0.3	-1.4	-1.4	-2.4
	80	3.1	2.3	2.3	1.8	-0.1	-0.9	-1.9
	100	0	0.4	1.8	-0.1	-0.8	0	-1.2
	120	-	-2.2	-0.7	-2.7	-3.4	-0.9	-1.9
	160	-	-	1.3	-0.7	-1.6	1.0	0

Table 2.5.15

CSD-2UF [%]

		Size					
		14	17	20	25	32	40
Ratio	50	0	1.9	1.8	-0.1	-1.9	-1.7
	80	2.9	1.6	1.9	1.6	-0.3	-1
	100	0	-0.2	1.5	-0.3	-0.9	-0.1
	120	-	-2.8	-0.9	-2.8	-3.5	-6.7
	160	-	-	1.1	-0.8	-1.6	1

Output bearing

The CSD-2UH and CSD-2UF Gears are provided with a heavy duty cross roller bearing at the output.

• Rating table

Table 2.5.16

	Symbol [Unit]	Size													
		14		17		20		25		32		40		50	
Version		2UH	2UF	2UH	2UF	2UH	2UF	2UH	2UF	2UH	2UF	2UH	2UF	2UH	-
Bearing type[1)]		C	C	C	C	C	C	C	C	C	C	C	C	C	-
Pitch circle diameter	d_p [m]	0.0350	0.0500	0.0425	0.0600	0.0500	0.0700	0.0620	0.0850	0.0800	0.1110	0.0960	0.1330	0.1190	-
Distance[2)]	R [m]	0.0095	0.0118	0.0099	0.0123	0.0102	0.0128	0.0130	0.0140	0.0144	0.0168	0.0151	0.0215	0.0192	-
Dynamic load rating	C [N]	4700	5780	5290	10400	5780	14600	9600	21800	15000	38200	21300	43300	34800	-
Static load rating	C_0 [N]	6070	9000	7550	16300	9000	22000	15100	35800	25000	65400	36500	81600	60200	-
Permissible dynamic tilting moment[3,4)]	M [Nm]	41	91	64	124	91	187	156	258	313	580	450	849	759	-
Tilting moment stiffness[5)]	K_B [Nm/arcmin]	13	37	23	45	37	73	70	114	157	291	265	521	497	-
Permissible axial load[4)]	F_a [N]	1010	1240	1130	2220	1240	3120	2050	4660	3210	8170	4560	9260	7440	-
Permissible radial load[4)]	F_r [N]	674	828	758	1490	828	2090	1380	3120	2150	5470	3050	6200	4990	-

1) Bearing type C = Cross roller bearing; F = Four point contact bearing
2) Distance between the centre of the rolling bearing and the screw mounting surface on the output side, see chapter Gear dimensioning.
3) These values are valid for moving gears. They are not based on the equation for lifetime of the output bearing but on the maximum allowable deflection of the Harmonic Drive® Gear Component Set. The values indicated in the table must not be exceeded even if the lifetime equation of the bearing permits higher values.
4) These data are valid for **M**: $F_a = 0$, $F_r = 0$ I **F_a**: $M = 0$, $F_r = 0$ I **F_r**: $M = 0$, $F_a = 0$
5) The value of tilting moment stiffness is the average value (± 20 %).

• Output bearing and housing tolerances

Data applies to rotating output flange.

Illustration 2.5.10 **CSD-2UH**

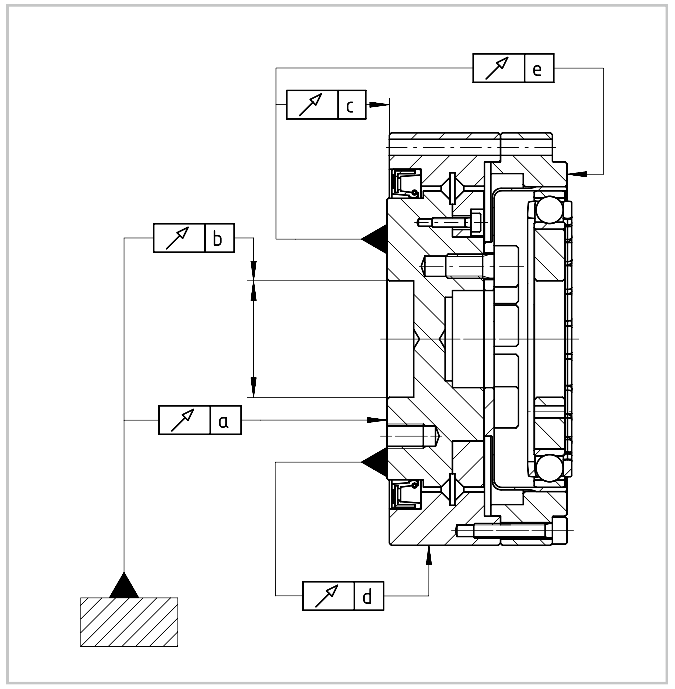


Illustration 2.5.11 **CSD-2UF**

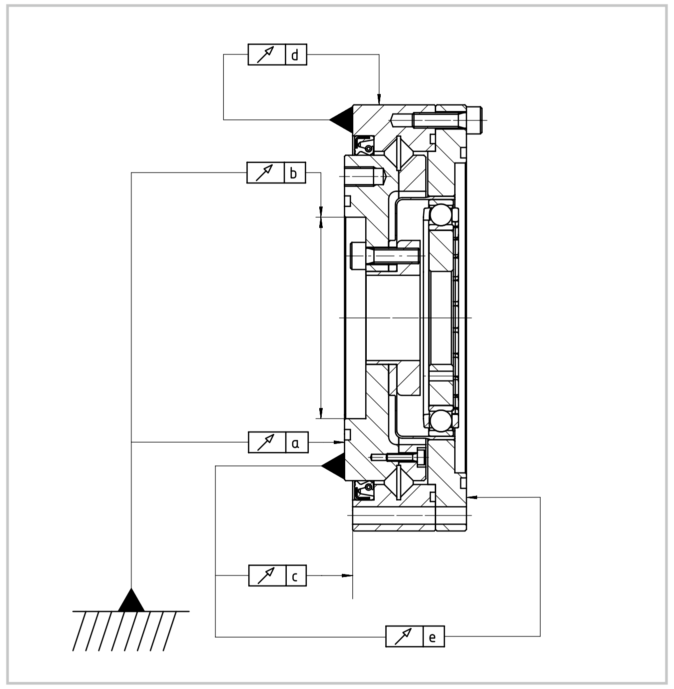


Table 2.5.17 **CSD-2UH [mm]**

Symbol	Size						
	14	17	20	25	32	40	50
a (axial runout)	0.010	0.010	0.010	0.015	0.015	0.015	0.018
b (radial runout)	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

Table 2.5.18 **CSD-2UF [mm]**

Symbol	Size					
	14	17	20	25	32	40
a (axial runout)	0.010	0.010	0.010	0.015	0.015	0.015
b (radial runout)	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

Assembly tolerances

We recommend observing the following tolerances of the connection components during assembly:

Illustration 2.5.12

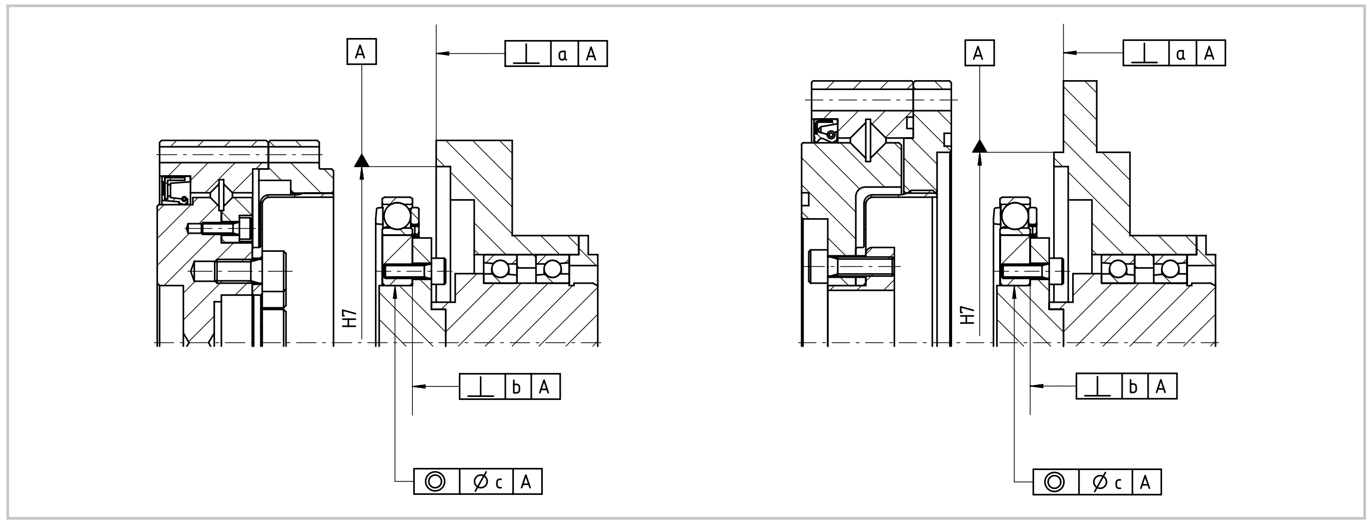


Table 2.5.19

CSD-2UH [mm]

Symbol	Recommended tolerance shaft/bore of the connection components	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
Øc	h6	0.016	0.018	0.019	0.022	0.022	0.024	0.030

Table 2.5.20

CSD-2UF [mm]

Symbol	Recommended tolerance shaft/bore of the connection components	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
Øc	h6	0.016	0.018	0.019	0.22	0.022	0.024

You will find more information on this in the Engineering data chapter.

Assembly

Illustration 2.5.13

CSD-2UH

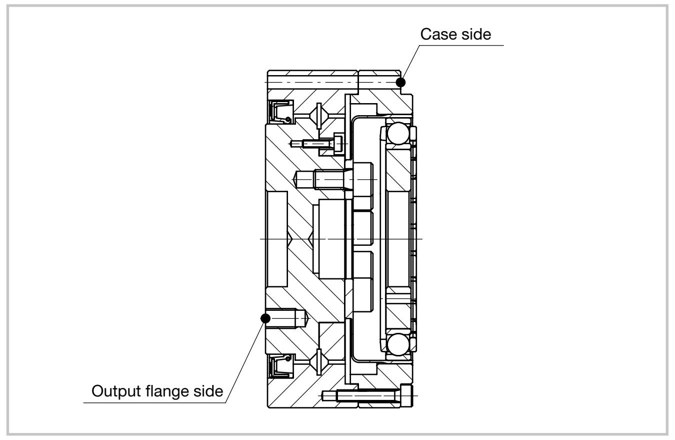
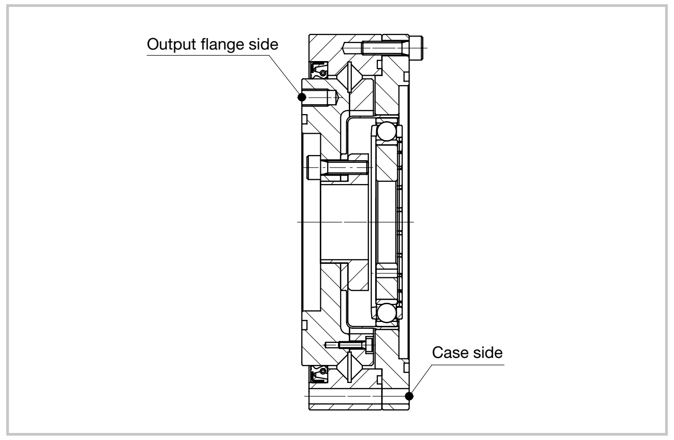


Illustration 2.5.14

CSD-2UF



Screw connection Output flange

Table 2.5.21

CSD-2UH

	[Unit]	Size						
		14	17	20	25	32	40	50
Number of screws		10	8	8	8	10	10	10
Size of screws		M3	M5	M6	M8	M8	M10	M12
Pitch circle diameter	[mm]	25	27	34	42	57	72	88
Screw tightening torque	[Nm]	2,0	9,0	15,3	37,0	37,0	74,0	128,0
Torque transmitting capacity	[Nm]	52	121	216	485	823	1660	2930

12.9 quality screws, friction coefficient μ = 0.15

Table 2.5.22

CSD-2UF

	[Unit]	Size					
		14	17	20	25	32	40
Number of screws		8	10	8	8	8	12
Size of screws		M3	M3	M4	M5	M6	M6
Pitch circle diameter	[mm]	42	50	60	73	96	116
Screw tightening torque	[Nm]	2.0	2.0	4.5	9.0	15.3	15.3
Torque transmitting capacity	[Nm]	70	104	168	328	612	1100

12.9 quality screws, friction coefficient μ = 0.15

Screw connection Housing

Table 2.5.23

CSD-2UH

	[Unit]	Size						
		14	17	20	25	32	40	50
Number of screws		6	10	12	18	18	18	22
Size of screws		M3	M3	M3	M3	M4	M5	M6
Pitch circle diameter	[mm]	49.0	56.0	64.0	79.0	104.0	117.5	147.0
Screw tightening torque	[Nm]	2.0	2.0	2.0	2.0	4.5	9.0	15.3
Torque transmitting capacity	[Nm]	61	116	160	296	658	1180	2570

12.9 quality screws, friction coefficient μ = 0.15

Table 2.5.24

CSD-2UF

	[Unit]	Size					
		14	17	20	25	32	40
Number of screws		6	8	8	10	10	10
Size of screws		M3	M3	M3	M4	M5	M6
Pitch circle diameter	[mm]	64	74	84	102	132	158
Screw tightening torque	[Nm]	2.0	2.0	2.0	4.5	9.0	15.3
Torque transmitting capacity	[Nm]	80	123	140	358	742	1250

12.9 quality screws, friction coefficient μ = 0.15

Screw connection on the Wave Generator

Illustration 2.5.15

	[Unit]	Size						
		14	17	20	25	32	40	50
Number of screws		4	4	4	4	4	4	4
Size of screws		M3	M3	M3	M3	M4	M5	M6
Pitch circle diameter	[mm]	17.0	21.0	26.0	30.0	40.0	50.0	60.0
Screw tightening torque	[Nm]	2.30	2.30	2.30	2.30	5.29	10.54	17.81
Torque transmitting capacity	[Nm]	10	12	15	18	47	104	187

You will find more information on this in the Engineering data chapter.

Design guidelines

To ensure optimum lubrication, the gear space should be kept compact. If the gear space is filled with more than 50 % grease, the risk of leakage increases. Therefore, the ratio of grease volume to gear space should be less than 0.5. If the Wave Generator is installed with a vertical axis and is mainly located on the top or bottom, the gap between the Wave Generator and the adapter flange on the input (motor) side should be filled with grease, see Table 2.5.25.

• Recommended housing dimensions

The gears are supplied with lifetime grease lubrication. Additional lubrication of the gears during assembly is not necessary. When assembling, the dimensions according to Table 2.5.25 should be taken into account.

Illustration 2.5.16 **CSD-2UH**

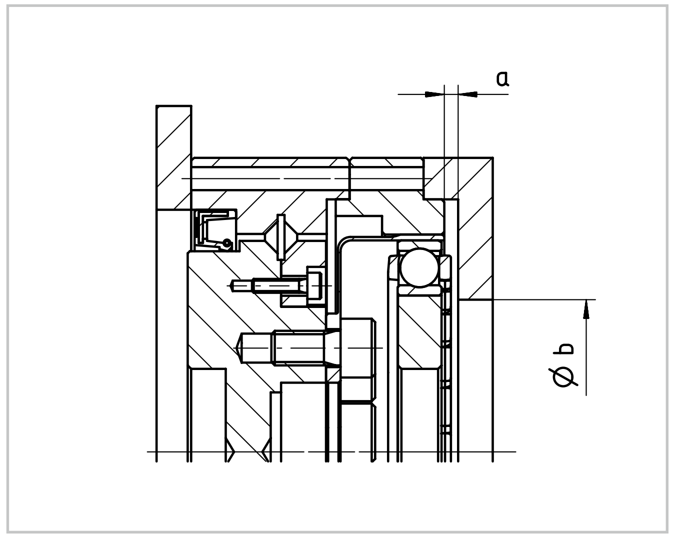


Illustration 2.5.17 **CSD-2UF**

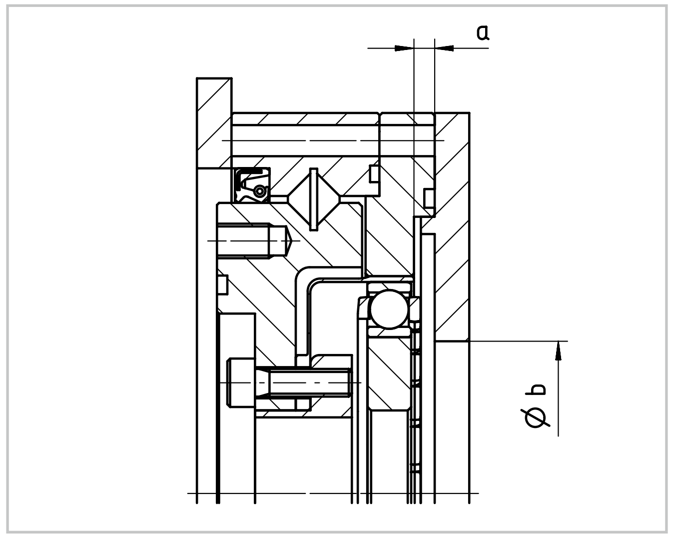


Table 2.5.25 **[mm]**

Symbol	Size						
	14	17	20	25	32	40	50[1)]
a*	1.0	1.0	1.5	1.5	2.0	2.5	3.5
a**	3.0	3.0	4.5	4.5	6.0	7.5	10.5
Øb $^{+0.5}_{0}$	16	26	30	37	37	45	45

1) Only available for version CSD-2UH
* For Wave Generator directed vertical or downward
** For Wave Generator directed upwards

• Materials and coatings used

Material:
Output bearing: Steel corrosion protected
Circular Spline: Grey cast iron corrosion protected
Flexspline: Bright steel
Wave Generator: Bright steel

Optional materials and coatings are available on request from Harmonic Drive SE.

Lubrication

The CSD-2UH and CSD-2UF Gears with output bearing are supplied fully greased. They are provided with lifetime grease lubrication at the factory. For the lubrication of the gearboxes we recommend the lubricants listed in Table 2.4.42. Please note that for the installation position “Wave Generator top” or “Wave Generator bottom” according to Table 2.5.26, an additional quantity of grease is required, which must be ordered separately.

Table 2.5.26

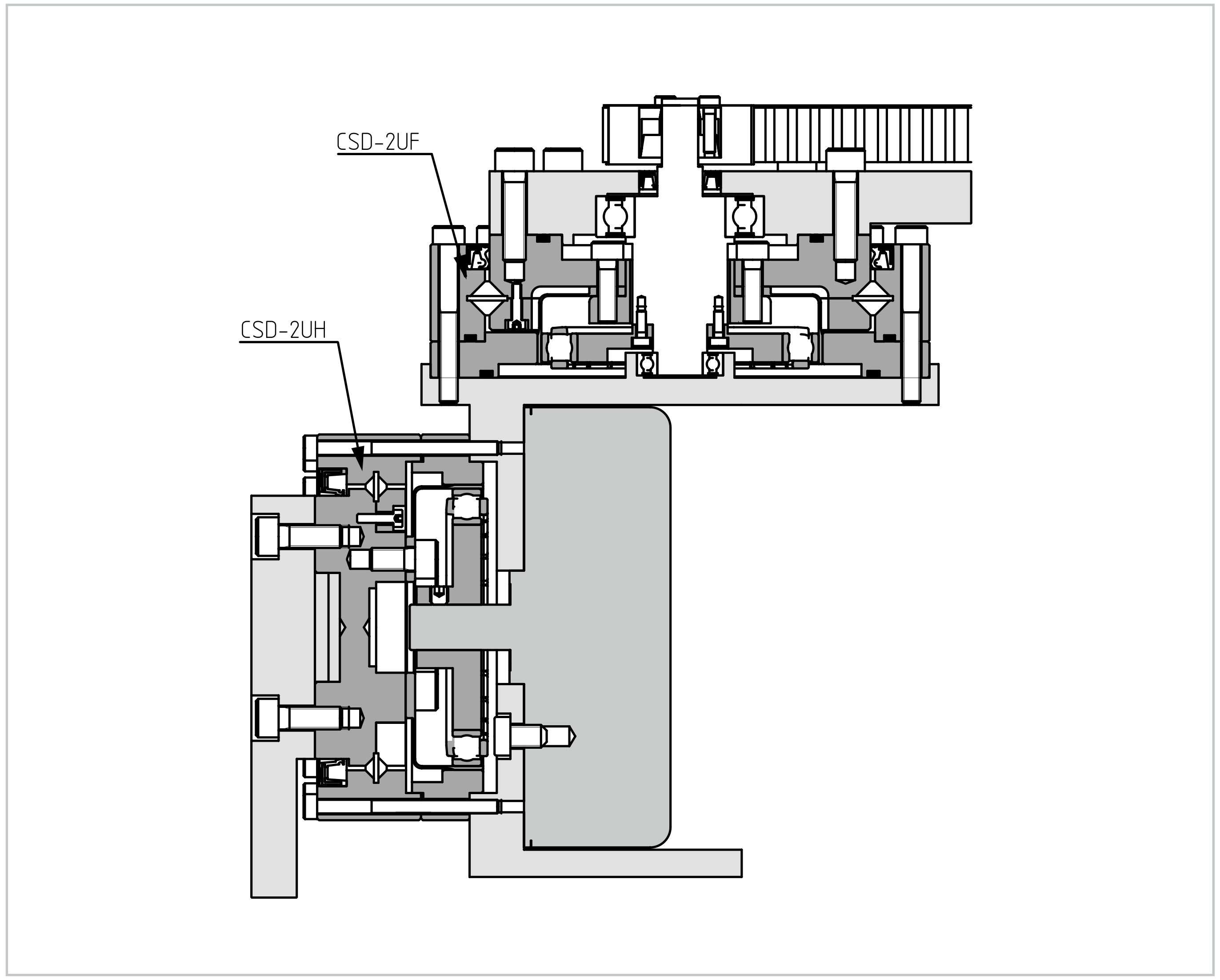
Harmonic Drive® Grease	Size						
	14	17	20	25	32	40	50
SK-1A	-	-	O	O	O	O	O
SK-2	O	O	Δ	Δ	Δ	Δ	Δ
4BNo.2	□	□	□	□	□	□	□

O Standard grease
□ Recommended for very high loads or very high demands on the service life of the grease
Δ Optional grease, please consult us

You will find more information on this in the Engineering data chapter.

Application example

Illustration 2.5.18



Product description

Highest torque capacity and lifetime precision

The SHG-2UH/2SO/2SH Series Gears with output bearing are characterised by their high torque capacity, lifetime and overload capacity and are optionally available with a large hollow shaft.

The HFUS-2UH/-2SO/-2SH Series Gears, with output bearing, complement the available SHG sizes and ratios with a slightly lower service life in comparison.

In addition to the proven strain wave gear technology, SHG-2UH/2SO/2SH Series is also available in Triangle Technology. Setting new standards in torsional stiffness, transmission accuracy and dynamics.

Features

- Highest torque capacity
- Highest service life
- Wide torque range
- Optionally available with large hollow shaft for the passage of supply cables or shafts
- Integrated precision cross roller bearing

SHG-2UH
HFUS-2UH
Hollow shaft gear to feed through supply lines for further gear systems

SHG-2SO
HFUS-2SO
Gear for direct motor mounting

SHG-2SH
HFUS-2SH
Hollow shaft gear without input bearing and input and output flange for integration into existing housing structure

Ordering code

Table 2.6.1

Ordering code	Tri	SHG	-	20	-	100	-	2UH	-	SP
Technology Standard Strain Wave Gear Principle (Field remains empty) Triangle Technology	[ ] Tri									
Series		SHG HFUS								
Ratio (in drive configuration: Circular Spline (CS) fixed, Wave Generator (WG) input, Flexspline (FS) output)				11 14 17 20 25 32 40 45 50 58 65						
Ratio (in drive configuration: Circular Spline (CS) fixed, Wave Generator (WG) input, Flexspline (FS) output)						30 50 80 100 120 160				
Version Closed hollow shaft gear with input bearing Motor mounted gear Open hollow shaft gear without input bearing								2UH 2SO 2SH		
Customised design Standard design (Field remains empty) Lightweight version (only for 2UH) Special design (on request)										[ ] LW SP

Please refer to the table of possible combinations.

Combinations

Table 2.6.2

SHG-2UH/-2SO/-2SH/-2UH-LW

		Size										
		11	14	17	20	25	32	40	45	50	58	65
Ratio	30	-	-	-	-	-	-	-	-	-	-	-
	50	-	•	•	•	•	•	•	•	-	-	-
	80	-	•	•	•	•	•	•	•	•	•	•
	100	-	•	•	•	•	•	•	•	•	•	•
	120	-	-	•	•	•	•	•	•	•	•	•
	160	-	-	-	•	•	•	•	•	•	•	•

Table 2.6.3

HFUS-2UH/-2SO/-2SH/-2UH-LW

		Size									
		11[1]	14	17	20	25	32	40	45	50	58
Ratio	30	-	•	•	•	•	•	-	-	-	-
	50	•	-	-	-	-	-	-	-	•	•
	80	-	-	-	-	-	-	-	-	-	-
	100	•	-	-	-	-	-	-	-	-	-
	120	-	-	-	-	-	-	-	-	-	-
	160	-	-	-	-	-	-	-	-	-	-

1) Only available for version -2UH

Table 2.6.4

TriSHG-2UH/-2SO/-2SH

		Size								
		14	17	20	25	32	40	45	50	58
Ratio	50	-	-	-	-	-	-	-	-	-
	80	-	o	o	o	o	o	o	o	o
	100	-	-	o	•	o	o	o	o	o
	120	-	-	-	o	o	o	o	o	o
	160	-	-	-	o	•	o	o	o	o

• available   o on request   - not available

Technical data

- Rating table

Table 2.6.5

SHG-/HFUS-2UH/2SO/2SH

Series	Size	Ratio	Limit for repeated peak torque	Limit for average torque	Rated torque at rated speed 2000 rpm	Limit for momentary peak torque	Max. input speed [rpm]	Limit for average input speed [rpm]	Moment of inertia	Weight
			T_R [Nm]	T_A [Nm]	T_N [Nm]	T_M [Nm]	Grease lubrication	Grease lubrication	2UH 2SO 2SH [x10⁻⁴]	2UH 2SO 2SH 2UH-LW
HFUS	11	50	8.3	5.5	3.5	17.0	8500	3500 1100[2]	0.080 - -	0.53 - - -
	11	100	11.0	8.9	5.0	25.0				
HFUS	14	30	9.0	6.8	4.0	17.0	8500	3500 1100[2]	0.091 0.033 0.091	0.71 0.41 0.45 0.55
SHG	14	50	23	9	7	46				
	14	80	30	14	10	61				
	14	100	36	14	10	70				
HFUS	17	30	16.0	12.0	8.8	30.0	7300	3500 1100[2]	0.193 0.079 0.193	1.00 0.57 0.63 0.80
SHG	17	50	44	34	21	91				
	17	80	56	35	29	113				
	17	100	70	51	31	143				
	17	120	70	51	31	112				
HFUS	20	30	27	20	15	50	6500	3500 1100[2]	0.404 0.193 0.404	1.38 0.81 0.89 1.10
SHG	20	50	73	44	33	127				
	20	80	96	61	44	165				
	20	100	107	64	52	191				
	20	120	113	64	52	191				
	20	160	120	64	52	191				
HFUS	25	30	50	38	27	95	5600	3500 1000[2]	1.070 0.413 1.070	2.10 1.31 1.44 1.60
SHG	25	50	127	72	51	242				
	25	80	178	113	82	332				
	25	100	204	140	87	369				
	25	120	217	140	87	395				
	25	160	229	140	87	408				
HFUS	32	30	100	75	54	200	4800	3500 1000[2]	2.850 1.690 2.850	4.50 2.94 3.10 3.60
SHG	32	50	281	140	99	497				
	32	80	395	217	153	738				
	32	100	433	281	178	841				
	32	120	459	281	178	892				
	32	160	484	281	178	892				
SHG	40	50	523	255	178	892	4000	3000 950[2]	9.280 4.500 9.280	7.70 5.10 5.40 6.20
	40	80	675	369	268	1270				
	40	100	738	484	345	1400				
	40	120	802	586	382	1530				
	40	160	841	586	382	1530				
SHG	45	50	650	345	229	1235	3800	3000 900[2]	13.80 8.680 13.80	10.00 6.50 6.90 8.00
	45	80	918	507	407	1651				
	45	100	982	650	459	2041				
	45	120	1070	806	523	2288				
	45	160	1147	819	523	2483				
HFUS	50	50	715	175[1]	122[1]	1430	3500	2500 850[2]	25.20 12.50 25.20	14.50 9.60 10.20 11.80
SHG	50	80	1223	675	484	2418				
	50	100	1274	866	611	2678				
	50	120	1404	1057	688	2678				
	50	160	1534	1096	688	3185				
HFUS	58	50	1020	260[1]	176[1]	1960	3000	2200 800[2]	49.50 27.30 49.50	20.00 13.50 14.10 16.40
SHG	58	80	1924	1001	714	3185				
	58	100	2067	1378	905	4134				
	58	120	2236	1547	969	4329				
	58	160	2392	1573	969	4459				
SHG	65	80	2743	1352	969	4836	2800	1900 800[2]	94.10 46.80 94.10	28.50 19.50 20.90 23.30
	65	100	2990	1976	1236	6175				
	65	120	3263	2041	1236	6175				
	65	160	3419	2041	1236	6175				

1) When using oil lubrication, a higher rated torque and average torque are possible. Please contact Harmonic Drive SE.
2) Valid for SHG-/HFUS-2UH and for SHG/HFUS-2SH when radial shaft seals are used on the hollow shaft.

i You will find more information on this in the Engineering data chapter.

Table 2.6.6

TriSHG-2UH/2SO/2SH

Series	Size	Ratio	Limit for repeated peak torque	Limit for average torque	Rated torque at rated speed 2000 rpm	Limit for momentary peak torque	Max. input speed [rpm]	Limit for average input speed [rpm]	Moment of inertia	Weight
			T_R [Nm]	T_A [Nm]	T_N [Nm]	T_M [Nm]	Grease lubrication	Grease lubrication	2UH 2SO 2SH [x10⁻⁴]	2UH 2SO 2SH 2UH-LW
TriSHG	25	100	204	140	87	369	5600	3500 1000[2]	1.070 0.413 1.070	2.10 1.31 1.44
	32	160	484	281	178	892	4800	3500 1000[2]	2.850 1.690 2.850	4.50 2.94 3.10

2) Valid for SHG-/HFUS-2UH and for SHG/HFUS-2SH when radial shaft seals are used on the hollow shaft.

You will find more information on this in the Engineering data chapter.

• Accuracy

Table 2.6.7

SHG-/HFUS-2UH/2SO/2SH [arcmin]

	Size										
	11		14			17			20 ... 65		
Ratio	≥50	100	30	50	≥80	30	50	≥80	30	50	≥80
Transmission accuracy	<2.0	<1.5	<1.5			<1.5			<1.5	<1.0	
Hysteresis loss	<2.0		<3.0	<2.0	<1.0	<3.0	<2.0	<1.0	<3.0	<2.0	<1.0
Lost motion	<1.0										
Repeatability	< ±0.1										

Table 2.6.8

TriSHG-2UH/2SO/2SH [arcmin]

	Size
	25 ... 32
Ratio	≥100
Transmission accuracy	<0.5
Hysteresis loss	<1.0
Lost motion	<1.0
Repeatability	< ±0.1

• Torsional stiffness

Table 2.6.9

SHG-/HFUS-2UH/2SO/2SH

	Symbol [Unit]	Size										
		11	14	17	20	25	32	40	45	50	58	65
Limit torques	T_1 [Nm]	0.8	2.0	3.9	7.0	14	29	54	76	108	168	235
	T_2 [Nm]	2.0	6.9	12	25	48	108	196	275	382	598	843
i = 30	K3 [x 10^4 Nm/rad]	-	0.34	0.67	1.10	2.10	4.90	-	-	-	-	-
	K2 [x 10^4 Nm/rad]	-	0.24	0.44	0.71	1.30	3.00	-	-	-	-	-
	K1 [x 10^4 Nm/rad]	-	0.19	0.34	0.57	1.00	2.40	-	-	-	-	-
i = 50	K3 [x 10^4 Nm/rad]	0.32	0.57	1.30	2.30	4.40	9.80	18.0	26.0	34.0	54.0	-
	K2 [x 10^4 Nm/rad]	0.30	0.47	1.10	1.80	3.40	7.80	14.0	20.0	28.0	44.0	-
	K1 [x 10^4 Nm/rad]	0.22	0.34	0.81	1.30	2.50	5.40	10.0	15.0	20.0	31.0	-
i ≥ 80	K3 [x 10^4 Nm/rad]	0.44	0.71	1.60	2.90	5.70	12.0	23.0	33.0	44.0	71.0	98.0
	K2 [x 10^4 Nm/rad]	0.34	0.61	1.40	2.50	5.00	11.0	20.0	29.0	40.0	61.0	88.0
	K1 [x 10^4 Nm/rad]	0.27	0.47	1.00	1.60	3.10	6.70	13.0	18.0	25.0	40.0	54.0

Table 2.6.10

TriSHG-2UH/2SO/2SH

	Symbol [Unit]	Size	
		25	32
Limit torques	T_1 [Nm]	14	29
	T_2 [Nm]	48	108
i ≥ 100	K3 [x 10^4 Nm/rad]	7.4	20.6
	K2 [x 10^4 Nm/rad]	6.5	16.9
	K1 [x 10^4 Nm/rad]	5.0	13.5

Output bearing

• Rating table

Table 2.6.11

	Symbol [Unit]	Size										
		11	14	17	20	25	32	40	45	50	58	65
Bearing type[1]		C	C	C	C	C	C	C	C	C	C	C
Pitch circle diameter	d_p [m]	0.043	0.050	0.060	0.070	0.085	0.111	0.133	0.154	0.170	0.195	0.218
Distance[2]	R [m]	0.0180	0.0217	0.0239	0.0255	0.0296	0.0364	0.0440	0.0475	0.0525	0.0622	0.0720
Dynamic load rating	C [N]	5290	5800	10400	14600	21800	38200	43300	77600	81600	87400	130000
Static load rating	C_0 [N]	7550	8600	16300	20000	35800	65400	81600	135000	149000	171000	223000
Permissible dynamic tilting moment[3,4]	M [Nm]	74	74	124	187	258	580	849	1127	1487	2180	2740
Tilting moment stiffness[5]	K_B [Nm/arcmin]	19	25	45	74	114	290	522	749	1020	1550	2155
Permissible axial load[4]	F_a [N]	1130	1239	2222	3119	4657	8161	9250	16578	17433	18672	27773
Permissible radial load[4]	F_r [N]	757	830	1489	2090	3120	5468	6198	11107	11680	12510	18608

1) Bearing type C = Cross roller bearing; F = Four point contact bearing
2) Distance between the centre of the rolling bearing and the screw mounting surface on the output side, see chapter Gear dimensioning.
3) These values are valid for moving gears. They are not based on the equation for lifetime of the output bearing but on the maximum allowable deflection of the Harmonic Drive® Gear Component Set. The values indicated in the table must not be exceeded even if the lifetime equation of the bearing permits higher values.
4) These data are valid for **M**: $F_a = 0$, $F_r = 0$ I **F_a**: $M = 0$, $F_r = 0$ I **F_r**: $M = 0$, $F_a = 0$
5) The value of tilting moment stiffness is the average value (± 20 %).

Output bearing and housing tolerances

In these gears with output bearing, the load is connected to the cross roller bearing via a flange. Depending on the type of mounting, the flange connected to the outer ring or the flange connected to the inner ring of the output bearing can be used as output, see Illustration 2.6.1 and Illustration 2.6.2. The tolerances listed in Table 2.6.12 and Table 2.6.13 include the sum of bearing and flange tolerances.

Flexspline fixed

Input: Wave Generator
Output: Circular Spline
Fixed: Flexspline

Illustration 2.6.1

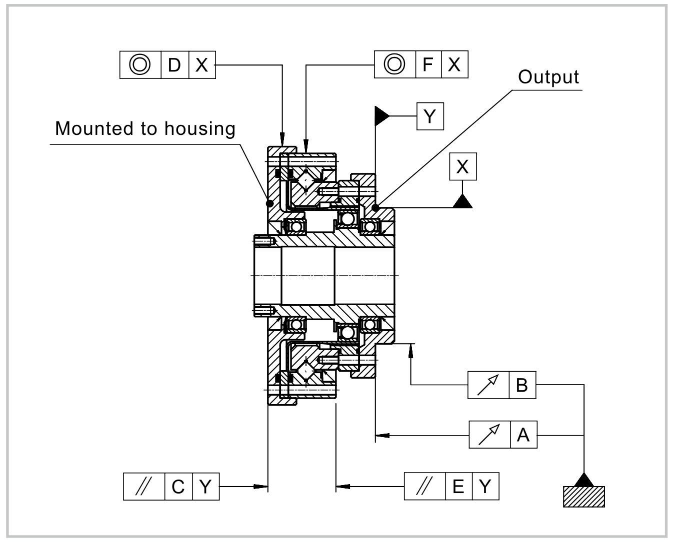


Table 2.6.12 **[mm]**

Symbol	Size										
	11	14	17	20	25	32	40	45	50	58	65
A (axial runout)	0.033	0.033	0.038	0.040	0.046	0.054	0.057	0.057	0.063	0.063	0.067
B (radial runout)	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

Illustration 2.6.2

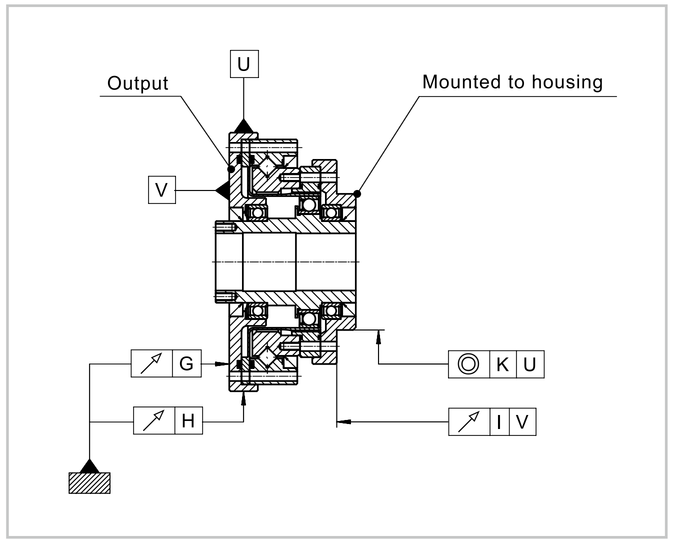


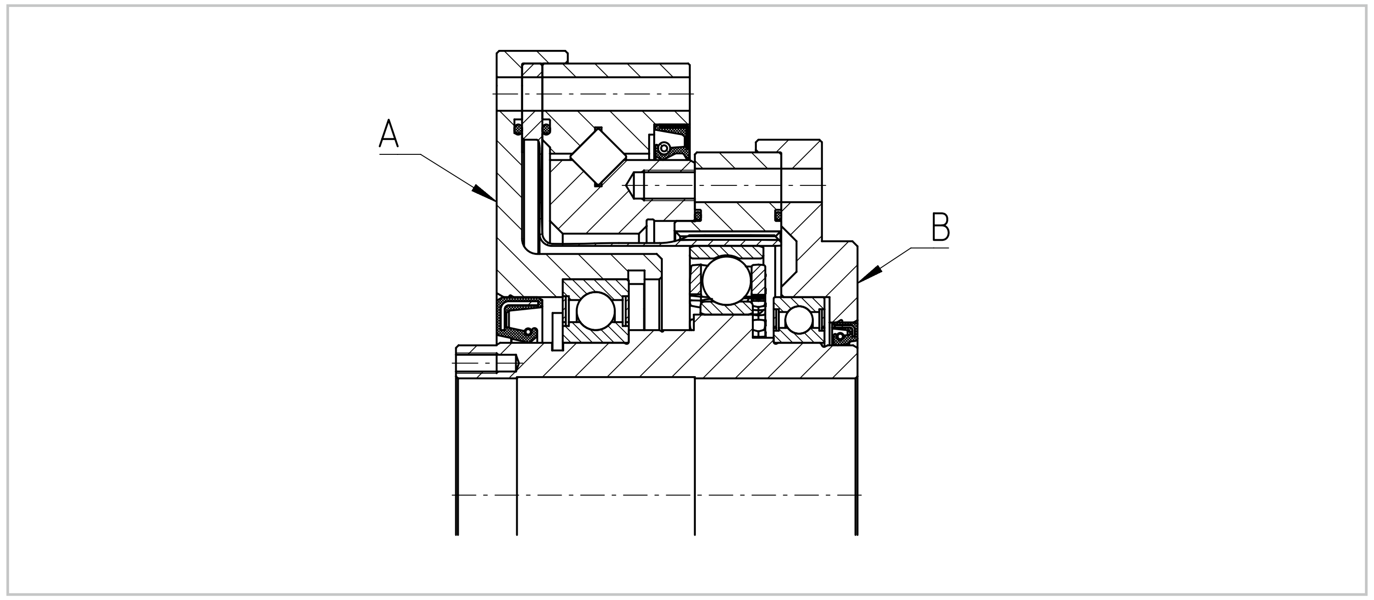
Table 2.6.13 **[mm]**

Symbol	Size										
	11	14	17	20	25	32	40	45	50	58	65
G (axial runout)	0.027	0.037	0.039	0.046	0.047	0.059	0.060	0.070	0.070	0.070	0.076
H (radial runout)	0.031	0.031	0.031	0.038	0.038	0.045	0.048	0.050	0.050	0.050	0.054
I	0.053	0.064	0.071	0.079	0.085	0.104	0.111	0.118	0.121	0.121	0.131
J	0.053	0.053	0.053	0.059	0.061	0.072	0.075	0.078	0.085	0.088	0.089

Assembly

Screw connection

Illustration 2.6.3



Screw connection on side A

Table 2.6.14 **SHG-2UH/-2SO/-2SH/-2UH-LW**

	[Unit]	Size									
		14	17	20	25	32	40	45	50	58	65
Number of screws		8	12	12	12	12	12	18	12	16	16
Size of screws		M3	M3	M3	M4	M5	M6	M6	M8	M8	M10
Pitch circle diameter	[mm]	64	74	84	102	132	158	180	200	226	258
Screw tightening torque	[Nm]	2.4	2.4	2.4	5.4	10.8	18.4	18.4	44.0	44.0	74.0
Torque transmitting capacity	[Nm]	128	222	252	516	1069	1813	3098	4163	6272	9546

12.9 quality screws, friction coefficient μ=0.15

Table 2.6.15 **HFUS-2UH/-2SO/-2SH/-2UH-LW**

	[Unit]	Size									
		11	14	17	20	25	32	40	45	50	58
Number of screws		4	8	12	12	12	12	-	-	12	16
Size of screws		M3	M3	M3	M3	M4	M5	-	-	M8	M8
Pitch circle diameter	[mm]	56.4	64.0	74.0	84.0	102.0	132.0	-	-	200.0	226.0
Screw tightening torque	[Nm]	2.0	2.0	2.0	2.0	4.5	9.0	-	-	37.0	37.0
Torque transmitting capacity	[Nm]	47	108	186	206	431	892	-	-	3489	5263

12.9 quality screws, friction coefficient μ=0.15

Screw connection on side B

Table 2.6.16

SHG-2UH/-2SO/-2SH/-2UH-LW

	[Unit]	Size									
		14	17	20	25	32	40	45	50	58	65
Number of screws		8	16	16	16	16	16	12	16	12	16
Size of screws		M3	M3	M3	M4	M5	M6	M8	M8	M10	M10
Pitch circle diameter	[mm]	44	54	62	77	100	122	140	154	178	195
Screw tightening torque	[Nm]	2.40	2.40	2.40	5.40	10.80	18.36	44.00	44.00	89.00	89.00
Torque transmitting capacity	[Nm]	88	216	248	520	1080	1867	2914	4274	5927	8658

12.9 quality screws, friction coefficient μ=0.15

Table 2.6.17

HFUS-2UH/-2SO/-2SH/-2UH-LW

	[Unit]	Size									
		11	14	17	20	25	32	40	45	50	58
Number of screws		6	8	16	16	16	16	-	-	16	12
Size of screws		M3	M3	M3	M3	M4	M5	-	-	M8	M10
Pitch circle diameter	[mm]	37	44	54	62	77	100	-	-	154	178
Screw tightening torque	[Nm]	2.0	2.0	2.0	2.0	4.5	9.0	-	-	37.0	74.0
Torque transmitting capacity	[Nm]	46	72	176	206	431	902	-	-	3587	4910

12.9 quality screws, friction coefficient μ=0.15

Screw connection on the input shaft

Table 2.6.18

SHG-/HFUS-/SHF-2UH/2SH/2UH-LW

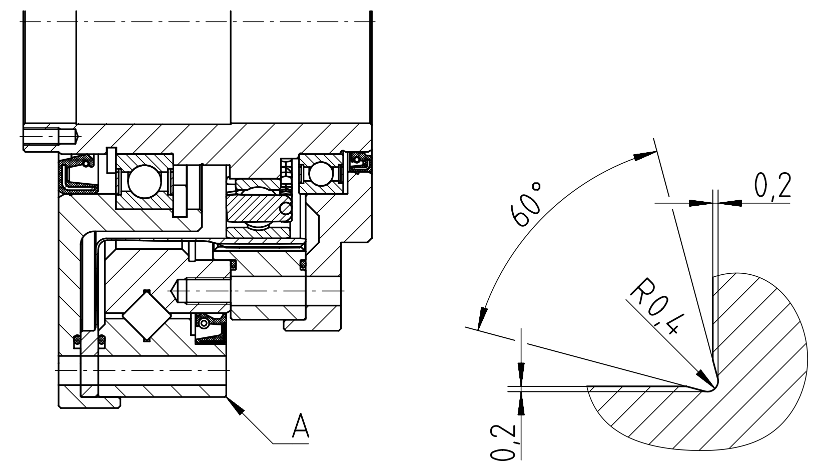
	[Unit]	Size								
		14	17	20	25	32	40	45	50	58
Number of screws		3	3	6	6	6	6	6	6	8
Size of screws		M3	M3	M3	M3	M3	M4	M4	M4	M4
Screw tightening torque	[Nm]	2.1	2.1	2.1	2.1	2.1	4.0	4.0	4.0	4.0

12.9 quality screws, friction coefficient μ=0.15

Housing detail

We recommend the following undercut on the customer flange.

Illustration 2.6.4



Technical data SHG-/HFUS-/TriSHG-/2UH

- Dimensions

Illustration 2.6.5

Size 11 ... 14 [mm]

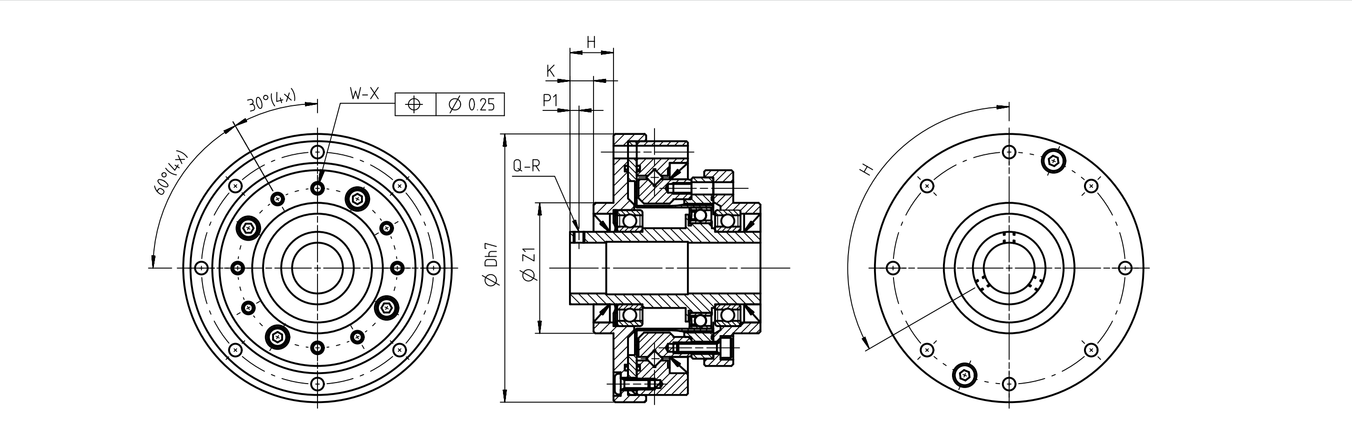


Illustration 2.6.6

Size 17 [mm]

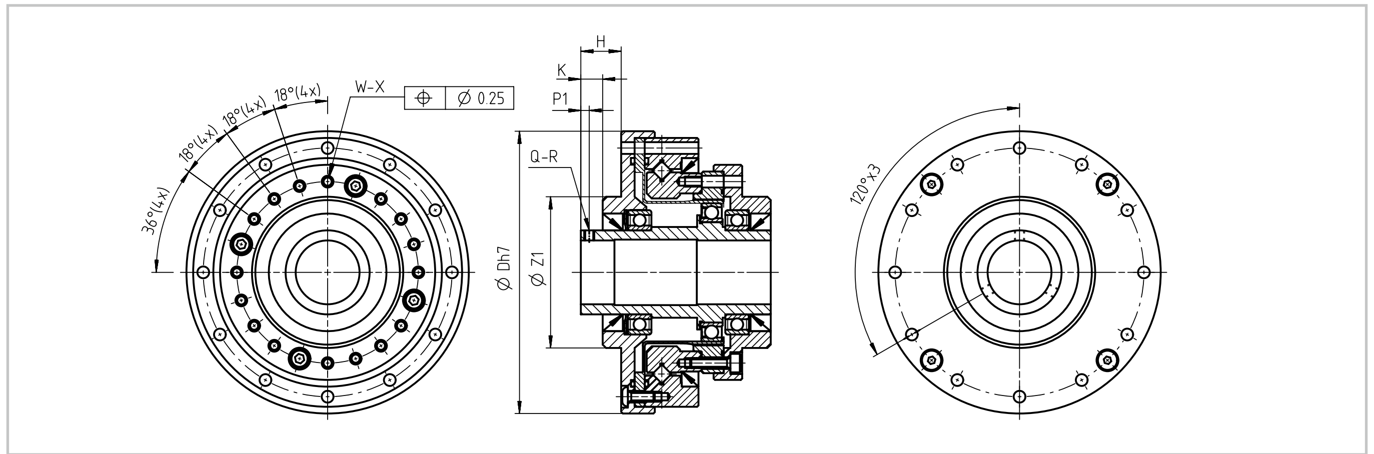


Illustration 2.6.7

Size 20 ... 65 [mm]

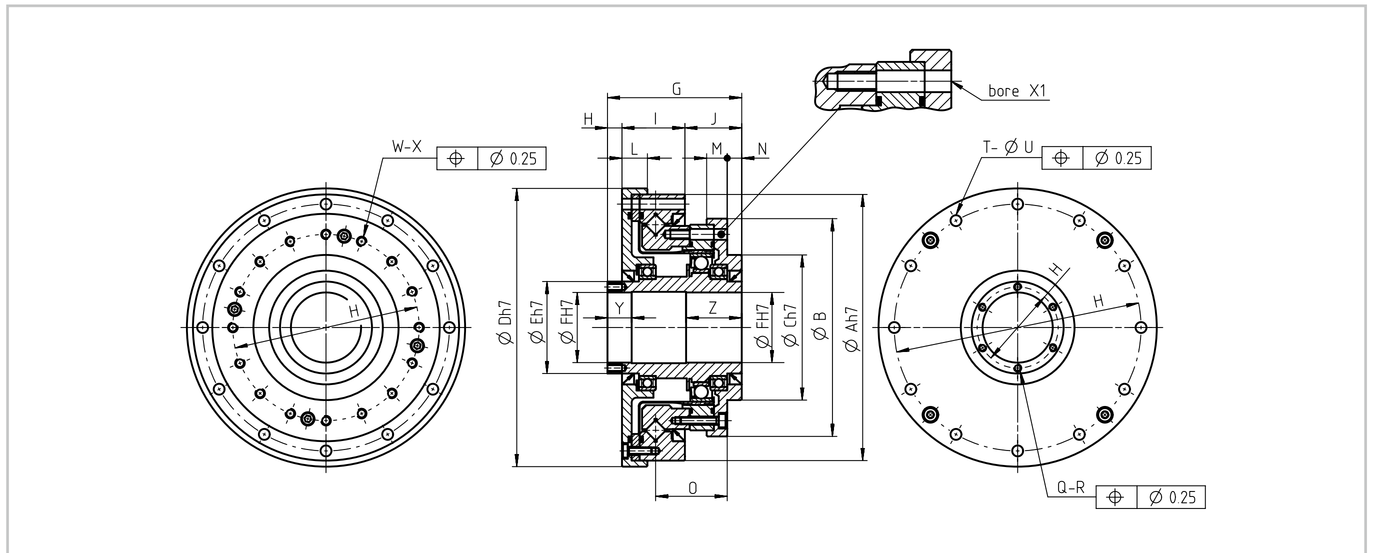


Table 2.6.19

SHG-/HFUS-/TriSHG-2UH [mm]

		Size										
		11	14	17	20	25	32	40	45	50	58	65
ØA h7		62	70	80	90	110	142	170	190	214	240	276
ØB	Standard	45.3	54.0	64.0	75.0	90.0	115.0	140.0	160.0	175.0	201.0	221.0
	LW	-	52.0	62.0	73.0	88.0	115.0	145.0	160.0	168.0	195.0	213.0
ØC h7		30.5	36.0	45.0	50.0	60.0	85.0	100.0	120.0	130.0	150.0	160.0
ØD h7		64	74	84	95	115	147	175	195	220	246	284
ØE h7		18	20	25	30	38	45	59	64	74	84	96
ØF h7		14	14	19	21	29	36	46	52	60	70	80
G		48.0	52.5	56.5	51.5	55.5	65.5	79.0	85.0	93.0	106.0	128.0
H		14	12	12	$5.0^{+1.2}_{-0.9}$	$6.0^{+1.2}_{-0.9}$	$7.0^{+0.7}_{-0.6}$	$8.0^{+0.7}_{-0.6}$	$8.0^{+0.8}_{-0.6}$	$9.0^{+0.8}_{-0.6}$	$10.0^{+0.9}_{-0.7}$	$10.0^{+0.5}_{-2.0}$
I		19.0	20.5	23.0	25.0	26.0	32.0	38.0	42.0	45.0	52.0	56.5
J		15.0	20.0	21.5	21.5	23.5	26.5	33.0	35.0	39.0	44.0	57.5
K		$6.5^{+0.5}_{-0.75}$	6.5±1.2	$6.5^{+1.0}_{-1.1}$	-	-	-	-	-	-	-	-
L		8.0	9.0	10.0	10.5	10.5	12.0	14.0	15.0	16.0	17.0	18.0
M	Standard	6.5	8.0	8.5	9.0	8.5	9.5	13.0	12.0	12.0	15.0	19.5
	LW	-	11.5	12.0	13.5	15.5	20.5	25.0	27.0	30.0	35.0	42.5
N		6.5	7.5	8.5	7.0	6.0	5.0	7.0	7.0	7.0	7.0	12.0
O		17.5	21.7	23.9	25.5	29.6	36.4	44.0	47.5	52.5	62.2	72.0
O1		10	10	10	10	10	10	12	15	15	15	20
O2		20	20	22	22	23	25	32	35	37	43	54
ØP		-	-	-	25.5	33.5	40.5	52.0	58.0	67.0	77.0	88.0
P1		-	2.5	2.5	-	-	-	-	-	-	-	-
Q		-	3	3	6	6	6	6	6	6	8	6
R		-	M3	M3	M3x6	M3x6	M3x6	M4x8	M4x8	M4x8	M4x8	M5x10
ØS		56.4	64.0	74.0	84.0	102.0	132.0	158.0	180.0	200.0	226.0	258.0
T		4	8	12	12	12	12	12	18	12	16	16
ØU		3.5	3.5	3.5	3.5	4.5	5.5	6.6	6.6	9.0	9.0	11.0
ØV		37	44	54	62	77	100	122	140	154	178	195
W[1]		6	8	16	16	16	16	16	12	16	12	16
X[1]		M3x5	M3x5	M3x6	M3x6	M4x7	M5x8	M6x10	M8x10	M8x11	M10x15	M10x15
Bore hole X1		Ø3.4x8.5	Ø3.5x11.5	Ø3.5x12.0	Ø3.5x13.5	Ø4.5x15.5	Ø5.5x20.5	Ø6.6x25.0	Ø9.0x27.0	Ø9.0x30.0	Ø11.0x35.0	Ø11.0x42.5
Y		13	10	10	10	10	10	12	15	15	15	20
Z		16	20	22	22	23	25	32	35	37	43	54
ØZ1		36	36	45	-	-	-	-	-	-	-	-

CAD drawings for download: www.harmonicdrive.co.uk

• No load starting torque

Table 2.6.20

SHG-/HFUS-2UH [Ncm]

Ratio	Series	Size										
		11	14	17	20	25	32	40	45	50	58	65
30	HFUS	-	11.0	30	43	64	112	-	-	-	-	-
50	SHG	-	8.8	27	36	56	85	136	165	-	-	-
	HFUS	7.1	-	-	-	-	-	-	-	216	297	-
80	SHG	-	7.5	25	33	50	74	117	138	179	244	314
	HFUS	-	-	-	-	-	-	-	-	-	-	-
100	SHG	-	6.9	24	32	49	72	112	131	171	231	297
	HFUS	5.9	-	-	-	-	-	-	-	-	-	-
120	SHG	-	-	24	31	48	68	110	126	165	223	287
	HFUS	-	-	-	-	-	-	-	-	-	-	-
160	SHG	-	-	-	31	47	67	105	122	156	213	276
	HFUS	-	-	-	-	-	-	-	-	-	-	-

Table 2.6.21

TriSHG-2UH [Ncm]

Ratio	Series	Size	
		25	32
100	SHG	53	-
160	SHG	-	65

• No load back driving torque

Table 2.6.22

SHG-/HFUS-2UH [Nm]

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

Table 2.6.23

TriSHG-2UH [Ncm]

Ratio	Series	Size	
		25	32
100	SHG	67	-
160	SHG	-	-

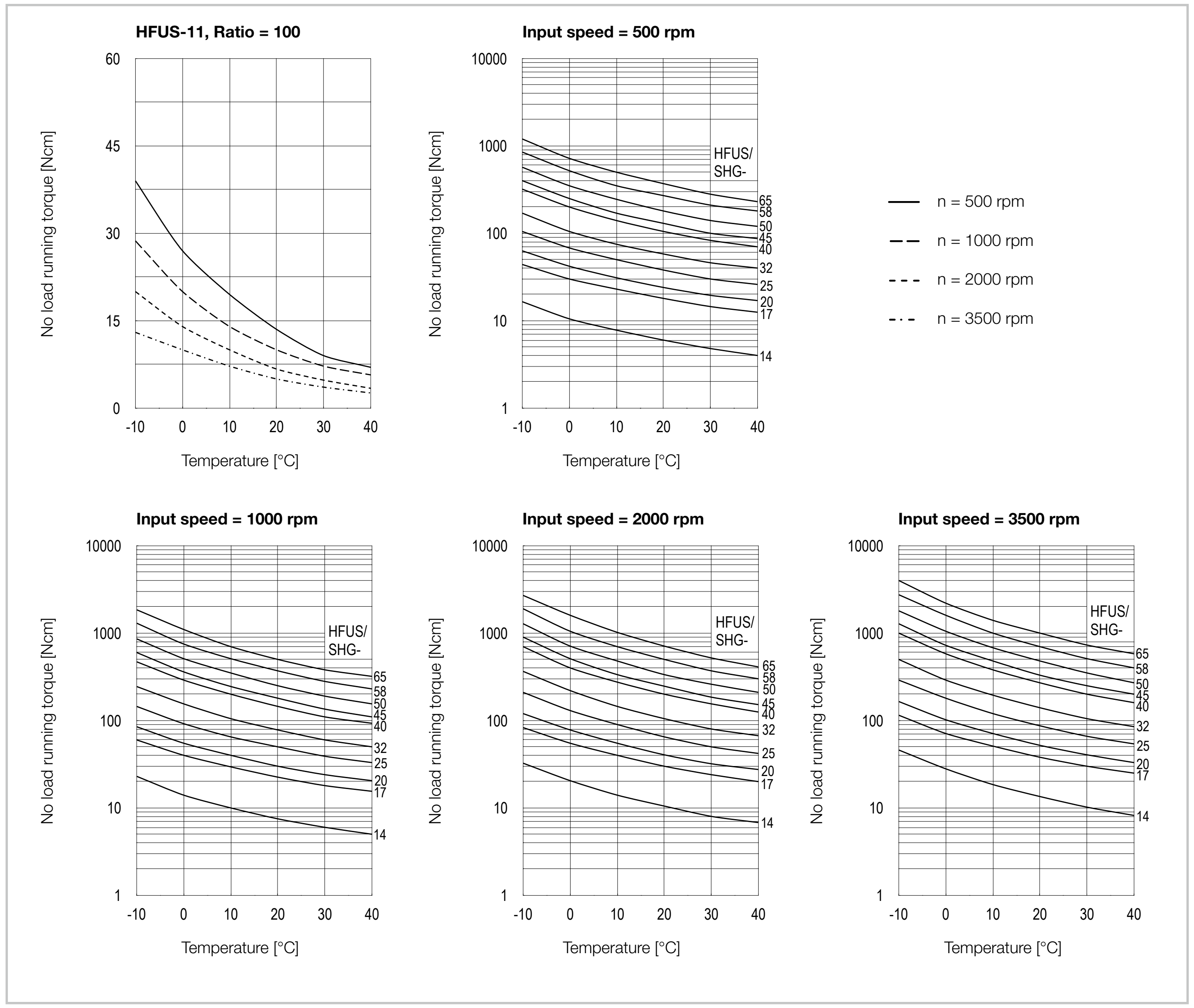
You will find more information on this in the Engineering data chapter.

• No load running torque

The diagrams apply to Harmonic Drive® Grease SK-2 (size 11 … 17) and SK-1A (size ≥ 20).

Illustration 2.6.8

SHG-/HFUS-2UH



Compensation values for no load running torque

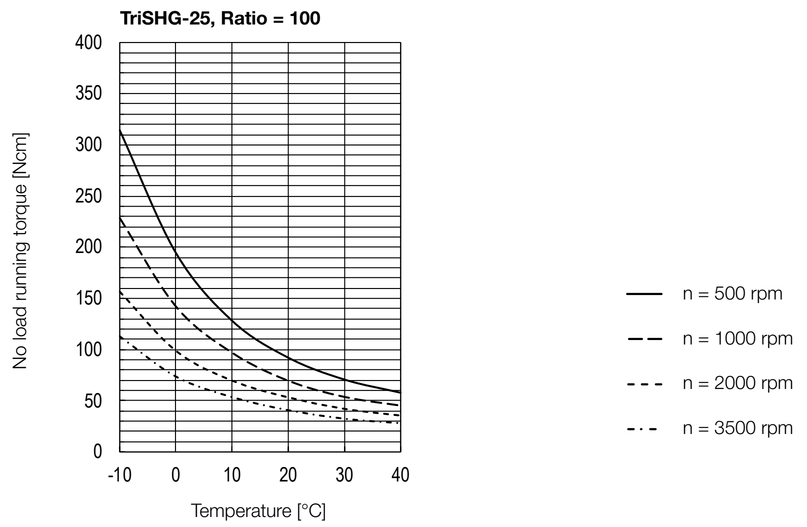
Table 2.6.24

SHG-/HFUS-2UH [Ncm]

Ratio	Size										
	11	14	17	20	25	32	40	45	50	58	65
30	-	2.6	4.1	5.9	9.6	18.3	-	-	-	-	-
50	0.5	1.1	1.8	2.6	4.2	8.0	13.3	18.2	23.9	34.6	-
80	-	0.2	0.4	0.5	0.8	1.5	2.4	3.3	4.3	6.2	8.1
120	-	-	-0.2	-0.4	-0.6	-1.1	-1.7	-2.4	-3.1	-4.4	-5.8
160	-	-	-	-0.8	-1.3	-2.5	-4.0	-5.5	-7.2	-10.3	-13.7

Illustration 2.6.9

TriSHG-2UH

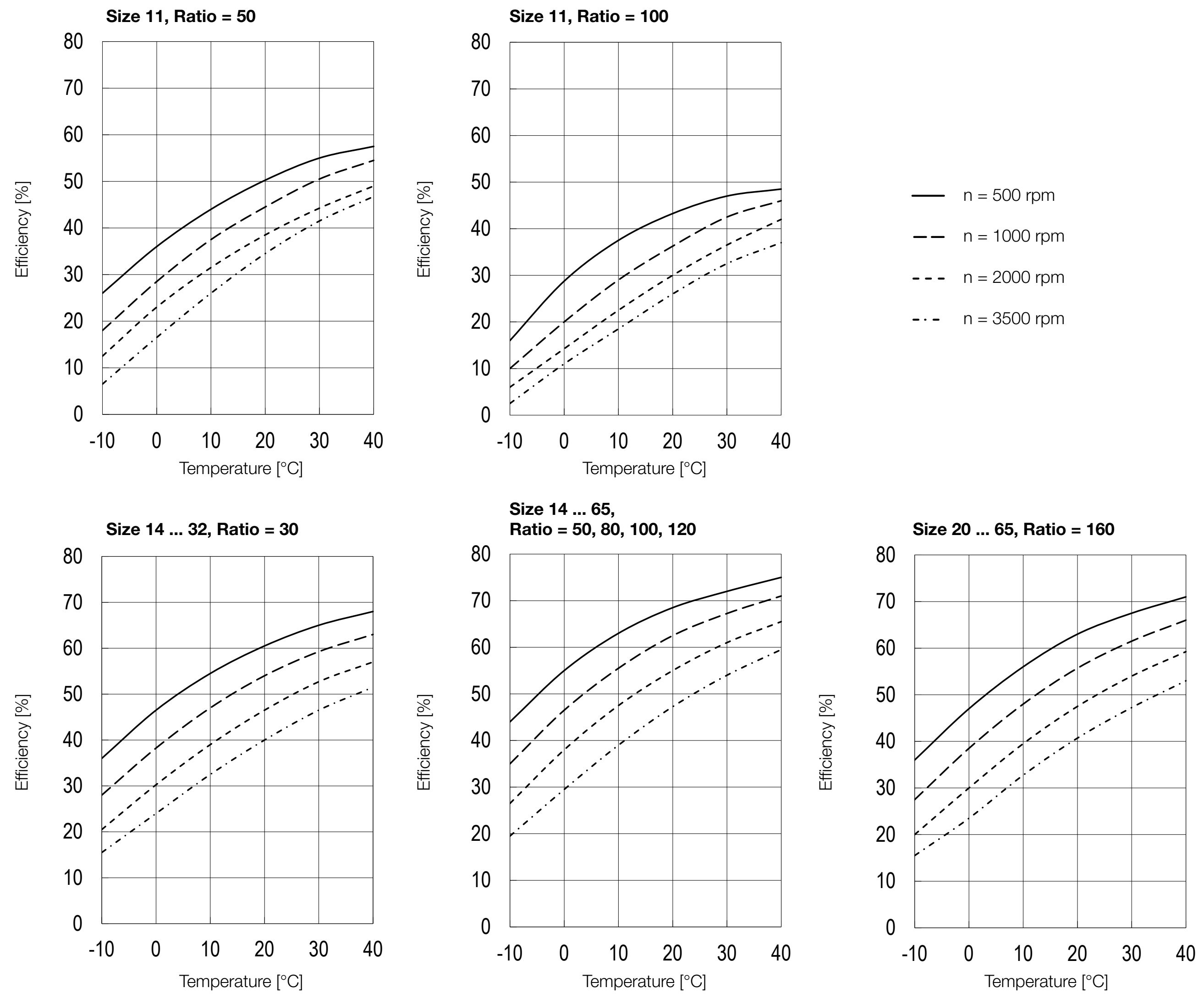


- Efficiency

Efficiency for grease lubrication at rated torque. The diagrams apply to Harmonic Drive® Grease SK-2 (size 11 … 17) and SK-1A (size ≥ 20).

Illustration 2.6.10

SHG-/HFUS-2UH

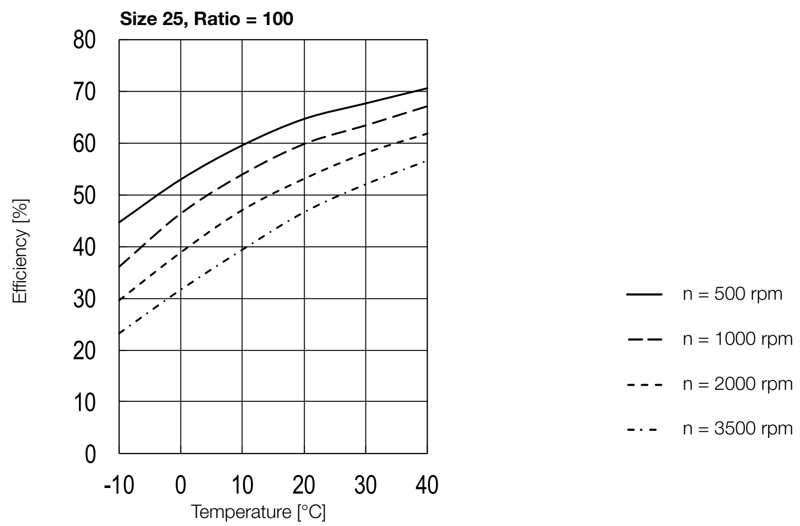


You will find more information on this in the Engineering data chapter.

Efficiency for grease lubrication at rated torque. The diagrams apply to Harmonic Drive® Grease Flexolub®-A1.

Illustration 2.6.11

TriSHG-2UH



You will find more information on this in the Engineering data chapter.

Efficiency calculation

The efficiency depends on the following parameters: Gear ratio, input speed, load torque, temperature, lubricant and lubricant quantity. If the load torque is lower than the rated torque, the efficiency will be lower than the efficiency than that indicated in the efficiency curves. The torque specific efficiency is determined by means of the the calculation factor K. For gears with bearing mounted and sealed input shaft, the additional reduction in efficiency is taken into account by the correction value η_e.

Calculation example:

Product: SHG-20-80-2UH

- Input speed: 1000 rpm
- (Average) load torque T_{av}: 36 Nm
- Rated torque T_N (catalogue reference): 44 Nm
- Grease lubrication with Harmonic Drive® Grease SK-1A, lubricant temperature: 20 °C

1. Calculation of the torque factor
   $V = T_{av}/T_N = 36/44 = 0.82$ (for V > 1 is K = 1)
2. Reading the calculation factor K from diagram Illustration 2.6.12: K = 0.91
3. Reading the efficiency from the efficiency curve Illustration 2.6.10: η = 63 %
4. Reading the efficiency correction value from diagram Illustration 2.6.13: ηe = -6,5 %
5. Calculation of the load-dependent efficiency
   $\eta_L = K \cdot (\eta + \eta e) = 0{,}91 \cdot (63\ \% - 6{,}5\ \%) = 51\ \%$

Illustration 2.6.12

Calculation factor K

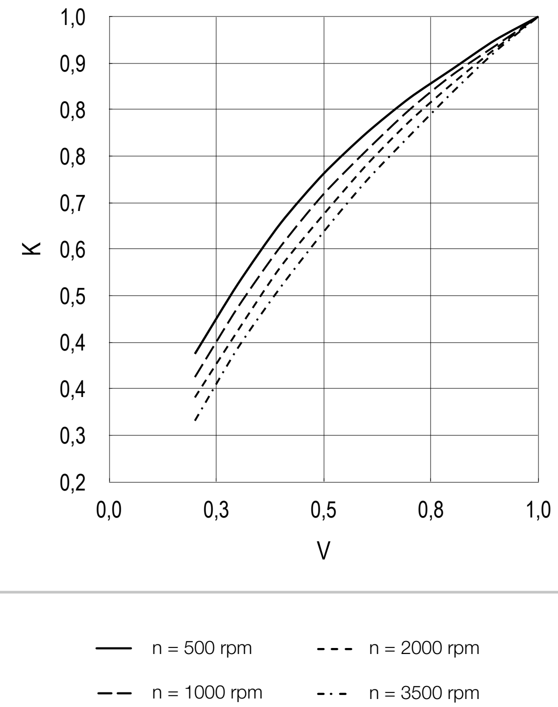
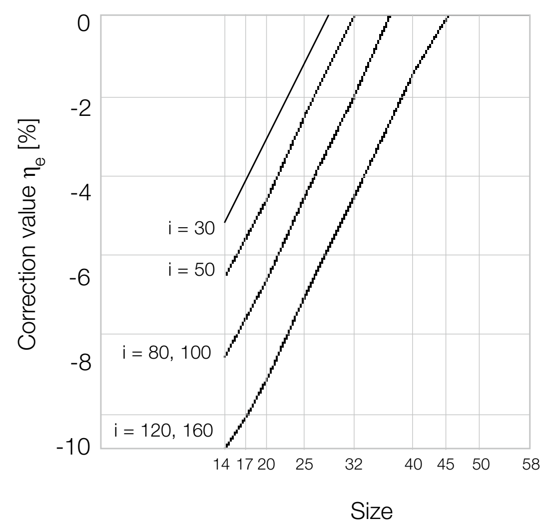


Illustration 2.6.13

Correction value η_e

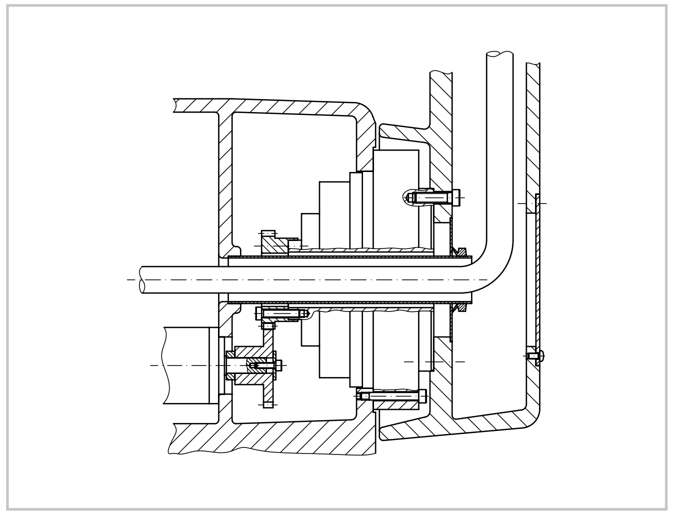


• Continuous operation hollow shaft gears SHG-/HFUS-/TriSHG-2UH

The friction of the oil seals on the input can lead to an additional temperature increase in the hollow shaft gears during operation. Therefore, a reduced "limit for average input speed" applies to these gears. For continuous operation at nominal speed, the max. operating times specified in Table 2.6.25, should not be exceeded.

Alternatively, a design according to Illustration 2.6.14 can be used. In this example, the oil seals on the input (high-speed) have been removed. There are no restrictions on the duty cycle when using this design. The removal of one or both oil seals on the input should only be carried out if grease or base oil leakage is permitted or if this is excluded by the installation position.

Illustration 2.6.14



• Maximum permissible operating time for continuous operation

Table 2.6.25

SHG-/HFUS-/TriSHG-2UH

Operating time	[Unit]	Size									
		14	17	20	25	32	40	45	50	58	65
At operation without load	[min]	90	90	90	60	45	40	35	30	20	15
At rated torque	[min]	60	60	60	45	35	30	25	20	15	10

The data given in Table 2.6.25 applies to:
- Ambient temperature: 25 °C
- Input speed: 2000 rpm
- Max. lubrication temperature: 80 °C
- Mounting of the gear on a plate with the following dimensions:
  - Plate height: 330 mm
  - Plate thickness: 15 mm for sizes ≤ 32
- 30 mm for sizes ≥ 40
- Plate material: Steel
- An additional output flange is not mounted

Input bearing

The hollow shaft of the SHG-/HFUS-2UH Gears is supported by two single row deep groove ball bearings. Illustration 2.6.15 shows the points of application of force of the radial and axial loads given in in Table 2.6.26, Illustration 2.6.16 and Illustration 2.6.17. Example: If the hollow shaft of a SHG-40-2UH Gear is preloaded with an axial load of 500 N, the maximum permissible radial load is 420 N, see Illustration 2.6.16.

The maximum values shown here apply to an average input speed of 2000 rpm and an average bearing life of L_{10} = 7000 h.
The SHG-/HFUS-2UH Gears are typically intended for tooth belt actuators. For applications requiring precise axial position of the input shaft, please consult Harmonic Drive SE.

Table 2.6.26

		Size										
		11	14	17	20	25	32	40	45	50	58	65
Bearing A	Model	6804ZZ	6804ZZ	6805ZZ	6806ZZ	6808ZZ	6909ZZ	6912ZZ	6913ZZ	6915ZZ	6917ZZ	6920ZZ
	Dynamic load rating C [N]	4000	4000	4300	4500	4900	14100	16400	17400	24400	32000	42500
	Static load rating C_0 [N]	2470	2470	2950	3450	4350	10900	14300	16100	22600	29600	36500
Bearing B	Model	6704ZZ	6804ZZ	6805ZZ	6806ZZ	6808ZZ	6909ZZ	6812ZZ	6813ZZ	6815ZZ	6817ZZ	6820ZZ
	Dynamic load rating C [N]	1400	4000	4300	4500	4900	5350	11500	11900	12500	18700	19600
	Static load rating C_0 [N]	720	2470	2950	3450	4350	5250	10900	12100	13900	20000	21200
a	[mm]	25.7	27.0	29.0	27.0	29.5	33.0	39.5	44.0	49.0	56.2	67.0
b	[mm]	15.5	16.5	17.5	15.5	16.5	23.0	27.5	28.5	31.5	36.5	44.5
Max. permissible radial load	F_r [N]	-	230	250	275	250	770	1060	900	1370	1720	2300

Illustration 2.6.15

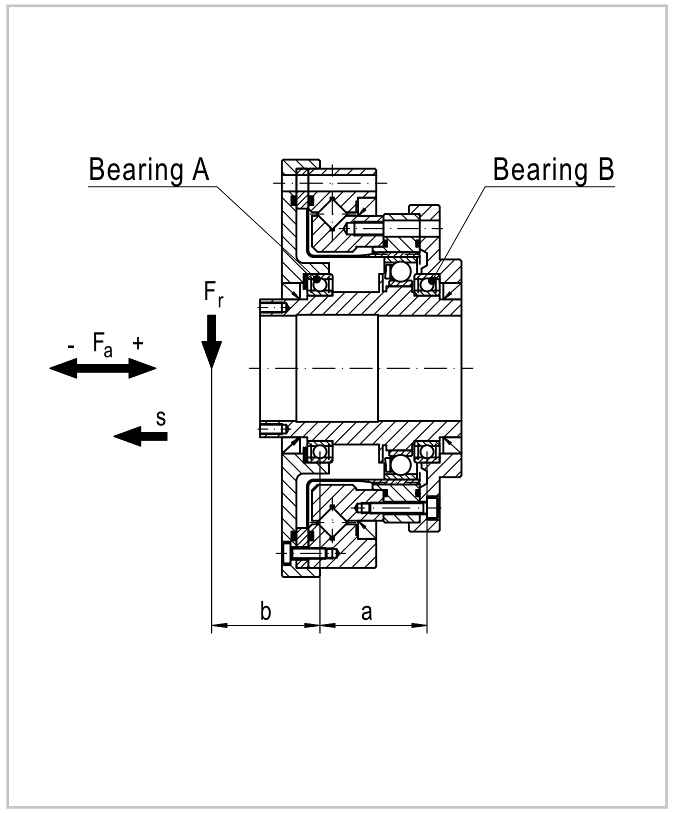


Illustration 2.6.16

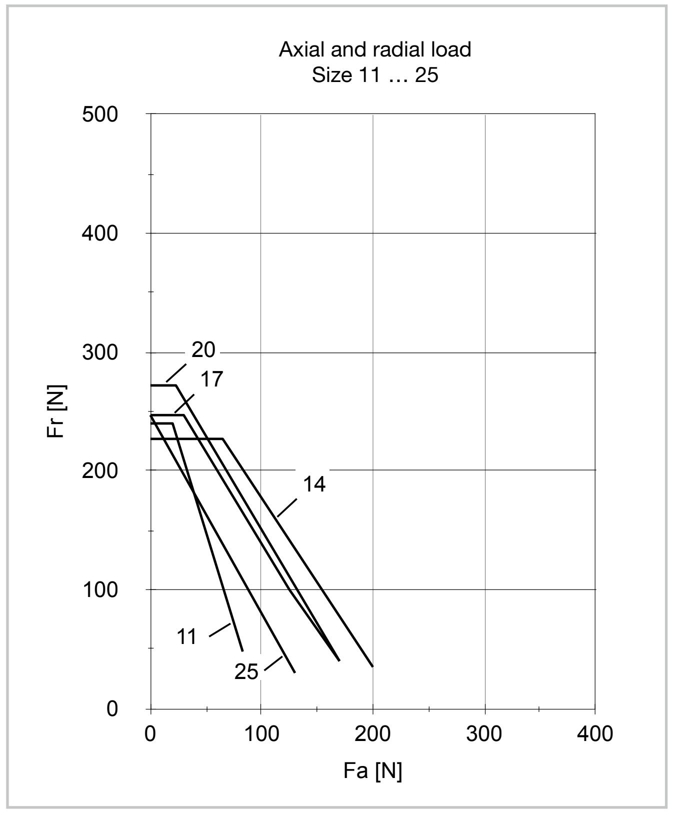
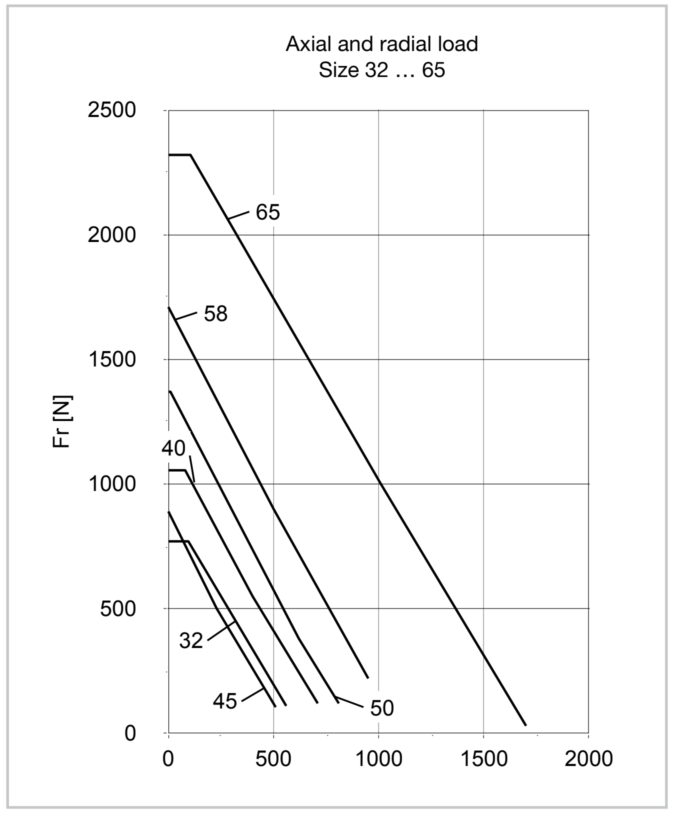


Illustration 2.6.17

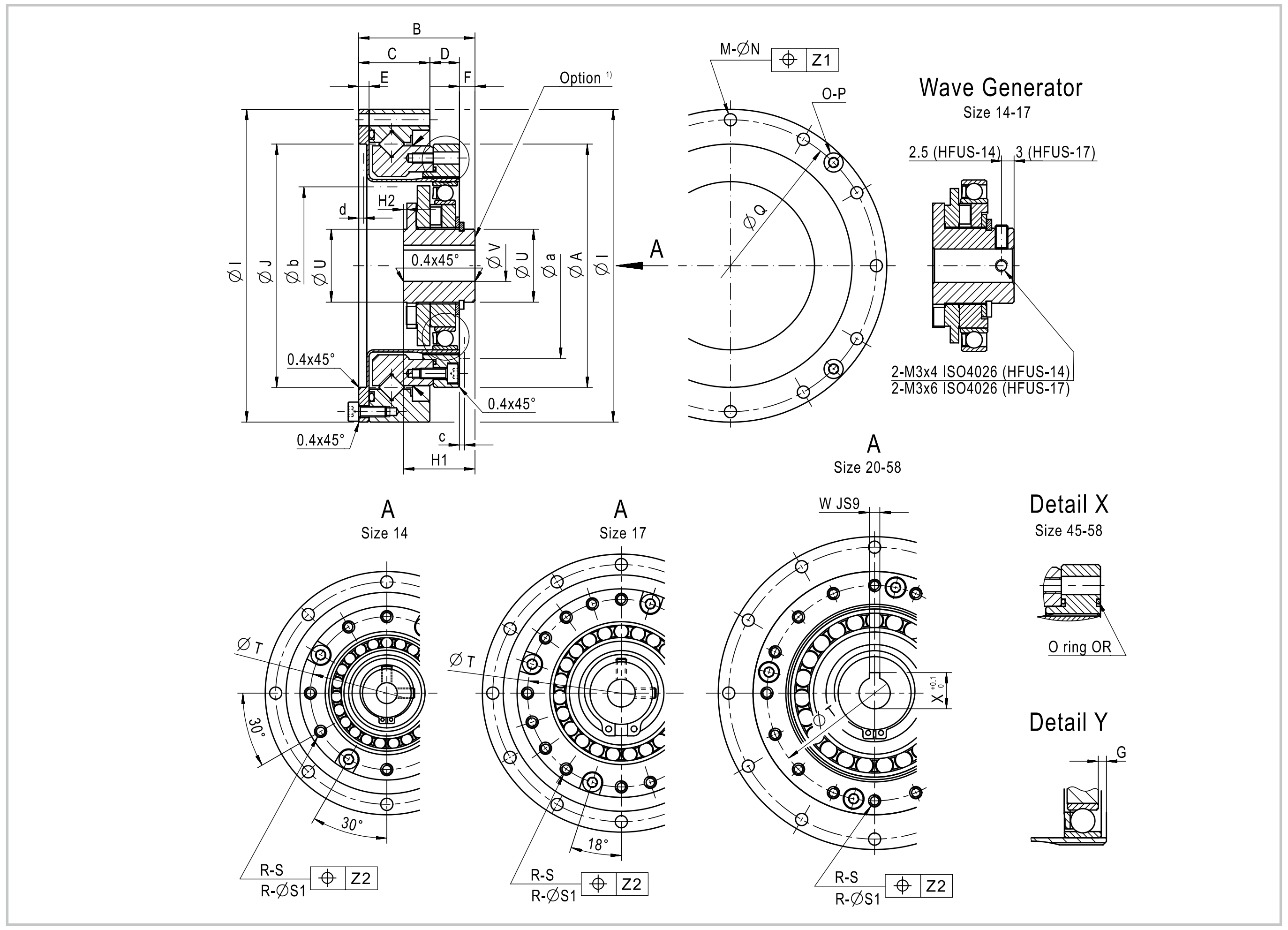


Technical data SHG-/HFUS-/TriSHG-2SO

• Dimensions

Illustration 2.6.18

Size 14 ... 65 [mm]



• Accuracy of the Oldham coupling

Harmonic Drive® Gears are zero backlash. If an Oldham coupling is used, a small backlash in the range of a few seconds of arc occurs outside the tooth engagement, see Table 2.6.27. This small amount of backlash does not occur with a Solid Wave Generator.

Table 2.6.27

[arcsec]

Ratio	Series	Size 14	17	20	25	32	40	45	50	58	65
30	HFUS	60	33	28	28	23	-	-	-	-	-
50	SHG	36	20	17	17	14	14	12	-	-	-
	HFUS	-	-	-	-	-	-	-	12	10	-
80	SHG	23	13	11	11	9	9	8	8	6	6
	HFUS	-	-	-	-	-	-	-	-	-	-
100	SHG	18	10	9	9	7	7	6	6	5	5
	HFUS	-	-	-	-	-	-	-	-	-	-
120	SHG	-	8	8	8	6	6	5	5	4	4
	HFUS	-	-	-	-	-	-	-	-	-	-
160	SHG	-	-	6	6	5	5	4	4	3	3
	HFUS	-	-	-	-	-	-	-	-	-	-

You will find more information on this in the Engineering data chapter.

Table 2.6.28

SHG-/HFUS-/TriSHG-2SO [mm]

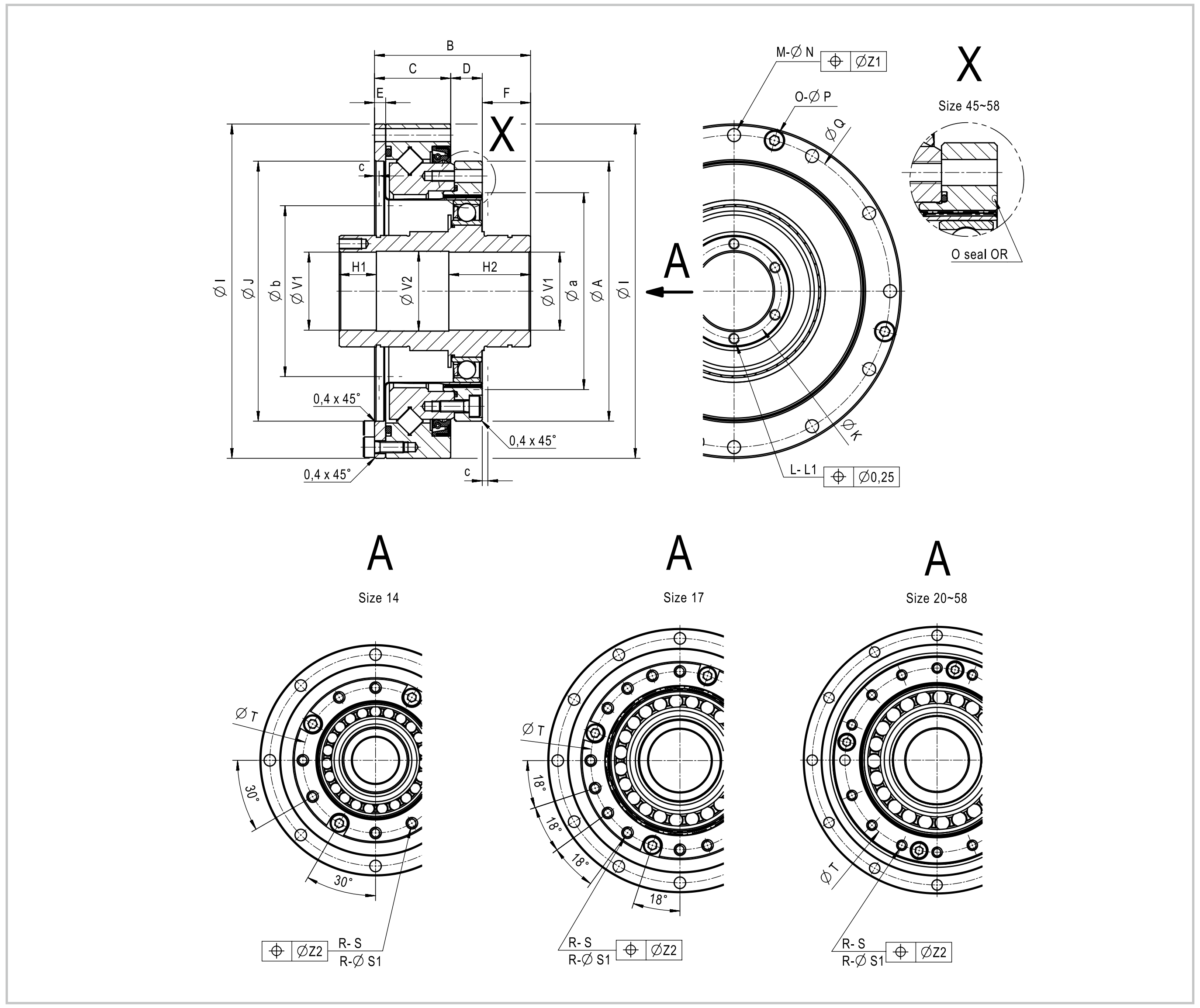
		Size 14	17	20	25	32	40	45	50	58	65
ØA h6		50	60	70	85	110	135	155	170	195	215
B	HFUS	28.5 $^{0}_{-0.8}$	32.5 $^{0}_{-0.9}$	33.5 $^{0}_{-1.0}$	37.0 $^{0}_{-1.1}$	44.0 $^{0}_{-1.1}$	-	-	64.0 $^{0}_{-1.3}$	75.5 $^{0}_{-1.3}$	-
	SHG	28.5 $^{0}_{-0.4}$	32.5 $^{0}_{-0.4}$	33.5 $^{0}_{-0.4}$	37.0 $^{0}_{-0.5}$	44.0 $^{0}_{-0.6}$	53.0 $^{0}_{-0.6}$	58.0 $^{0}_{-0.6}$	64.0 $^{0}_{-0.7}$	75.5 $^{0}_{-0.7}$	83.0 $^{0}_{-0.7}$
C		16.5	19.0	20.5	22.0	27.0	33.0	36.5	39.0	46.0	49.5
D		7.0	7.5	8.5	12.0	15.0	18.0	20.0	24.0	27.0	32.0
E		2.4	3.0	3.0	3.3	3.6	4.0	4.5	5.0	5.8	6.5
F		5.0	6.0	4.5	3.0	2.0	2.0	1.5	1.0	2.5	1.5
G	HFUS	0.4	0.3	0.1	2.1	2.5	-	-	4.2	4.8	-
	SHG	1.4	1.6	1.5	3.5	4.2	5.6	6.3	7.0	8.2	9.5
H1	HFUS	17.6 $^{0}_{-0.1}$	19.5 $^{0}_{-0.1}$	20.1 $^{0}_{-0.1}$	20.2 $^{0}_{-0.1}$	22.0 $^{0}_{-0.1}$	-	-	32.0 $^{0}_{-0.1}$	34.9 $^{0}_{-0.1}$	-
	SHG	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 $^{0}_{-0.1}$
H2		-	-	-	-	-	0.4	-	0.8	-	-
ØI	HFUS	70 h6	80 h6	90 h6	110 h6	142 h6	-	-	214 h6	240 h6	276 h6
	SHG	70 h7	80 h7	90 h7	110 h7	142 h7	170 h7	190 h7	214 h7	240 h7	276 h7
ØJ	HFUS	48 h6	60 h6	70 h6	88 h6	114 h6	-	-	175 h6	203 h6	232 h6
	SHG	48 h7	60 h7	70 h7	88 h7	114 h7	140 h7	158 h7	175 h7	203 h7	232 h7
M		8	12	12	12	12	12	18	12	16	16
ØN		3.5	3.5	3.5	4.5	5.5	6.6	6.6	9.0	9.0	11.0
O		2	4	4	4	4	6	6	6	8	8
P		M3x6	M3x6	M3x8	M3x8	M4x8	M4x10	M4x8	M5x12	M5x12	M6x16
ØQ		64	74	84	102	132	158	180	200	226	258
R		8	16	16	16	16	16	12	16	12	16
S		M3x5	M3x6	M3x6	M4x7	M5x8	M6x10	M8x10	M8x11	M10x15	M10x15
ØT		44	54	62	77	100	122	140	154	178	195
ØU		14	18	21	26	26	32	32	32	40	48
ØV H7		6	8	9	11	14	14	19	19	22	24
W		-	-	3 Js9	4 Js9	5 Js9	5 Js9	6 Js9	6 Js9	6 JS9	8 Js9
X		-	-	10.4	12.8	16.3	16.3	21.8	21.8	24.8	27.3
Z1		0.25	0.25	0.25	0.25	0.25	0.30	0.30	0.50	0.50	0.50
Z2		0.25	0.25	0.25	0.25	0.25	0.30	0.50	0.50	0.50	0.50
Minimum housing clearance	Øa	38	45	53	66	86	106	119	133	154	172
	Øb	31	38	45	56	73	90	101	113	131	150
	c	1.0	1.0	1.5	1.5	1.5	2.0	2.0	2.0	2.5	2.5
	d	1.7	2.1	2.0	2.0	2.0	2.0	2.3	2.5	2.9	3.5
O ring		-	-	-	-	-	-	121.5x2.0	134.5x2.0	157.0x2.0	S175

Technical data SHG-/HFUS-/TriSHG-2SH

- Dimensions

Illustration 2.6.19

Size 14 ... 65 [mm]



Wave Generator Details

Illustration 2.6.20

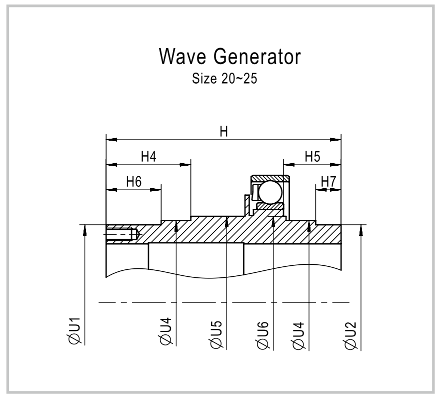


Illustration 2.6.21

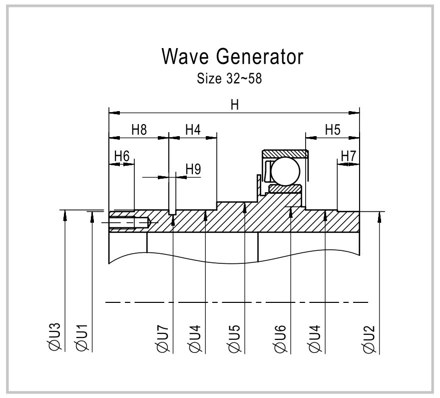


Illustration 2.6.22

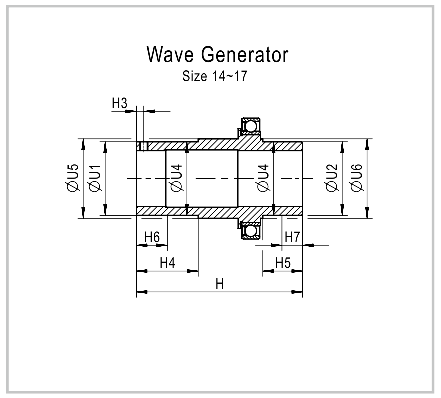


Table 2.6.29

SHG-/HFUS-/TriSHG-2SH [mm]

		Size									
		14	17	20	25	32	40	45	50	58	65
ØA h6		50	60	70	85	110	135	155	170	195	215
B		36.5 $^{0}_{-0.8}$	40.5 $^{0}_{-0.9}$	42.0 $^{0}_{-1.0}$	45.5 $^{0}_{-1.1}$	53.5 $^{0}_{-1.1}$	66.0 $^{0}_{-1.1}$	71.5 $^{0}_{-1.2}$	78.0 $^{0}_{-1.3}$	90.0 $^{0}_{-1.3}$	107.0 $^{0}_{-1.3}$
C		16.5	19.0	20.5	22.0	27.0	33.0	36.5	39.0	46.0	49.5
D		7.0	7.5	8.5	12.0	15.0	18.0	20.0	24.0	27.0	32.0
E		2.4	3.0	3.0	3.3	3.6	4.0	4.5	5.0	5.8	6.5
F		13.0	14.0	13.0	11.5	11.5	15.0	15.0	15.0	17.0	25.5
H		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 $^{0}_{-0.1}$	85.0 $^{0}_{-0.1}$	93.0 $^{0}_{-0.1}$	106.0 $^{0}_{-0.1}$	128.0 $^{0}_{-0.1}$
H1		10	10	10	10	10	12	15	15	15	20
H2		20	22	22	23	25	32	35	37	43	54
H3		2.5	2.5	-	-	-	-	-	-	-	-
H4		20.0	21.5	19.0	20.0	13.9	15.1	15.6	18.6	21.1	23.1
H5	HFUS	12.5	13.5	12.5	13.0	13.0	-	-	17.5	20.0	-
	SHG						16.5	17.5			
H6		13.0	14.5	12.0	13.5	-	-	8.0	9.0	10.0	14.0
H7	HFUS	5.5	6.5	5.5	6.5	6.0	-	-	8.0	7.5	11.5
	SHG						7.0	8.0			
H8		-	-	-	-	15.1	18.9	19.4	20.9	24.2	31.4
H9		-	-	-	-	1.9	2.2	2.7	2.7	3.2	3.1
ØI h6		70	80	90	110	142	170	190	214	240	276
ØJ H6		48	60	70	88	114	140	158	175	203	232
ØK		-	-	25.5	33.5	40.5	52.0	58.0	67.0	77.0	88.0
L		3	3	6	6	6	6	6	6	8	6
L1		M3	M3	M3x6	M3x6	M3x6	M4x8	M4x8	M4x8	M4x8	M5x10
M		8	12	12	12	12	12	18	12	16	16
ØN		3.5	3.5	3.5	4.5	5.5	6.6	6.6	9.0	9.0	11.0
O		2	4	4	4	4	6	6	6	8	8
P		M3x6	M3x6	M3x8	M3x8	M4x8	M4x10	M4x10	M5x12	M5x12	M6x16
ØQ		64	74	84	102	132	158	180	200	226	258
R		8	16	16	16	16	16	12	16	12	16
S		M3x5	M3x6	M3x8	M3x8	M4x8	M4x10	M4x10	M5x12	M5x12	M6x16
S1		Ø3.5x6.0	Ø3.5x6.0	Ø3.5x7.5	Ø4.5x10	Ø5.5x14	Ø6.6x17	Ø9.0x19	Ø9.0x22	Ø11.0x25	Ø11.0x29
ØT		44	54	62	77	100	122	140	154	178	195
ØU1 h7		20	25	30	38	45	59	64	74	84	96
ØU2		20 f7	25 f7	30 f7	40 h9	45 f7	59 h9	59 h9	69 h9	84 h9	96 h9
ØU3	HFUS	-	-	-	-	-	-	-	75 h9	85 h9	-
	SHG						60 f7	65 f7	75 f7	85 f7	100 f7
ØU4 j6		20	25	30	40	45	60	65	75	85	100
ØU5		22.0	27.0	32.0	42.0	49.0	65.0	70.0	80.0	91.5	111.0
ØU6		22	27	32	42	47	62	69	79	90	106
ØU7		-	-	-	-	42.5	57.0	62.0	72.0	81.5	96.5
ØV1 H7		14	19	21	29	36	46	52	60	70	80
ØV2		14.5	19.5	21.5	29.5	36.5	46.5	52.5	60.5	70.5	80.5
Z1		0.25	0.25	0.25	0.25	0.25	0.30	0.30	0.50	0.50	0.50
Z2		0.25	0.25	0.25	0.25	0.25	0.30	0.50	0.50	0.50	0.50
O ring		-	-	-	-	-	-	121.5x2	134.5x2	157.0x2	S175
Minimum housing clearance	Øa	38	45	53	66	86	106	119	133	154	172
	Øb	31	38	45	56	73	90	101	113	131	150
	c	1.0	1.0	1.5	1.5	1.5	2.0	2.0	2.0	2.5	2.5
	d	1.7	2.1	2.0	2.0	2.0	2.0	2.3	2.5	2.9	3.5

Assembly SHG-/HFUS-/TriSHG-2SO/2SH

• Assembly tolerances

Illustration 2.6.23

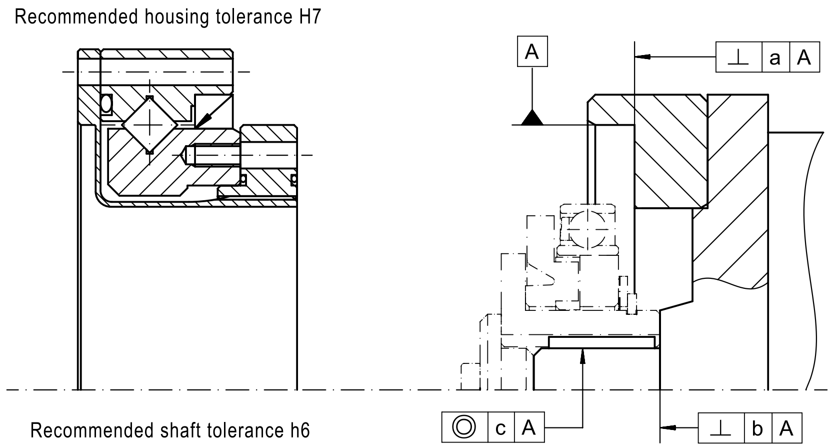


Table 2.6.30

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	0.024	0.032	0.032	0.032	0.032
	(0.008)	(0.010)	(0.010)	(0.012)	(0.012)	(0.012)	(0.012)	(0.015)	(0.015)	(0.015)
c	0.030	0.034	0.044	0.047	0.047	0.050	0.063	0.066	0.068	0.070
	(0.016)	(0.018)	(0.019)	(0.022)	(0.022)	(0.022)	(0.024)	(0.030)	(0.033)	(0.035)

Screw connection on the Wave Generator

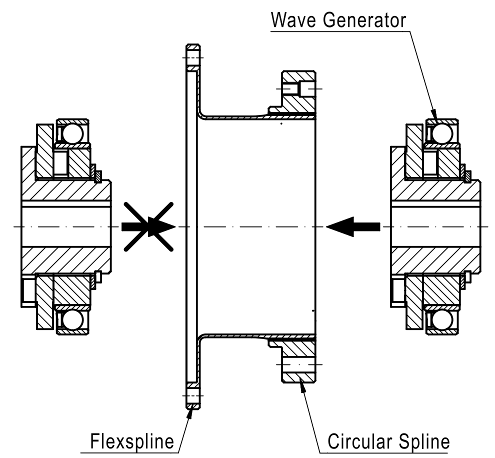
Illustration 2.6.24

	[Unit]	Size							
		20	25	32	40	45	50	58	65
		SHG/HFUS	SHG/HFUS	SHG/HFUS	SHG/HFUS	SHG/HFUS	SHG/HFUS	SHG/HFUS	SHG
Number of screws		6	6	6	6	6	6	6	6
Size of screws		M3	M3	M3	M4	M4	M4	M4	M5
Pitch circle diameter	[mm]	22.5	33.5	40.5	52.0	58.0	67.0	77.0	88.0
Screw tightening torque	[Nm]	2.30	2.30	2.30	5.29	5.29	5.29	5.29	10.54
Torque transmitting capacity	[Nm]	31	41	50	110	126	121	139	311

• Installation of the Wave Generator

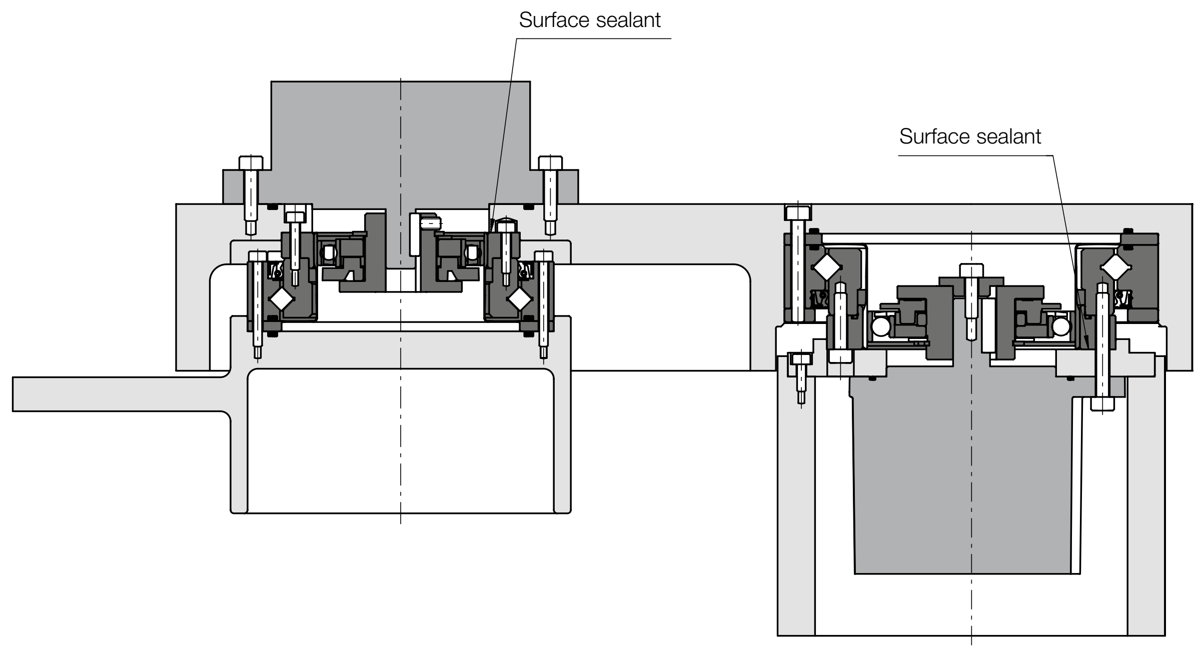
The Wave Generator must be mounted in the direction of the arrow. When the Wave Generator is inserted into the Flexspline, it adapts to the elliptical shape of the Wave Generator.

Illustration 2.6.25



• Application example

Illustration 2.6.26



Design guidelines

• Materials and coatings used

Table 2.6.31

Version	SHG-/HFUS-/ TriSHG-2UH	SHG-/HFUS-/ TriSHG-2SO	SHG-/HFUS-/ TriSHG-2SH	SHG-/HFUS-2UH-LW
Output bearing	Burnished steel[2]			
Circular Spline	Grey cast iron			
Flexspline	Bright steel			
Wave Generator (Hollow shaft by 2UH/2SH)	Bright steel			
Input flange	Bright steel	x	x	Bright aluminium
Output flange (Version 2SO Adapter flange[1])	Bright steel	High-strength aluminium or steel, coating as per confirmation drawing	x	Bright aluminium
Screws	Coated against corrosion			

x not available in this version
[1] If supplied by Harmonic Drive SE
[2] no corrosion protection

Optional materials are available on request.

Lubrication

• Grease lubrication SHG-/HFUS/TriSHG-2UH/(2UH-LW)

The Gears with output bearing SHG-/HFUS-2UH/2UH-LW are supplied fully greased. They are provided with lifetime grease lubrication at the factory. We recommend the use of the greases listed in Table 2.6.32. The output bearing is greased with Harmonic Drive® Grease 4BNo.2.

• Grease lubrication SHG-/HFUS/TriSHG-2SO and SHG-/HFUS/TriSHG-2SH

These gears are supplied without lifetime grease lubrication and must be lubricated by the customer before commissioning. The recommended types of grease are shown in Table 2.6.32. If a different grease is used, the grease type is noted on the customer's drawing. When standard gears SHG-/HFUS-2SO and -2SH are delivered, the Flexspline and Circular Spline teeth are already lubricated. Before assembly, the Wave Generator ball bearing and the inside of the Flexspline must be greased. Additional grease may need to be placed in front of the Wave Generator face. The dimension "s" should correspond approximately to the height of the Wave Generator ball bearing.

When grease lubrication is used, it is important to ensure sufficient grease quantity at the points to be lubricated. This can be achieved by optimising the installation space between the gear and the housing, see Illustration 2.6.27.

Illustration 2.6.27 shows the areas to be lubricated.

Illustration 2.6.27

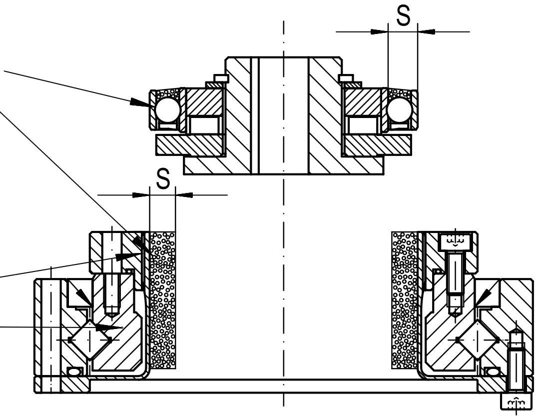


Table 2.6.32 **SHG-/HFUS-2UH/2SO/2SH**

Ratio	Harmonic Drive® Grease	Size 11	14	17	20	25	32	40	45 ... 58	65
30 (HFUS)	Flexolub®-A1[1]	-	O	O	O	O	O	-	-	-
	SK-1A	-	-	-	Δ	Δ	Δ	-	-	-
	SK-2	-	Δ	Δ	-	-	-	-	-	-
	4BNo.2	-	Δ	Δ	□	□	□	-	-	-
≥50	SK-1A	-	-	-	O	O	O	O	O	O
	SK-2	O	O	O	Δ	Δ	Δ	Δ	-	-
	4BNo.2	-	□	□	□	□	□	□	□	□
	Flexolub®-A1[1]	-	Δ	Δ	Δ	Δ	Δ	Δ	Δ	-

[1] only for HFUS Series
O Standard grease
□ Recommended for very high loads or very high demands on the service life of the grease
Δ Optional grease, please consult Harmonic Drive SE

Table 2.6.33 **TriSHG-2UH/2SO/2SH**

Ratio	Harmonic Drive® Grease	Size 25 … 32
100 … 160	Flexolub®-A1	O
	SK-1A	-
	SK-2	Δ
	4BNo.2	Δ

O Standard grease
□ Recommended for very high loads or very high demands on the service life of the grease
Δ Optional grease, please consult Harmonic Drive SE

i You will find more information on this in the Engineering data chapter.

- ## Grease quantity SHG-/HFUS/TriSHG-2SO and SHG-/HFUS/TriSHG-2SH

Table 2.6.35 and Table 2.6.34 show the grease quantities for SHG-/HFUS/TriSHG-2SO and SHG-/HFUS/TriSHG-2SH in the various mounting positions.

Table 2.6.34

Grease quantity SHG-/HFUS-/TriSHG-2SO [g]

		Size									
		14	17	20	25	32	40	45	50	58	65
Mounting position	Wave Generator vertical	5.8	11	18	32	64	120	185	235	385	385
	Wave Generator down	7.5	13	19	37	74	130	200	255	400	400
	Wave Generator up	8.9	15	22	42	84	150	230	290	480	480

Table 2.6.35

Grease quantity SHG-/HFUS-/TriSHG-2SH [g]

		Size									
		14	17	20	25	32	40	45	50	58	65
Mounting position	Wave Generator vertical	5.7	8.4	10	17	30	49	79	99	155	207
	Wave Generator down	7.4	10	11	22	40	59	94	119	170	242
	Wave Generator up	8.8	12	14	27	50	79	124	154	250	342

- ## Grease quantity for installations in the gear compartment

If installations are planned in the gear compartment (e.g. flanges), the grease quantity must be considered separately. As the gear heats up during operation, to avoid an excessive increase in pressure, we generally recommend that the ratio of grease volume to housing volume should not exceed 60 %. Illustration 2.6.28 shows the available gearbox volume for the lubricant. In this case, please contact Harmonic Drive SE.

Illustration 2.6.28

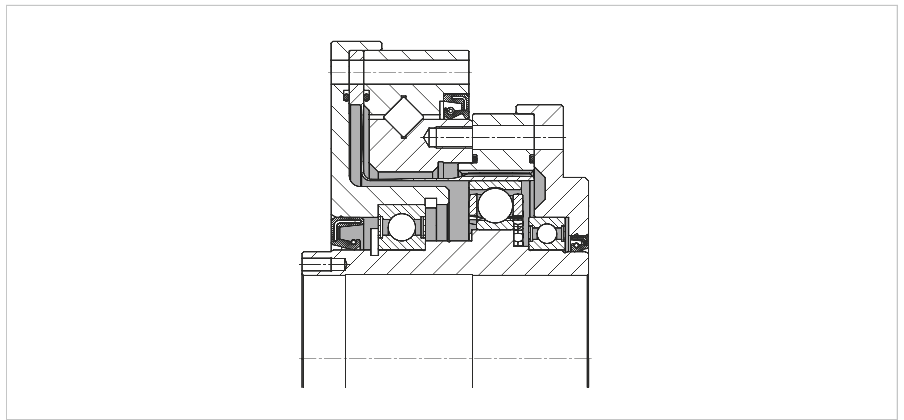
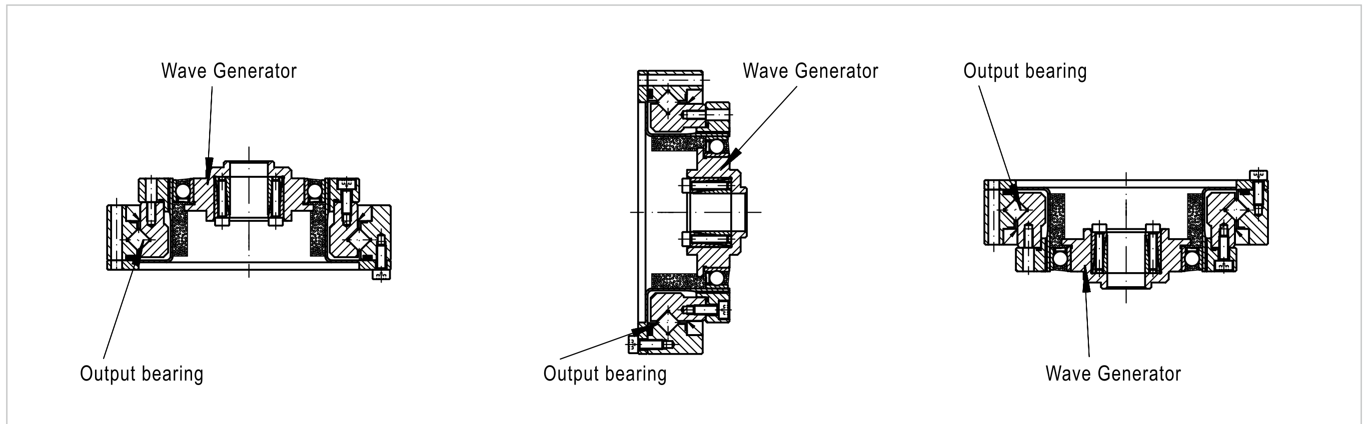
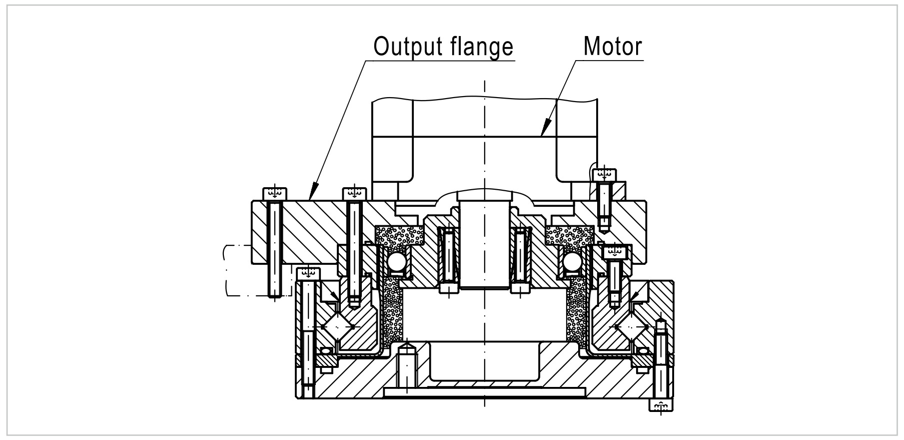


Illustration 2.6.29



The mounting positions "Wave Generator top" or "Wave Generator bottom" defined in the following text refer to the relative position of the Wave Generator to the output bearing of the gear, see Illustration 2.6.30.
If the Wave Generator is mainly used on top, additional grease filling is required. In this case, approx. 60 % of the available volume in the adapter flange should be filled with grease.

Illustration 2.6.30



- ## Oil lubrication

Harmonic Drive® Gears with output bearing with oil lubrication are customer specific special designs. Lubrication and relubrication are determined individually.

You will find more information on this in the Engineering data chapter.

Product description

Light and short hollow shaft gear

The SHD-2SH Series Gears with high capacity tilt resistant bearing are characterised by their very short design. Compared to the SHG/HFUS Series, the axial length is reduced by about 50 %. In addition, this series has a very low weight and a Wave Generator with a large hollow shaft for the passage of supply lines.

Features

- Very short design
- Very low weight
- Large hollow shaft
- High single stage reduction ratios
- Zero backlash
- High transmission accuracy
- High torque capacity
- High torsional stiffness

Ordering code

Table 2.7.1

Ordering code	SHD	-	25	-	100	-	2SH	-	SP
Series	SHD								
Size (corresponds to the pitch circle diameter of the Flexspline toothing in inches x 10)			14 17 20 25 32 40						
Ratio (in drive configuration: Circular Spline (CS) fixed, Wave Generator (WG) input, Flexspline (FS) output)					50 80 100 120 160				
Version Gears for motor mounting							2SH		
Customised design Standard design (field remains empty) Special design (on request)									[ ] SP

Please refer to the table of possible combinations.

Combinations

Table 2.7.2

		Size					
		14	17	20	25	32	40
Ratio	50	●	●	●	●	●	●
	80	●	●	●	●	●	●
	100	●	●	●	●	●	●
	120	-	●	●	●	●	●
	160	-	-	●	●	●	●

● available o on request - not available

Technical data

• Rating table

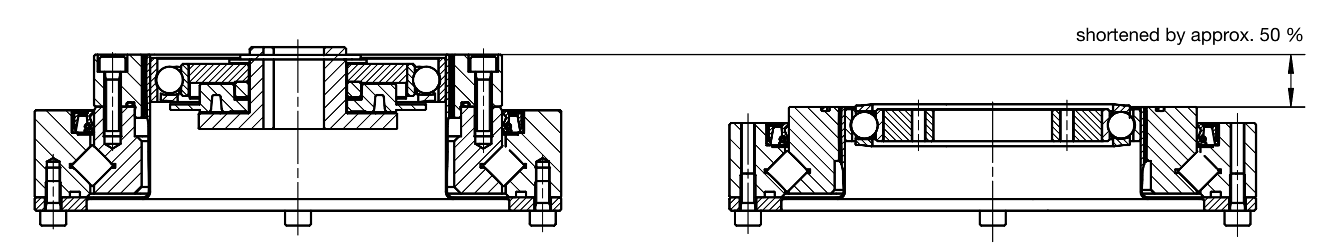
Table 2.7.3

Size	Ratio	Limit for repeated peak torque	Limit for average torque	Rated torque at rated speed 2000 rpm	Limit for momentary peak torque	Max. input speed [rpm]	Limit for average input speed [rpm]	Moment of inertia	Weight
	i	T_R [Nm]	T_A [Nm]	T_N [Nm]	T_M [Nm]	Grease lubrication	Grease lubrication	[kgm²]	[kg]
14	50	12.0	4.8	3.7	23.0	8500	3500	0.021x10⁻⁴	0.33
	80	16.0	7.7	5.4	35.0				
	100	19.0	7.7	5.4	35.0				
17	50	23	18	11	48	7300	3500	0.054x10⁻⁴	0.42
	80	29	19	15	61				
	100	37	27	16	71				
	120	37	27	16	71				
20	50	39	24	17	69	6500	3500	0.090x10⁻⁴	0.52
	80	51	33	24	89				
	100	57	34	28	95				
	120	60	34	28	95				
	160	64	34	28	95				
25	50	69	38	27	127	5600	3500	0.282x10⁻⁴	0.91
	80	96	60	44	179				
	100	110	75	47	184				
	120	117	75	47	204				
	160	123	75	47	204				
32	50	151	75	53	268	4800	3500	1.090x10⁻⁴	1.87
	80	213	117	83	398				
	100	233	151	96	420				
	120	247	151	96	445				
	160	261	151	96	445				
40	50	281	137	96	480	4000	3000	2.850x10⁻⁴	3.09
	80	364	198	144	686				
	100	398	260	185	700				
	120	432	315	205	765				
	160	453	316	206	765				

You will find more information on this in the Engineering data chapter.

• Comparison SHG-2SH to SHD-2SH

Illustration 2.7.1



• Dimensions

Illustration 2.7.2 [mm]

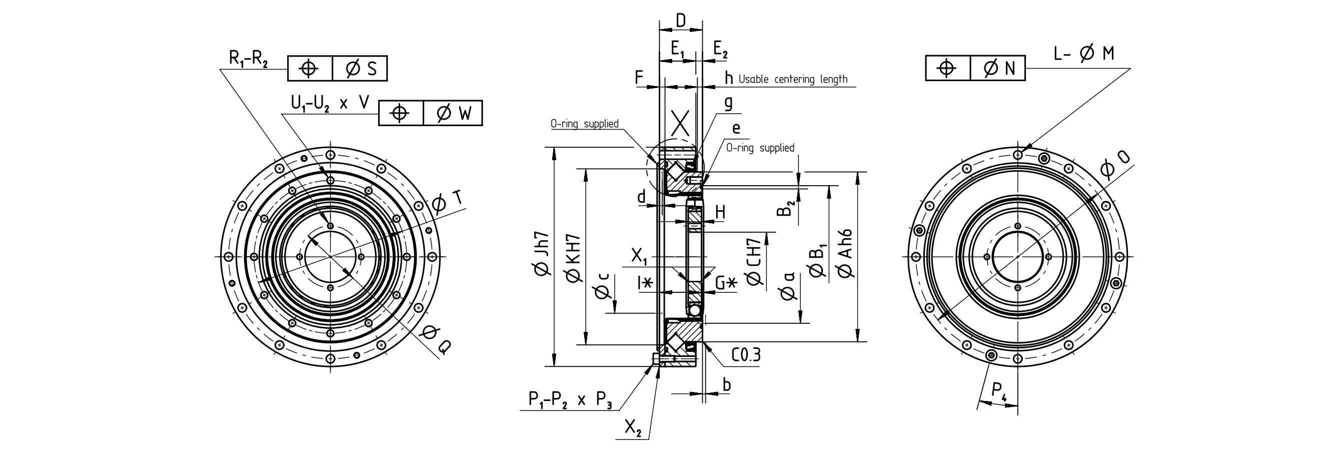


Table 2.7.4 [mm]

		Size 14	17	20	25	32	40
ø A h6		$49^{0}_{-0.016}$	$59^{0}_{-0.019}$	$69^{0}_{-0.019}$	$84^{0}_{-0.022}$	$110^{0}_{-0.022}$	$132^{0}_{-0.025}$
ø B_1		$39.1^{+0.1}_{0}$	$48.0^{+0.1}_{0}$	$56.8^{+0.1}_{0}$	$70.5^{+0.1}_{0}$	$92.0^{+0.1}_{0}$	$112.4^{+0.1}_{0}$
B_2		$0.8^{+0.15}_{0}$	$1.1^{+0.25}_{0}$	$1.4^{+0.25}_{0}$	$1.7^{+0.25}_{0}$	$2.0^{+0.25}_{0}$	$2.2^{+0.25}_{0}$
ø C 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 ±0.1	22.0 ±0.1	27.9 ±0.1	33.0 ±0.1
E_1		15.5	16.5	17.0	20.0	23.6	28.0
E_2		2.0	2.0	2.0	2.0	4.3	5.0
F		2.4	3.0	3.0	3.3	3.6	4.0
G*		1.8	1.6	1.2	0.4	0.6	0.8
H		$4.0^{0}_{-0.1}$	$5.0^{0}_{-0.1}$	$5.2^{0}_{-0.1}$	$6.3^{0}_{-0.1}$	$8.6^{0}_{-0.1}$	$10.3^{0}_{-0.1}$
I*		$15.7^{0}_{-0.2}$	$16.9^{0}_{-0.2}$	$17.8^{0}_{-0.2}$	$21.6^{0}_{-0.2}$	$27.3^{0}_{-0.2}$	$32.2^{0}_{-0.2}$
ø J H7		$70^{0}_{-0.030}$	$80^{0}_{-0.030}$	$90^{0}_{-0.035}$	$110^{0}_{-0.035}$	$142^{0}_{-0.040}$	$170^{0}_{-0.040}$
ø K 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
ø M		3.5	3.5	3.5	4.5	5.5	6.6
ø N		0.25	0.25	0.25	0.25	0.25	0.30
ø O		64	74	84	102	132	158
Screw designation	P_1	2	2	2	4	4	4
	P_2	M3	M3	M3	M3	M4	M4
	P_3	6	6	8	8	8	10
P_4		22.5 °	15 °	15 °	15 °	15 °	15 °
ø Q		17	21	26	30	40	50
R_1		4	4	4	4	4	4
R_2		M3	M3	M3	M3	M4	M5
ø S		0.25	0.25	0.25	0.25	0.25	0.25
ø T		43.0	52.0	61.4	76.0	99.0	120.0
Thread designation	U_1	8	12	12	12	12	12
	U_2	M3	M3	M3	M4	M5	M6
	V	4.5	4.5	4.5	6.0	8.0	9.0
ø W		0.25	0.25	0.25	0.25	0.25	0.30
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
Minimum housing clearance	ø a	36.5	45.0	53.0	66.0	86.0	106.0
	b	1.0	1.0	1.5	1.5	2.0	2.5
	ø c	31	38	45	56	73	90
	d	1.4	1.8	1.7	1.8	1.8	1.8
e		d37.10 d0.60	d45.40 d0.80	d53.28 d0.99	d66.50 d1.30	d87.50 d1.50	d107.50 d1.60
g		D49585	D59685	D69785	D84945	D1101226	D1321467
h		1.5	1.5	1.5	1.5	3.3	4.0

CAD drawings for download: www.harmonicdrive.co.uk

Accuracy

Table 2.7.5 **[arcmin]**

	Size					
	14		17		20 ... 40	
Ratio	50	>50	50	>50	50	>50
Transmission accuracy	<1.5		<1.5		<1.0	
Hysteresis loss	<2.5	<2.0	<2.0	<1.0	<2.0	<1.0

Torsional stiffness

Table 2.7.6

	Symbol [Unit]	Size					
		14	17	20	25	32	40
Limit torques	T_1 [Nm]	2.0	3.9	7.0	14.0	29.0	54.0
	T_2 [Nm]	6.9	12.0	25.0	48.0	108.0	196.0
i = 50	K_3 [x 10^4 Nm/rad]	0.47	1.20	2.00	3.70	8.40	15.00
	K_2 [x 10^4 Nm/rad]	0.37	0.88	1.30	2.70	6.10	11.00
	K_1 [x 10^4 Nm/rad]	0.29	0.67	1.10	2.00	4.70	8.80
i ≥ 80	K_3 [x 10^4 Nm/rad]	0.61	1.30	2.50	4.70	11.00	20.00
	K_2 [x 10^4 Nm/rad]	0.44	0.94	1.70	3.70	7.80	14.00
	K_1 [x 10^4 Nm/rad]	0.40	0.84	1.30	2.70	6.10	11.00

No load starting torque

Table 2.7.7 **[Ncm]**

Ratio	Size					
	14	17	20	25	32	40
50	6.2	19	25	39	60	95
80	5.0	16	23	36	55	83
100	4.8	17	22	34	50	78
120	-	13	22	34	48	77
160	-	-	22	33	47	74

No load back driving torque

Table 2.7.8 **[Nm]**

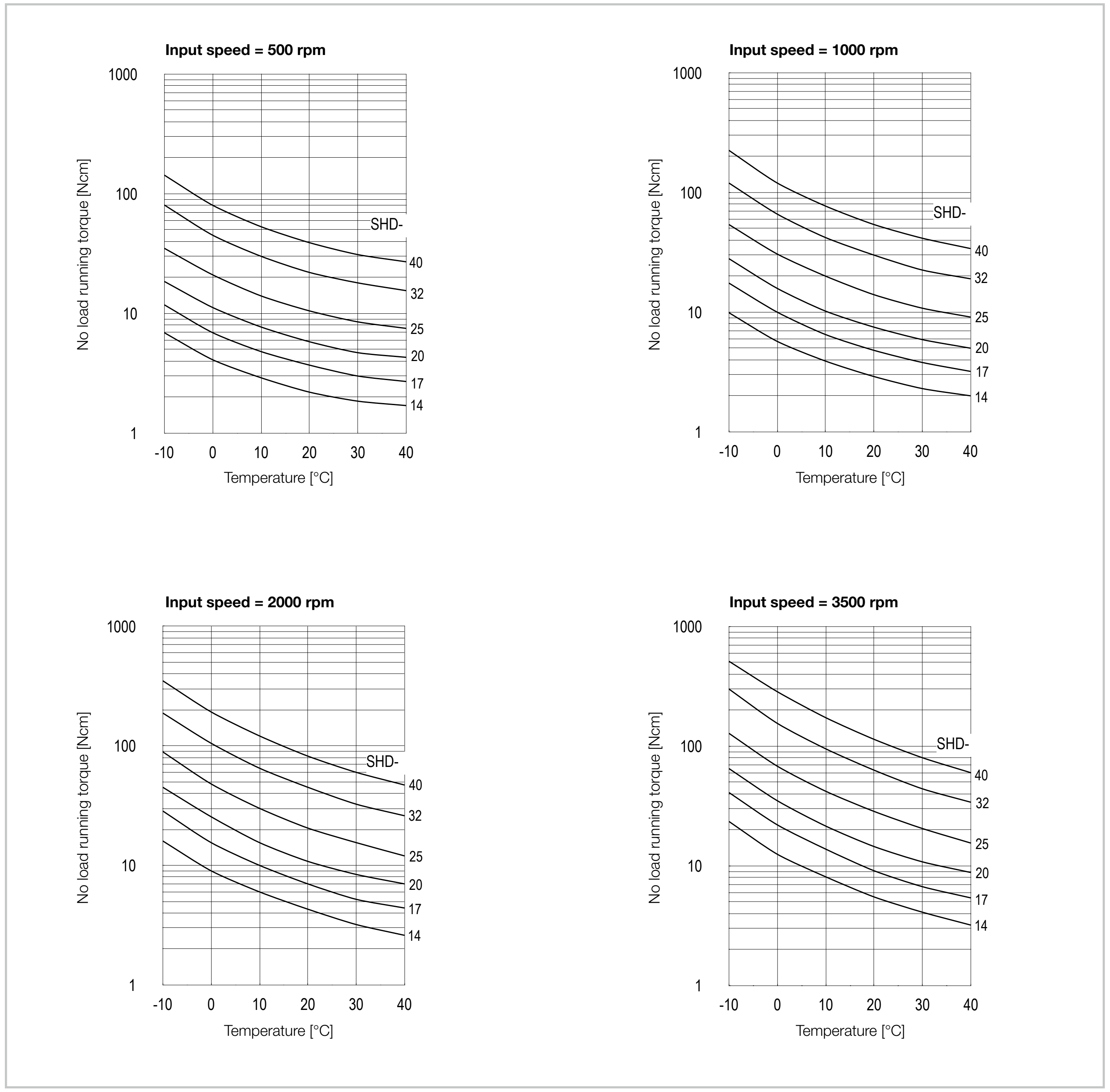
Ratio	Size					
	14	17	20	25	32	40
50	3.7	11	15	24	36	57
80	4.3	15	21	32	46	72
100	5.8	21	27	41	60	94
120	-	28	33	51	68	113
160	-	-	42	64	91	143

You will find more information on this in the Engineering data chapter.

No load running torque

The diagrams apply to Harmonic Drive® Grease SK-2 (size 14, 17) or SK-1A (size ≥ 20).

Illustration 2.7.3



Compensation values for no load running torque

When using gears with ratios other than i = 100 please apply the compensation values for the table to the values taken from the curves.

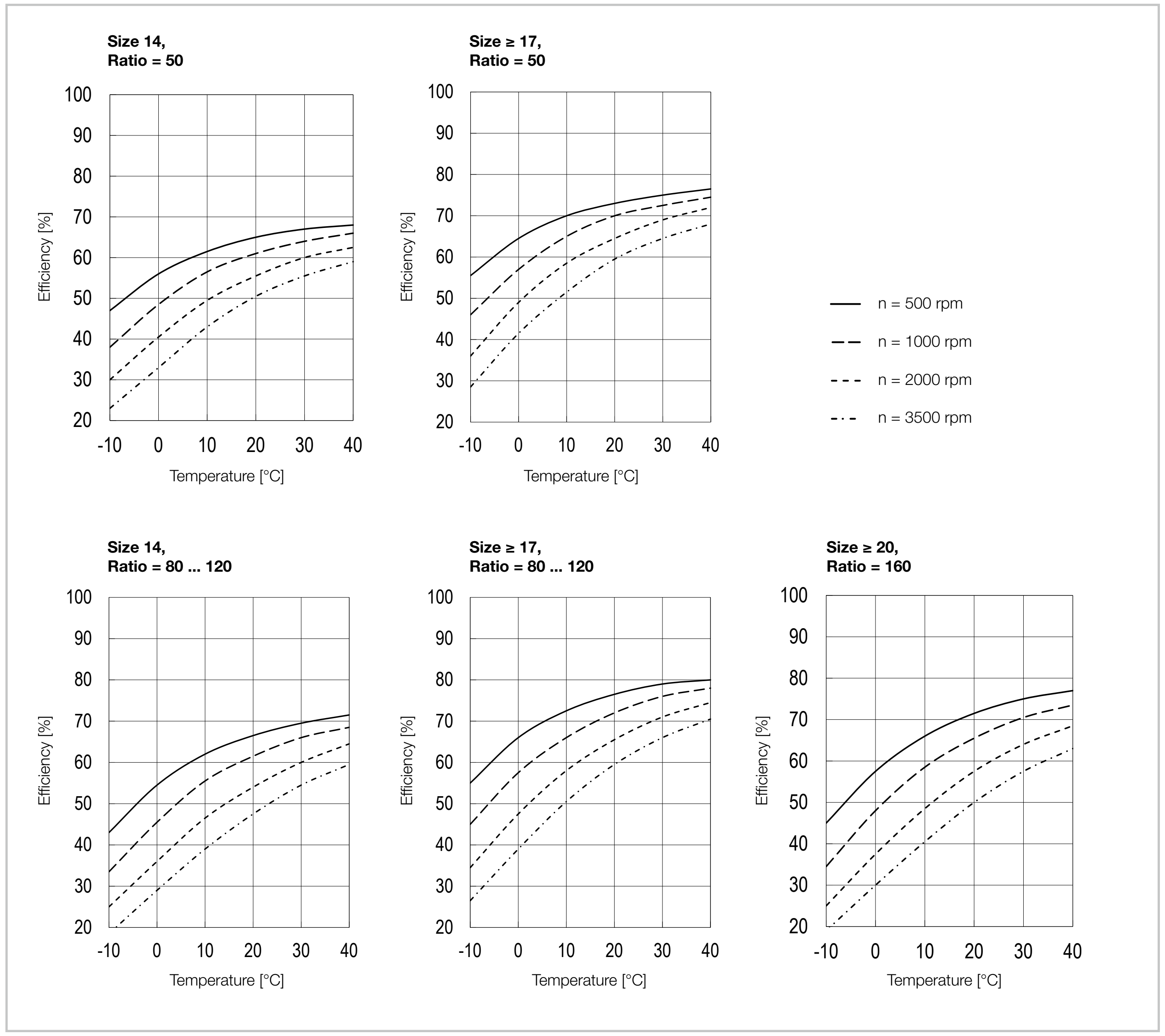
Table 2.7.9 **[Ncm]**

Ratio	Size					
	14	17	20	25	32	40
50	1.0	1.6	2.4	4.0	7.0	13.0
80	0.2	0.3	0.5	0.8	1.4	2.4
120	-	-0.2	-0.3	-0.5	-1.0	-1.7
160	-	-	-0.7	-1.2	-2.4	-3.9

• Efficiency

Efficiency for grease lubrication at rated torque
The diagrams apply to Harmonic Drive® Grease SK-2 (size 14, 17) or SK-1A (size ≥ 20).

Illustration 2.7.4



You will find more information on this in the Engineering data chapter.

Efficiency calculation

The efficiency depends on the following parameters: Gear ratio, input speed, load torque, temperature, lubricant and lubricant quantity. If the load torque is lower than the rated torque, the efficiency will be lower than the efficiency than that indicated in the efficiency curves. The torque specific efficiency is determined by means of the the calculation factor K.

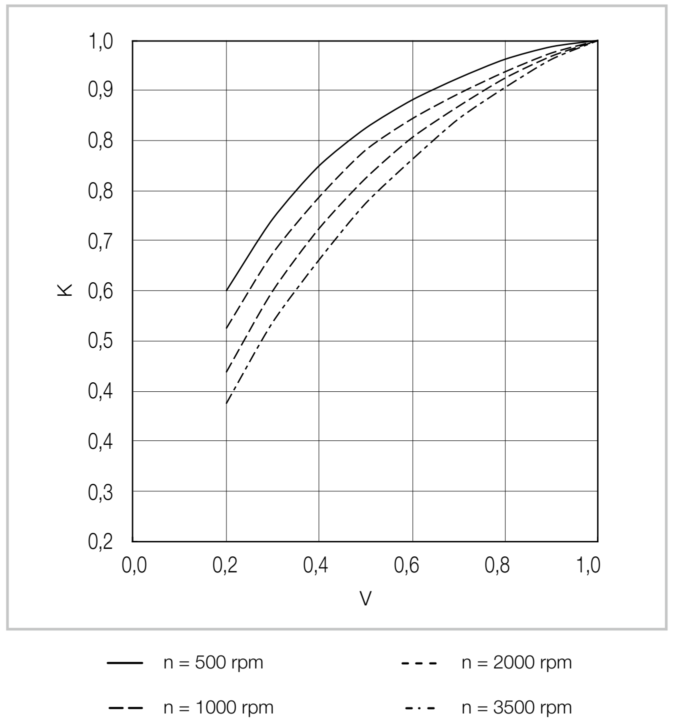
Calculation example
Product: SHD-20-80-2SH

- Input speed: 1000 rpm
- (Average) load torque T_{av}: 20 Nm
- Rated torque T_N (catalogue reference): 24 Nm
- Grease lubrication with Harmonic Drive® Grease SK-1A, lubricant temperature: 20 °C

1. Calculation of the torque factor
   $V = T_{av}/T_N = 20/24 = 0.83$ (For V > 1 is K = 1)
2. Reading the calculation factor K from diagram Illustration 2.7.5: K = 0.95
3. Reading the efficiency from the efficiency curve Illustration 2.7.4: η = 73 %
4. Calculation of the load dependant efficiency
   $\eta_L = 73\ \% \cdot 0.95 = 69\ \%$

Illustration 2.7.5

Calculation factor K



Correction value for efficiency
When using support bearings and radial shaft seals on the input side, the following correction values for the efficiency must be taken into account.

Table 2.7.10 [%]

Ratio	Size				
	50	80	100	120	160
14	0	3.1	0	-	-
17	2.4	1.9	0	-2.6	-
20	2.1	2.1	1.6	-0.9	1.3
25	-0.7	1.6	-0.3	-2.9	-0.8
32	-1.9	2.0	-1.1	-3.7	-1.6
40	-1.9	-1.2	-0.2	-1.1	0.9

Output bearing

The SHD-2SH Gears are equipped with a heavy duty cross roller bearing on the output. This bearing, which is specially adapted to the dimensions of the SHD Gear Component Set, absorbs high axial and radial forces as well as high tilting moments. This keeps the gear free from external loads, ensuring a long service life and consistent accuracy. For the user, the integration of this output bearing means a significant reduction in design, manufacturing and assembly costs, as additional external bearings are not required.

• Rating table

Table 2.7.11

	Symbol [Unit]	Size 14	17	20	25	32	40
Bearing type[1]		C	C	C	C	C	C
Pitch circle diameter	d_p [m]	0.0503	0.0610	0.0700	0.0860	0.1120	0.1330
Distance[2]	R [m]	0.0111	0.0115	0.0110	0.0121	0.0173	0.0195
Dynamic load rating	C [N]	2900	5200	7300	10900	19100	21600
Static load rating	C_0 [N]	4300	8100	11000	17900	32700	40800
Permissible dynamic tilting moment[3,4]	M [Nm]	37	62	93	129	290	424
Tilting moment stiffness[5]	K_B [Nm/arcmin]	21	37	61	90	239	422
Permissible axial load[4]	F_a [N]	620	1111	1560	2329	4080	4615
Permissible radial load[4]	F_r [N]	415	744	1045	1560	2734	3092

1) Bearing type C = Cross roller bearing; F = Four point contact bearing
2) Distance between the centre of the rolling bearing and the screw mounting surface on the output side, see chapter Gear dimensioning.
3) These values are valid for moving gears. They are not based on the equation for lifetime of the output bearing but on the maximum allowable deflection of the Harmonic Drive® Gear Component Set. The values indicated in the table must not be exceeded even if the lifetime equation of the bearing permits higher values.
4) These data are valid for **M**: $F_a = 0$, $F_r = 0$ I **F_a**: $M = 0$, $F_r = 0$ I **F_r**: $M = 0$, $F_a = 0$
5) The value of tilting moment stiffness is the average value (± 20 %).

Assembly tolerances

We recommend observing the following tolerances during assembly:

Illustration 2.7.6

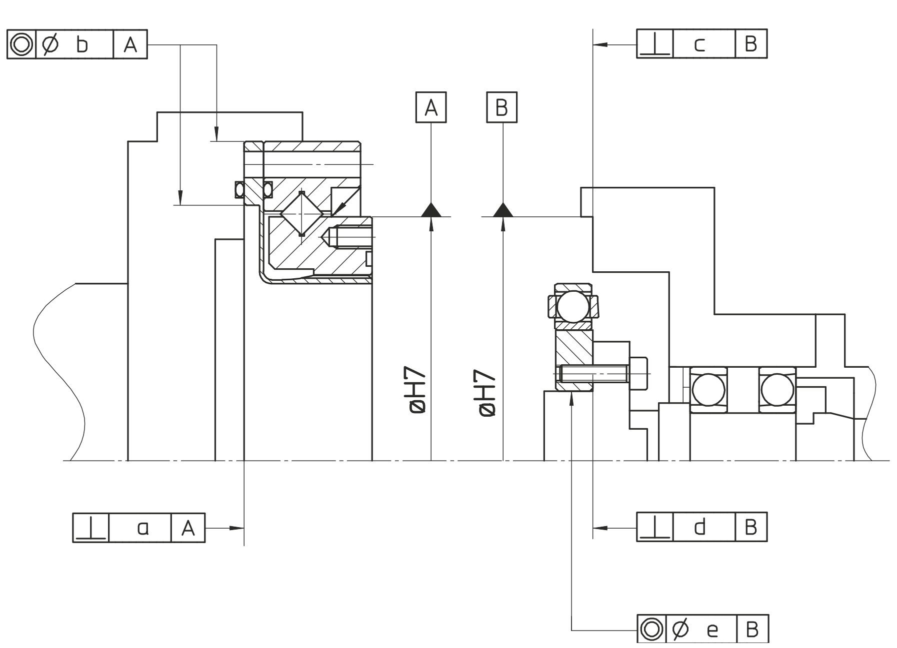


Table 2.7.12 [mm]

Symbol	Recommended tolerance Shaft/Bore of connection components	Size 14	17	20	25	32	40
a		0.016	0.021	0.027	0.035	0.042	0.048
Ø b	H6 / h6	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
Ø e	h6	0.016	0.018	0.019	0.022	0.022	0.024

Motor shaft tolerances should comply with DIN 42955 R.

You will find more information on this in the Engineering data chapter.

• O ring groove on Flexspline

Recommended dimensions of the O ring groove on the Flexspline in the customer flange.

Illustration 2.7.7

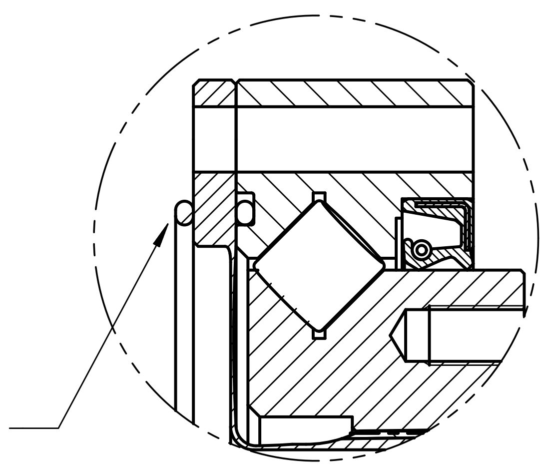


Illustration 2.7.8

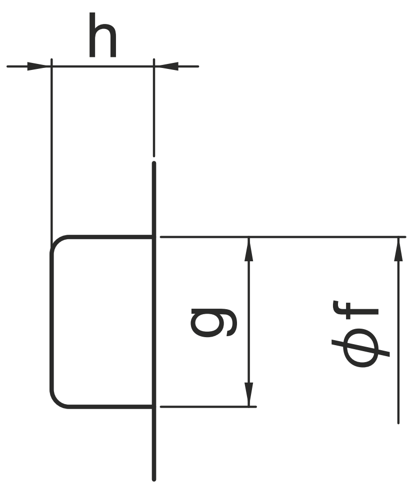
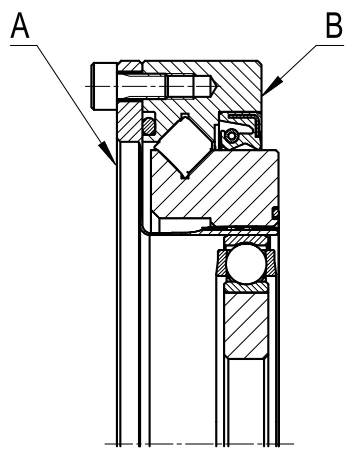


Table 2.7.13 [mm]

Symbol	Size 14		17		20		25		32		40	
Øf	57.0	+0.1/0	68.1	+0.1/0	78.0	+0.1/0	94.8	+0.1/0	123.0	+0.1/0	148.0	+0.1/0
g	2.0	+0.25/0	2.0	+0.25/0	2.7	+0.25/0	2.4	+0.25/0	2.7	+0.25/0	2.7	+0.25/0
h	1.10	0/-0.1	1.10	0/-0.1	1.50	0/-0.1	1.35	0/-0.1	1.50	0/-0.1	1.50	0/-0.1
O ring	54.38 x 1.19		64.00 x 1.50		72.00 x 2.00		88.62 x 1.78		117.00 x 2.00		142.00 x 2.00	

Assembly

Illustration 2.7.9



- ## Assembly on the A side (Flexspline)

Table 2.7.14

	[Unit]	Size					
		14	17	20	25	32	40
Number of screws		8	12	12	12	12	12
Size of screws		M3	M3	M3	M4	M5	M6
Pitch circle diameter	[mm]	64	74	84	102	132	158
Screw tightening torque	[Nm]	2.0	2.0	2.0	4.5	9.0	15.3
Torque transmitting capacity	[Nm]	108	186	210	431	892	1509

12.9 quality screws, friction coefficient μ = 0.15

- ## Assembly on the B side (Circular Spline)

Table 2.7.15

	[Unit]	Size					
		14	17	20	25	32	40
Number of screws		8	12	12	12	12	12
Size of screws		M3	M3	M3	M4	M5	M6
Pitch circle diameter	[mm]	43.0	52.0	61.4	76.0	99.0	120.0
Screw tightening torque	[Nm]	2.0	2.0	2.0	4.5	9.0	15.3
Torque transmitting capacity	[Nm]	72	130	154	321	668	1148

12.9 quality screws, friction coefficient μ = 0.15

- ## Assembly on the Wave Generator

Table 2.7.16

	[Unit]	Size					
		14	17	20	25	32	40
Number of screws		4	4	4	4	4	4
Size of screws		M3	M3	M3	M3	M4	M5
Pitch circle diameter	[mm]	17	21	26	30	40	50
Screw tightening torque	[Nm]	2.0	2.0	2.0	2.0	4.5	9.0

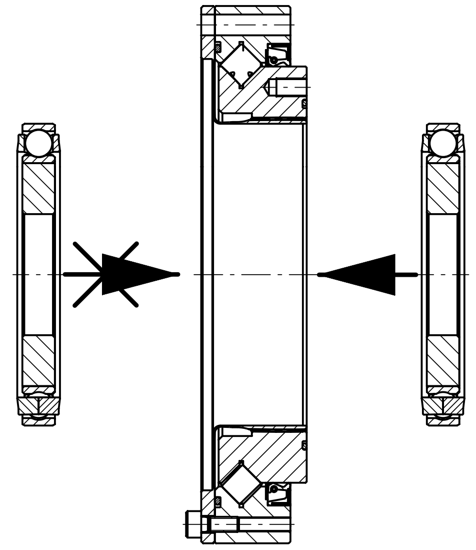
12.9 quality screws, friction coefficient μ = 0.15

ⓘ You will find more information on this in the Engineering data chapter.

- ## Installation of the Wave Generator

The Wave Generator must be mounted in the direction of the arrow. When the Wave Generator is inserted into the Flexspline, it adapts to the elliptical shape of the Wave Generator.

Illustration 2.7.10

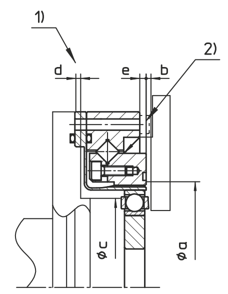


Design guidelines

To ensure optimum lubrication, the gear housing should be kept compact. If the gear housing is filled with more than 50 % grease, the risk of leakage increases. Therefore, the ratio of grease volume to gear housing should be less than 0.5. When installing with a vertical axis and the Wave Generator mainly on top or bottom, the gap between the Wave Generator and the adapter flange on the input side (engine) should be filled with grease.

- ## Recommended housing dimensions

Illustration 2.7.11



1) d = Max. permissible centring length if centring is carried out on the inside of the Flexspline.
2) Avoid contact between screw and flange

Table 2.7.17 **[mm]**

Symbol	Size					
	14	17	20	25	32	40
Øa	36.5	45.0	53.0	66.0	86.0	106.0
b	1.0 (3.0)	1.0 (3.0)	1.5 (4.5)	1.5 (4.5)	2.0 (6.0)	2.5 (7.5)
Øc	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	4.0

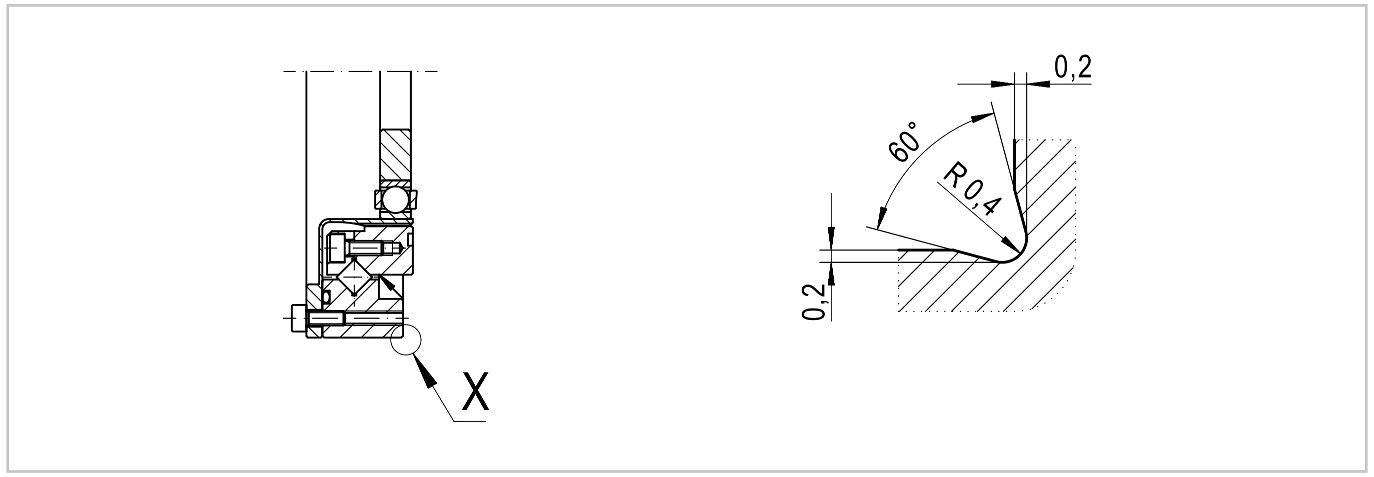
The values in brackets refer to a mounting position with the Wave Generator on top.

ⓘ You will find more information on this in the Engineering data chapter.

• Housing detail

We recommend the following undercut on the customer flange.

Illustration 2.7.12



• Materials and coatings used

Material:
Output bearing: bright steel
Flexspline: bright steel
Wave Generator: bright steel

Optional materials and coatings are available on request from Harmonic Drive SE.

Lubrication

When standard SHD-2SH Gears with output bearing are delivered, the gears and the output bearing are already lubricated. Before commissioning, the Wave Generator ball bearing and the inside of the Flexspline must be greased. We recommend the use of the greases listed in Table 2.7.18.

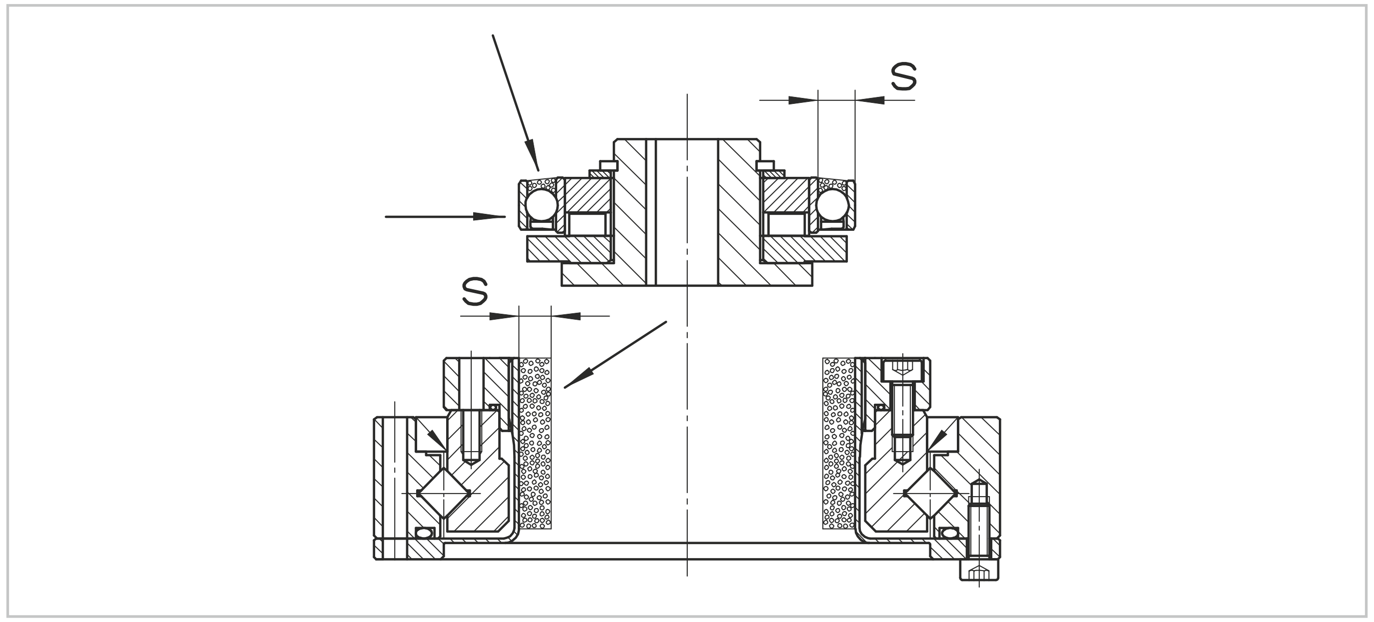
Table 2.7.18

Harmonic Drive® Grease	Size					
	14	17	20	25	32	40
SK-1A	-	-	O	O	O	O
SK-2	O	O	Δ	Δ	Δ	Δ
4BNo.2	□	□	□	□	□	□

O Standard grease
□ Recommended for very high loads or very high demands on the service life of the grease
Δ Optional grease, please consult us

Illustration 2.7.13 shows the areas to be lubricated.

Illustration 2.7.13



• Grease quantity

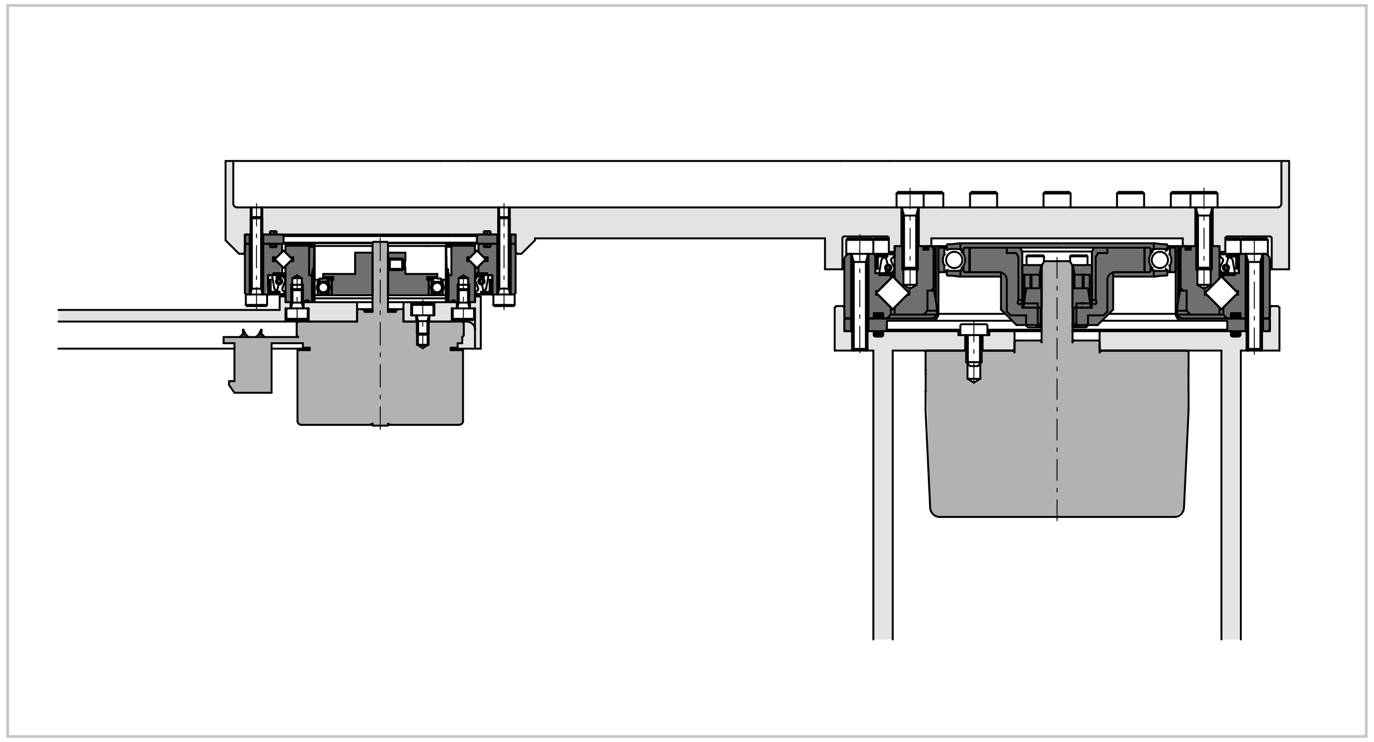
Table 2.7.19 [g]

	Size					
	14	17	20	25	32	40
Standard grease quantity	5	9	13	24	51	99

You will find more information on this in the Engineering data chapter.

Application example

Illustration 2.7.14



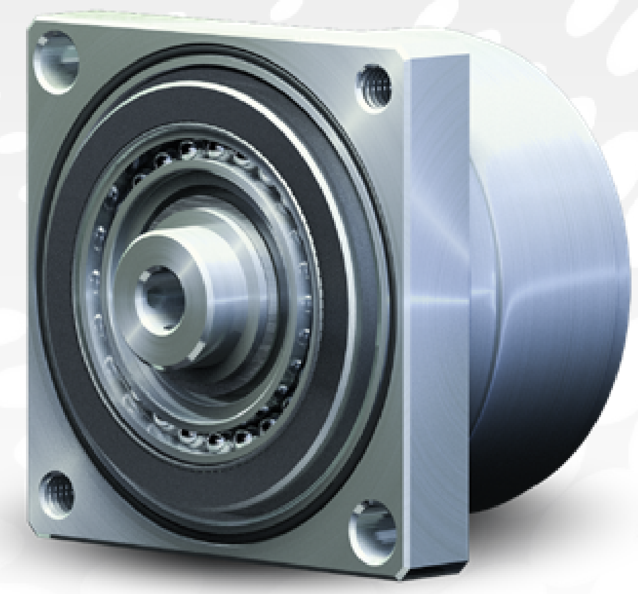
Product description

Precision gear for low torque range

The CSF Mini Series Gears consist of an HFUC Gear Component Set and an output bearing. They are suitable for applications with low torques and are characterised by highest precision and the lowest weight.

Features

- Six versions for different installation applications
- Lowest weight
- Integrated output bearing
- Direct motor attachment possible
- For precise applications in small torque ranges



Ordering code

Table 2.8.1

Ordering code	CSF	-	3B	-	100	-	1U-CC	-	SP
Series	CSF								
Size/Product generation (corresponds to the pitch circle diameter of the Flexspline toothing in inches x 10)			3B 5 7 8 11 14						
Ratio (in drive configuration: Circular Spline (CS) fixed, Wave Generator (WG) input, Flexspline (FS) output)					30 50 80 100				
Version									
Output shaft, input shaft, wide mounting flange							1U		
Output shaft, input hub, wide mounting flange							1U-CC		
Output shaft, input hub, narrow mounting flange							2XH-J		
Output flange, input shaft, wide mounting flange							1U-F		
Output flange, input hub, wide mounting flange							1U-CC-F		
Output flange, input hub, narrow mounting flange							2XH-F		
Customised design									
Standard design (field remains empty)									[ ]
Special design (on request)									SP

Please refer to the table of possible combinations.

Combinations

Table 2.8.2

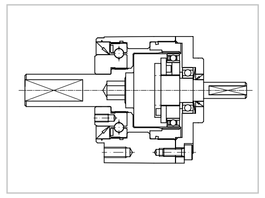
		Size					
		3B	5	7	8	11	14
Ratio	30	•	•	•	•	•	•
	50	•	•	•	•	•	•
	80	-	-	-	-	-	•
	100	•	•	•	•	•	•
Version	1U	•	•	-	•	•	•
	1U-CC	•	•	-	•	•	•
	2XH-J	-	•	•	•	•	•
	1U-F	-	•	-	•	•	•
	1U-CC-F	-	•	-	•	•	•
	2XH-F	-	•	•	•	•	•

• available o on request - not available

See next page for version information.

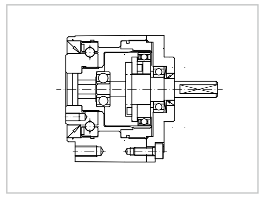
Versions

Illustration 2.8.1



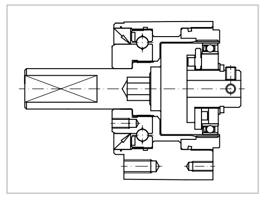
CSF-1U
(Size 3 ... 14)
Output shaft, input shaft, wide mounting flange

Illustration 2.8.4



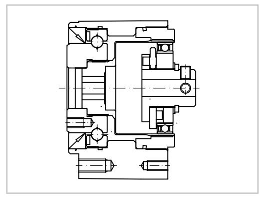
CSF-1U-F
(Size 5 ... 14)
Output flange, input shaft, wide mounting flange

Illustration 2.8.2



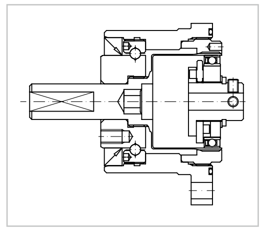
CSF-1U-CC
(Size 3 ... 14)
Output shaft, input hub, wide mounting flange

Illustration 2.8.5



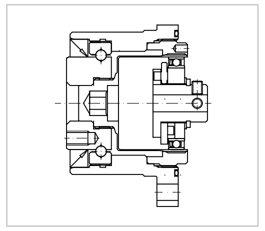
CSF-1U-CC-F
(Size 5 ... 14)
Output flange, input hub, wide mounting flange

Illustration 2.8.3



CSF-2XH-J
(Size 5 ... 14)
Output shaft, input hub, narrow mounting flange

Illustration 2.8.6



CSF-2XH-F
(Size 5 ... 14)
Output flange, input hub, narrow mounting flange

Technical data

Rating table

Table 2.8.3

Size	Ratio	Limit for repeated peak torque	Limit for average torque	Rated torque at rated speed 2000 rpm	Limit for momentary peak torque	Max. input speed [rpm]	Limit for average input speed [rpm]	Moment of inertia		Weight
	i	T_R [Nm]	T_A [Nm]	T_N [Nm]	T_M [Nm]	Lubrication Grease	Lubrication Grease	-1U-(F) [kgcm²]	-1U-CC-(F) -2XH-J, -F [kgcm²]	[kg]
3B	30	0.13	0.10	0.06	0.22	10000	6500	$5.3x10^{-7}$	$7x10^{-7}$	see Dimensions
	50	0.21	0.13	0.11	0.41					
	100	0.30	0.23	0.15	0.57					
5	30	0.50	0.38	0.25	0.90	10000	6500	$2.5x10^{-4}$	$2.5x10^{-4}$	
	50	0.90	0.53	0.40	1.80					
	100	1.40	0.94	0.60	2.70					
7	30	1.00	0.77	0.48	1.80	8500	3500	-	$1.1x10^{-3}$	
	50	1.8	1.1	0.8	3.5					
	100	2.6	1.8	1.2	5.2					
8	30	1.8	1.4	0.9	3.3	8500	3500	$3.2\ x10^{-3}$	$3.0x10^{-3}$	
	50	3.3	2.3	1.8	6.6					
	100	4.8	3.3	2.4	9.0					
11	30	4.5	3.4	2.2	8.5	8500	3500	$1.4x10^{-2}$	$1.2x10^{-2}$	
	50	8.3	5.5	3.5	17					
	100	11	8.9	5.0	25					
14	30	9	6.8	4.0	17	8500	3500	$3.4x10^{-2}$	$3.3x10^{-2}$	
	50	18	6.9	5.4	35					
	80	23	11	7.8	47					
	100	28	11	7.8	54					

You will find more information on this in the Engineering data chapter.

Dimensions

Illustration 2.8.7

CSF-3B-xx-1U [mm]

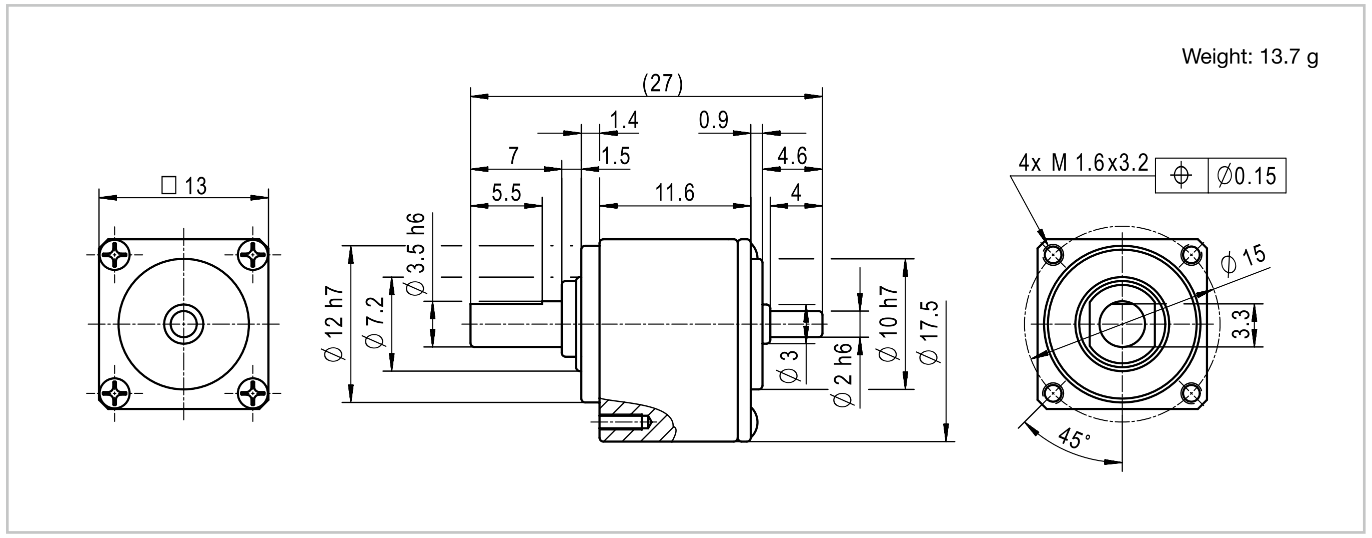


Illustration 2.8.8

CSF-3B-xx-1U-CC [mm]

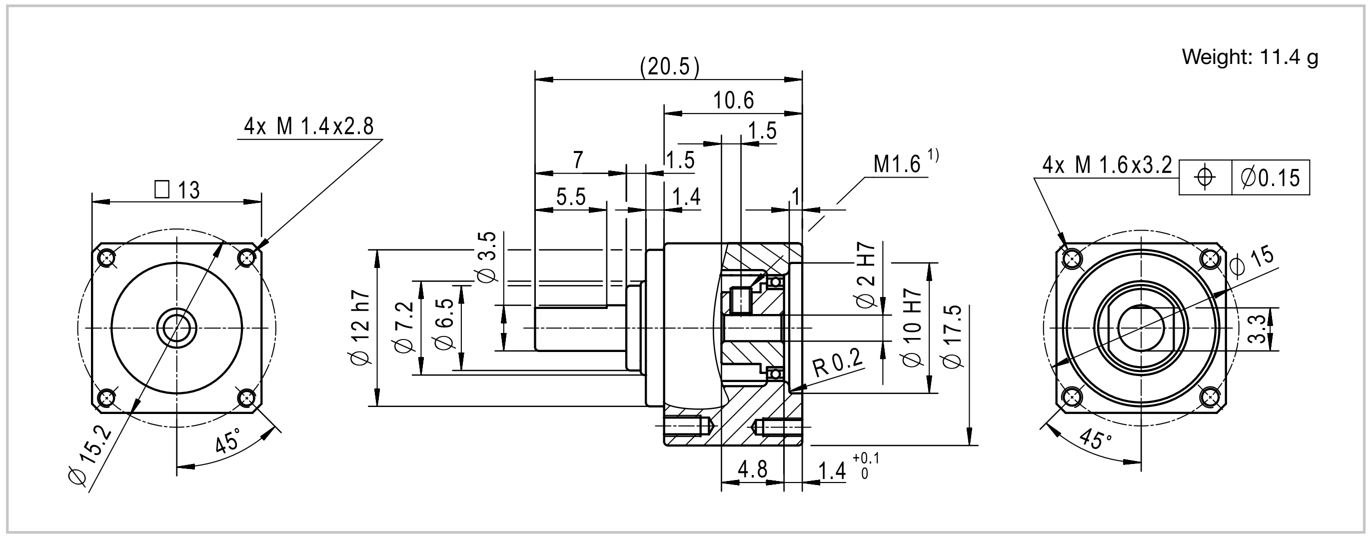


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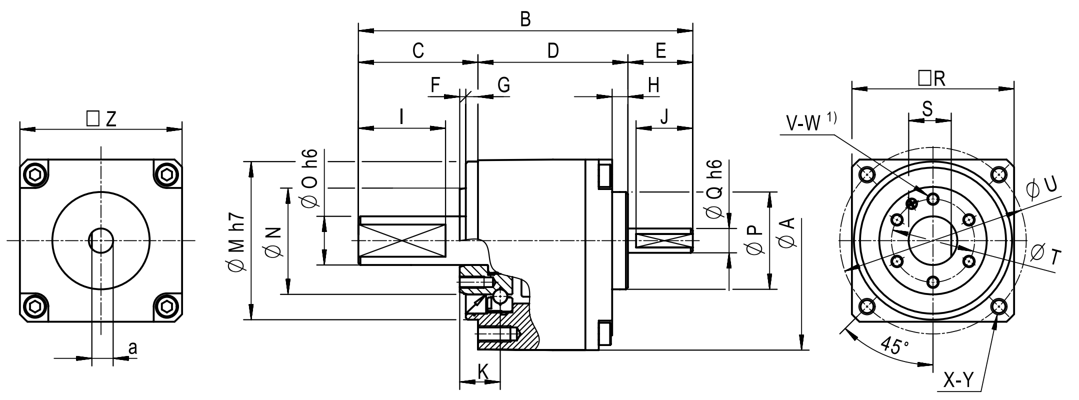
Illustration 2.8.9

CSF-5 ... 14-xx-1U [mm]



1) Evenly distributed

Table 2.8.4

[mm]

	Size			
	5	8	11	14
Ø A	26.5	40	54	68
B	37	65.5	82.5	95.4
C	13	23	29.5	29.5
D	16	29.5	37	49.9
E	8	13	16	16
F	0.5	0.5	0.5	1.5
G	2.5	2.5	3	3
H	0.8	2.6	3.9	8.4
I	9	18	21.5	23
J	7	11	14	14
K	4.85	7.3	9	11.4
Ø M h7	19.5	29	39	48
Ø N	13	20	26.5	33.5
Ø O h6	5	9	12	15
Ø P	9	16	24	32
Ø Q h6	3	5	6	8
□ R	20.4±0.42	30.7±0.46	40.9±0.50	51.1±0.50
S	4.6	8	10.5	14
Ø T	9.8	15.5	20.5	25.5
Ø U	23	35	46	58
V	3	4	6	6
W	M2x3	M3x4	M3x5	M4x6
X	4	4	4	4
Y	M2x3	M3x6	M4x8	M5x10
□ Z	20±0.42	30±0.46	40±0.50	50±0.50
a	2.6	4.5	5.5	7.5
Weight [g]	35	130	240	440

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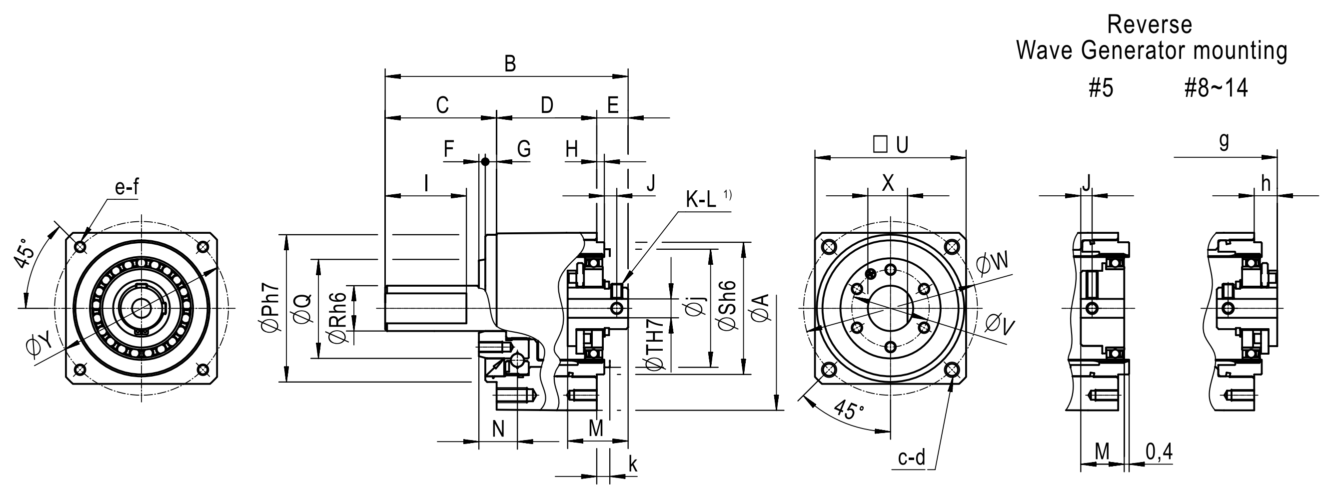
Illustration 2.8.10

CSF-5 ... 14-xx-1U-CC



1) With fastening screws ISO 4029
2) Evenly distributed

Table 2.8.5

[mm]

	Size			
	5	8	11	14
Ø A	26.5	40	54	68
B[1)]	30.5	51	64.3	70
C	13	23	29.5	29.5
D	12.7	21.5	26.5	33
E[1)]	$4.8^{0}_{-0.2}$	$6.5^{0}_{-0.3}$	$8.3^{0}_{-0.7}$	$7.5^{0}_{-0.8}$
F	0.5	0.5	0.5	1.5
G	2.5	2.5	3	3
H	1.3	1.5	2	2.5
I	9	18	21.5	23
J	2	2	3	2.5
K	2	2	2	2
L	M2x3	M2x3	M3x4	M3x4
M	6	12	16	17.6
N	4.85	7.3	9	11.4
Ø P h7	19.5	29	39	48
Ø Q	13	20	26.5	33.5
Ø R h6	5	9	12	15
Ø S h6	17	26	35	43
Ø T H7	3	3	5	6
□ U	20.4±0.42	30.7±0.46	40.9±0.5	51.1±0.5
Ø V	9.8	15.5	20.5	25.5
Ø W	23	35	46	58
X	4.6	8	10.5	14
ØY	22.5	34	46	58
a	3	4	6	6
b	M2x3	M3x4	M3x5	M4x6
c	4	4	4	4
d	M2x3	M3x6	M4x8	M5x10
e	4	4	4	4
f	M2x3	M2.5x5	M3x6	M4x8
g[1)]	27	48.7	62.1	70.4
h[1)]	-	$4.2^{0}_{-0.3}$	$6.1^{0}_{-0.7}$	$7.9^{0}_{-0.8}$
Øj	-	21,5	30,0	38,0
k	-	2,0	2,5	3,5
Weight [g]	27	111	176	335

1) Axial dimension taking into account the tolerances of the Wave Generator setting dimension. Compliance with this dimension is required to achieve the specified catalogue data.

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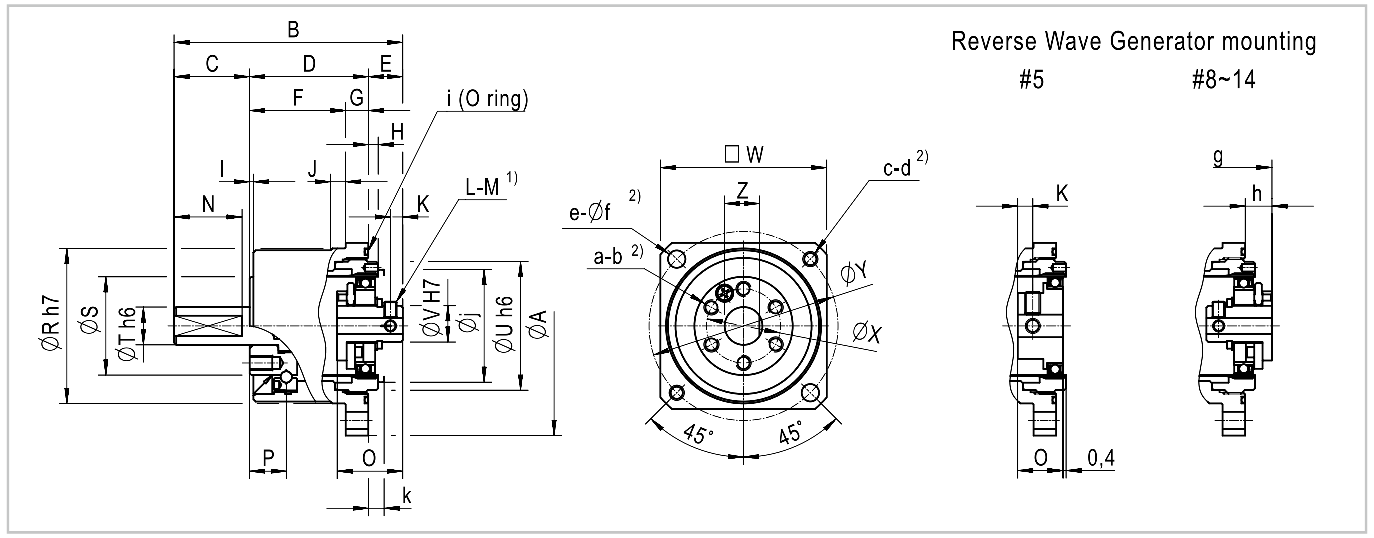
Illustration 2.8.11

CSF-5 ... 14-xx-2XH-J



1) With fastening screws ISO 4029
2) Evenly distributed

Table 2.8.6 **[mm]**

	Size				
	5	7	8	11	14
Ø A	29	37	43.5	58	73
B[1]	30.5	40.15	51	64.3	70
C	10	15	20	26	25
D	15.7	20.1	24.5	30	37.5
E[1]	$4.8^{0}_{-0.2}$	$5.05^{0}_{-0.2}$	$6.5^{0}_{-0.3}$	$8.3^{0}_{-0.7}$	$7.5^{0}_{-0.8}$
F	12.7	15.6	19	23.5	28
G	3	4.5	5.5	6.5	9.5
H	1.3	1.4	1.5	2	2.5
I	0.5	0.4	0.5	0.5	1.5
J	2	2.8	3	3	5
K	2	2	2	3	2.5
L	2	2	2	2	2
M	M2x3	M2x3	M2x3	M3x4	M3x4
N	9	13.5	18	21.5	23
O	6	6.7	12	16	17.6
P	4.85	6	7.3	9	11.4
Ø R h7	20.5	26	31	40.5	51
Ø S	13	16.5	20	26.5	33.5
Ø T h6	5	7	9	12	15
Ø U h6	17	21	26	35	43
Ø V H7	3	4	3	5	6
□ W	22±0.42	27.5±0.46	32±0.46	43±0.50	53±0.50
X	9.8	13	15.5	20.5	25.5
ØY	25	31.5	37.5	50	62
Z	4.6	6.2	8	10.5	14
a	3	4	4	6	6
b	M2x3	M2.5x3.5	M3x4	M3x5	M4x6
c	2	2	2	2	2
d	M2	M2.5	M3	M4	M5
e	2	2	2	2	2
Øf	2.3	2.9	3.4	4.5	5.5
g[1]	27	36.5	48.7	62.1	70.4
h[1]	-	-	$4.2^{0}_{-0.3}$	$6.1^{0}_{-0.7}$	$7.9^{0}_{-0.9}$
i	18.90x0.70	23.6x0.8	28.20x1.00	38.00x1.50	48.00x1.00
Øj	-	18.0	21.5	30.0	38.0
k	-	2.0	2.0	2.5	3.5
Weight [g]	27	50	111	176	335

1) Axial dimension taking into account the tolerances of the Wave Generator setting dimension. Compliance with this dimension is required to achieve the specified catalogue data.

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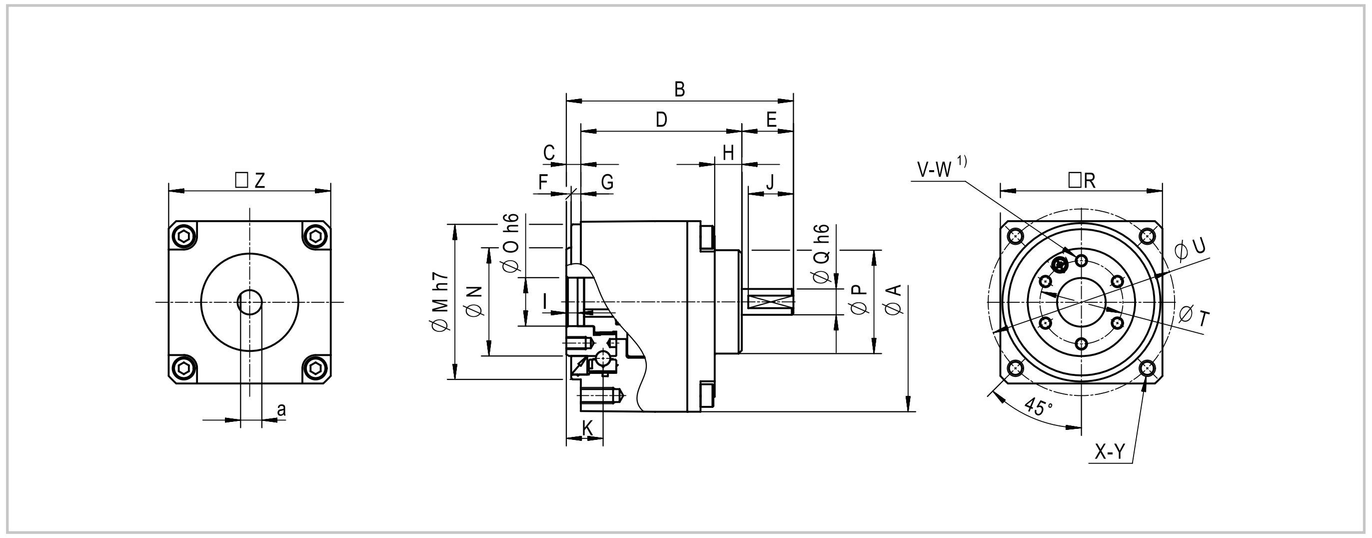
Illustration 2.8.12

CSF-5 ... 14-xx-1U-F



1) With fastening screws ISO 4029
2) Evenly distributed

Table 2.8.7 **[mm]**

	Size			
	5	8	11	14
Ø A	26.5	40	54	68
B	27	45.5	56.5	70.4
C	3	3	3.5	4.5
D	16	29.5	37	49.9
E	8	13	16	16
F	0.5	0.5	0.5	1.5
G	2.5	2.5	3	3
H	0.8	2.6	3.9	8.4
I	1.7	2.2	2.5	3.5
J	7	11	14	14
K	4.85	7.3	9	11.4
Ø M h7	19.5	29	39	48
Ø N	13	20	26.5	33.5
Ø O H7	5	9	12	15
Ø P	9	16	24	32
Ø Q h6	3	5	6	8
□ R	20.4±0.42	30.7±0.46	40.9±0.50	51.1±0.50
Ø T	9.8	15.5	20.5	25.5
Ø U	23	35	46	58
V	3	4	6	6
W	M2x3	M3x4	M3x5	M4x6
X	4	4	4	4
Y	M2x3	M3x6	M4x8	M5x10
□ Z	20±0.42	30±0.46	40±0.50	50±0.50
a	2.6	4.5	5.5	7.5
Weight [g]	34	120	220	405

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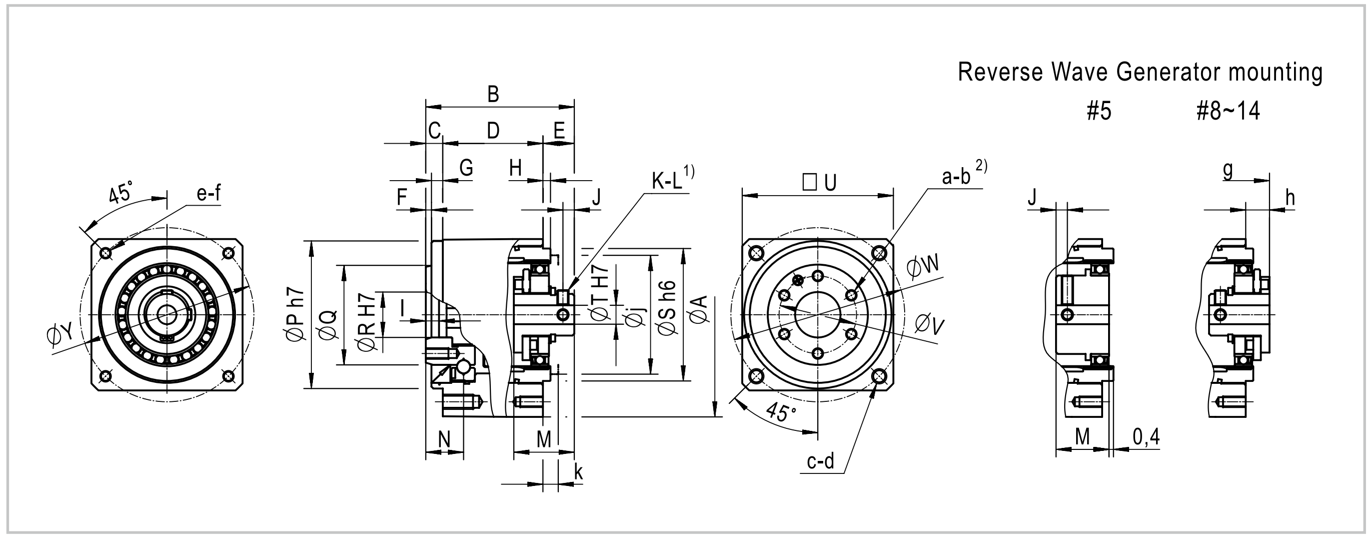
Illustration 2.8.13

CSF-5 … 14-xx-1U-CC-F



1) With fastening screws ISO 4029
2) Evenly distributed

Table 2.8.8

[mm]

	Size			
	5	8	11	14
Ø A	26.5	40	54	68
B1)	20.5	31	38.3	45
C	3	3	3.5	4.5
D	12.7	21.5	26.5	33
E1)	$4.8^{0}_{-0.2}$	$6.5^{0}_{-0.3}$	$8.3^{0}_{-0.7}$	$7.5^{0}_{-0.8}$
F	0.5	0.5	0.5	1.5
G	2.5	2.5	3	3
H	1.3	1.5	2	2.5
I	1.7	2.2	2.5	3.5
J	2	2	3	2.5
K	2	2	2	2
L	M2x3	M2x3	M3x4	M3x4
M	6	12	16	17.6
N	4.85	7.3	9	11.4
Ø P h7	19.5	29	39	48
Ø Q	13	20	26.5	33.5
Ø R H7	5	9	12	15
Ø S h6	17	26	35	43
Ø T H7	3	3	5	6
□ U	20.4±0.42	30.7±0.46	40.9±0.5	51.1±0.5
Ø V	9.8	15.5	20.5	25.5
Ø W	23	35	46	58
Ø Y	22.5	34	46	58
a	3	4	6	6
b	M2x3	M3x4	M3x5	M4x6
c	4	4	4	4
d	M2x3	M3x6	M4x8	M5x10
e	4	4	4	4
f	M2x3	M2.5x5	M3x6	M4x8
g1)	17	28.7	36.1	45.4
h1)	-	$4.2^{0}_{-0.3}$	$6.1^{0}_{-0.7}$	$7.9^{0}_{-0.8}$
Øj	-	21.5	30.0	38.0
k	-	2.0	2.5	3.5
Weight [g]	25	100	150	295

1) Axial dimension taking into account the tolerances of the Wave Generator setting dimension. Compliance with this dimension is required to achieve the specified catalogue data.

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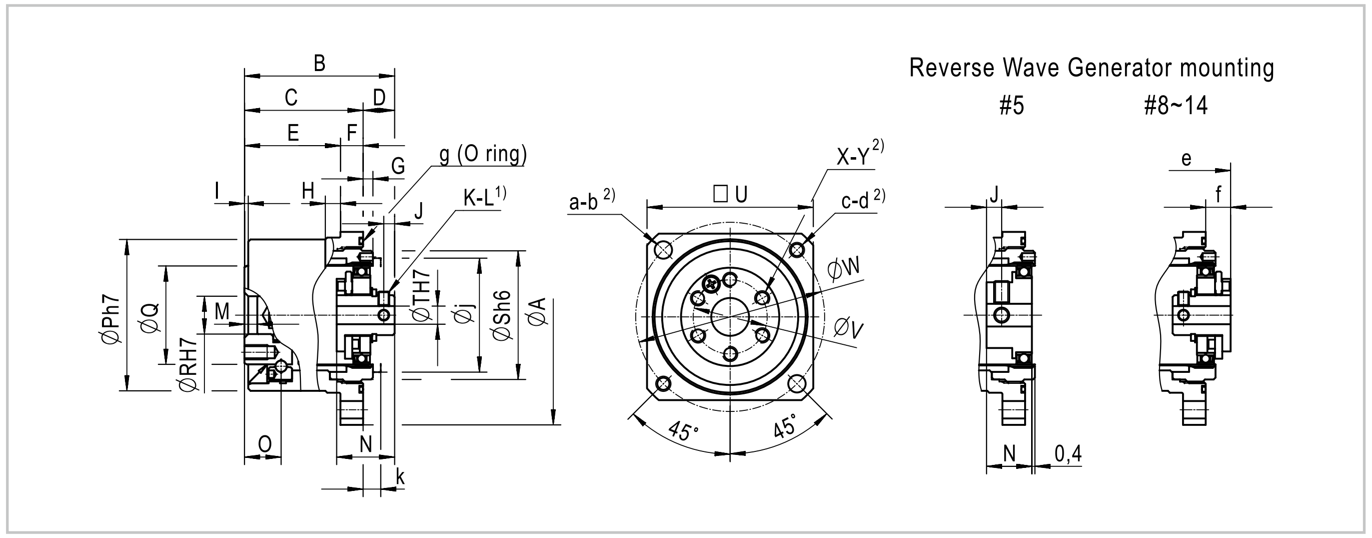
Illustration 2.8.14

CSF-5 … 14-xx-2XH-F



1) With fastening screws ISO 4029
2) Evenly distributed

Table 2.8.9

[mm]

	Size				
	5	7	8	11	14
Ø A	29	37	43.5	58	73
B1)	20.5	25.15	31	38.3	45
C	15.7	20.1	24.5	30	37.5
D1)	$4.8^{0}_{-0.2}$	$5.05^{0}_{-0.2}$	$6.5^{0}_{-0.3}$	$8.3^{0}_{-0.7}$	$7.5^{0}_{-0.8}$
E	12.7	15.6	19	23.5	28
F	3	4.5	5.5	6.5	9.5
G	1.3	1.4	1.5	2	2.5
H	2	2.8	3	3	5
I	0.5	00.45	0.5	0.5	1.5
J	2	2	2	3	2.5
K	2	2	2	2	2
L	M2x3	M2x3	M2x3	M3x4	M3x4
M	1.7	1.7	2.2	2.5	3.5
N	6	6.7	12	16	17.6
O	4.85	6	7.3	9	11.4
Ø P h7	20.5	26	31	40.5	51
Ø Q	13	16.5	20	26.5	33.5
Ø R H7	5	7	9	12	15
Ø S h6	17	21	26	35	43
Ø T H7	3	4	3	5	6
□ U	22±0.42	27.5±0.46	32±0.46	43±0.50	53±0.50
Ø V	9.8	13	15.5	20.5	25.5
Ø W	25	31.5	37.5	50	62
X	3	4	4	6	6
Y	M2x3	M2.5x3.5	M3x4	M3x5	M4x6
a	2	2	2	2	2
Ø b	2.3	2.9	3.4	4.5	5.5
c	2	2	2	2	2
d	M2	M2.5	M3	M4	M5
e1)	17	21.5	28.7	36.1	45.4
f1)	-	-	$4.2^{0}_{-0.3}$	$6.1^{0}_{-0.7}$	$7.9^{0}_{-0.8}$
g	18.90x0.70	23.6x0.8	28.20x1.00	38.00x1.50	48.00x1.00
Øj	-	18.0	21.5	30.0	38.0
k	-	2.0	2.0	2.5	3.5
Weight [g]	25	45	100	150	295

1) Axial dimension taking into account the tolerances of the Wave Generator setting dimension. Compliance with this dimension is required to achieve the specified catalogue data.

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Accuracy

Table 2.8.10 **[arcmin]**

	Size												
	3B		5		7		8		11			14	
Ratio	30	≥50	30	≥50	30	≥50	30	≥50	30	50	≥80	30	≥50
Transmission accuracy	<10		<4	<3	<3	<2.5	<2		<2.0	<1.5	<1.5	<2	<1.5
Hysteresis loss	<4.5	<4	<3		<3	<2	<3	<2	<3	<2	<2	<3	<1
Lost motion	<1.5						<1						
Repeatability	< ±1.17		< ±0.17				< ±0.1						

Torsional stiffness

Table 2.8.11

	Symbol [Unit]	Size/Version										
		3B	5		7		8		11		14	
		1U 1U-CC	1U 1U-CC 2XH-J	1U-F 1U-CC-F 2XH-F	2XH-J	2XH-F	1U 1U-CC 2XH-J	1U-F 1U-CC-F 2XH-F	1U 1U-CC 2XH-J	1U-F 1U-CC-F 2XH-F	1U 1U-CC 2XH-J	1U-F 1U-CC-F 2XH-F
Limit torques	T_1 [Nm]	0.016	0.075		0.15		0.29		0.8		2	
	T_2 [Nm]	0.05	0.22		0.40		0.75		2		6.9	
i=30	K_3 [Nm/rad]	51	120	160	270	300	460	540	1340	1580	2860	3350
	K_2 [Nm/rad]	40	110	130	200	240	390	440	1090	1240	2100	2350
	K_1 [Nm/rad]	27	90	100	170	170	310	340	770	840	1720	1880
i=50	K_3 [Nm/rad]	57	170	250	340	470	670	840	2360	3200	4400	5680
	K_2 [Nm/rad]	47	140	180	300	370	560	670	2250	3000	3780	4680
	K_1 [Nm/rad]	30	110	130	200	270	390	440	1770	2210	2860	3350
i≥80	K_3 [Nm/rad]	67	200	300	440	640	890	1200	2910	4320	5160	7000
	K_2 [Nm/rad]	54	180	270	370	540	800	1040	2430	3330	4600	6010
	K_1 [Nm/rad]	34	150	200	300	440	720	900	2060	2670	3780	4680

No load starting torque

Table 2.8.12 **[Ncm]**

Ratio	Size						
	3B		5	7	8	11	14
	1U	1U-CC					
30	0.34	0.32	0.53	0.87	1.3	3.4	6.4
50	0.30	0.28	0.40	0.59	0.8	2.0	4.1
80	-	-	-	-	-	-	2.8
100	0.26	0.24	0.30	0.44	0.59	1.5	2.5

No load back driving torque

Table 2.8.13 **[Nm]**

Ratio	Size						
	3B		5	7	8	11	14
	1U	1U-CC					
30	0.14	0.12	0.29	0.49	0.70	1.7	2.4
50	0.14	0.11	0.21	0.36	0.55	1.2	1.6
80	-	-	-	-	-	-	1.6
100	0.16	0.13	0.27	0.47	0.75	1.5	1.8

You will find more information on this in the Engineering data chapter.

No load running torque

The diagrams apply to products with reduction i=100 after a running-in period of at least 2 h with the input speed 2000 rpm and lubrication with Harmonic Drive® Grease SK-2.

Illustration 2.8.15 **CSF-3B-1U-CC**

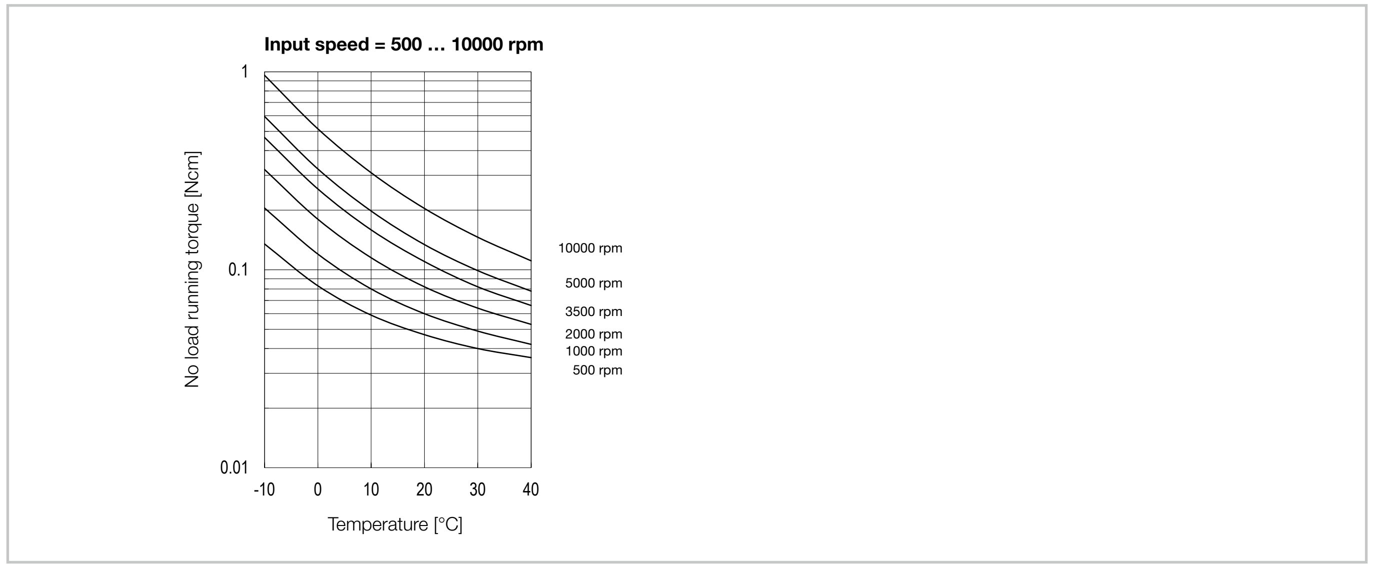


Illustration 2.8.16 **CSF-5 ... 14-1U**

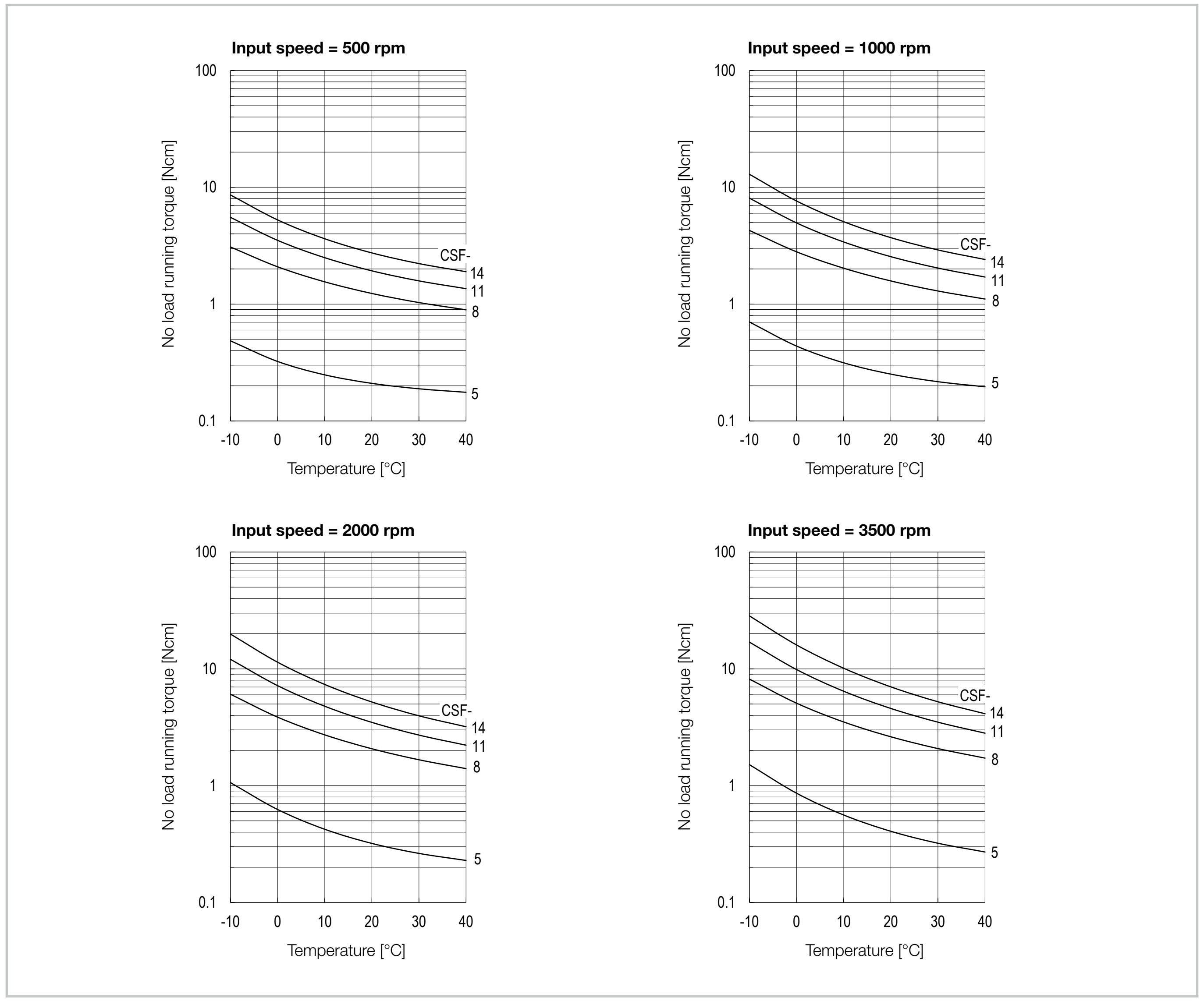
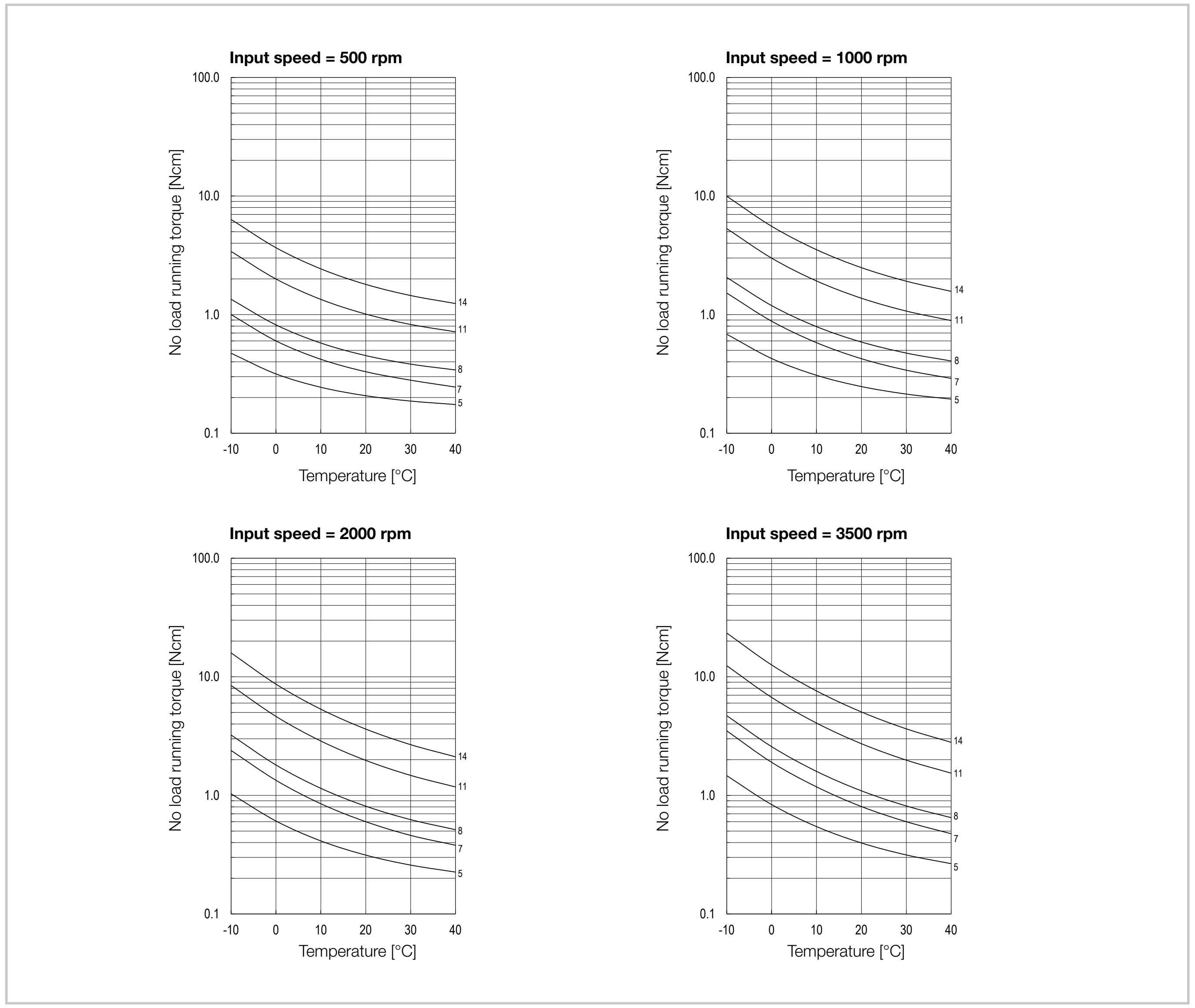


Illustration 2.8.17

CSF-5 ... 14-1U-CC, -2XH



Compensation values for no load running torque

When using gears with ratios other than i=100 please apply the compensation values from the table to the values taken from the curves (Illustration 2.8.15 - Illustration 2.8.17).

Table 2.8.14

[Ncm]

Size	Version	Ratio 30	Ratio 50	Ratio 80
3B	1U	0.026	0.023	–
	1U-CC	0.020	0.017	–
5		0.26	0.11	–
7		0.30	0.13	–
8		0.44	0.19	–
11		0.81	0.36	–
14		1.33	0.58	0.1

You will find more information on this in the Engineering data chapter.

- Efficiency

Efficiency for grease lubrication at rated torque

The diagrams apply to Harmonic Drive® Grease SK-2.

Illustration 2.8.18

CSF-3B-1U

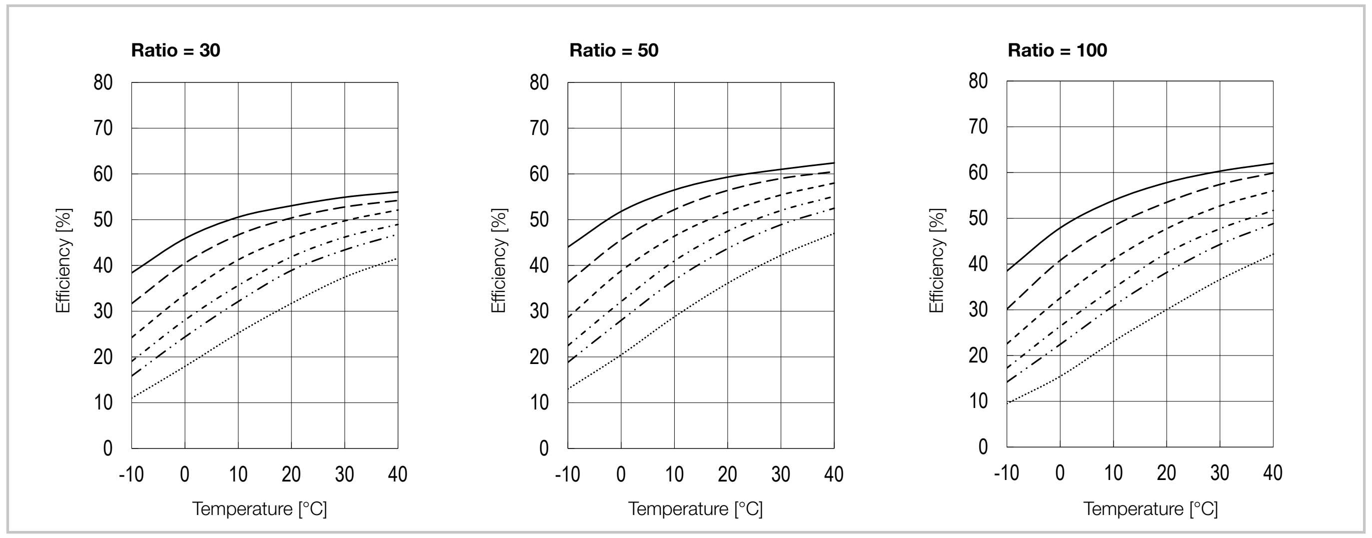


Illustration 2.8.19

CSF-3B-1U-CC

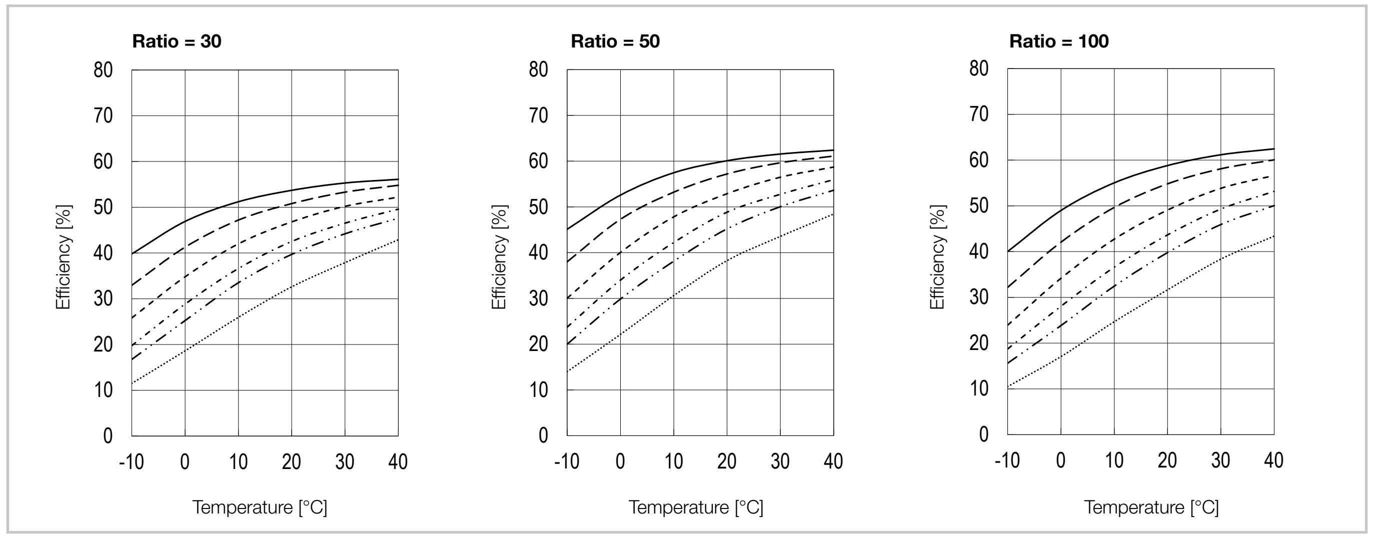
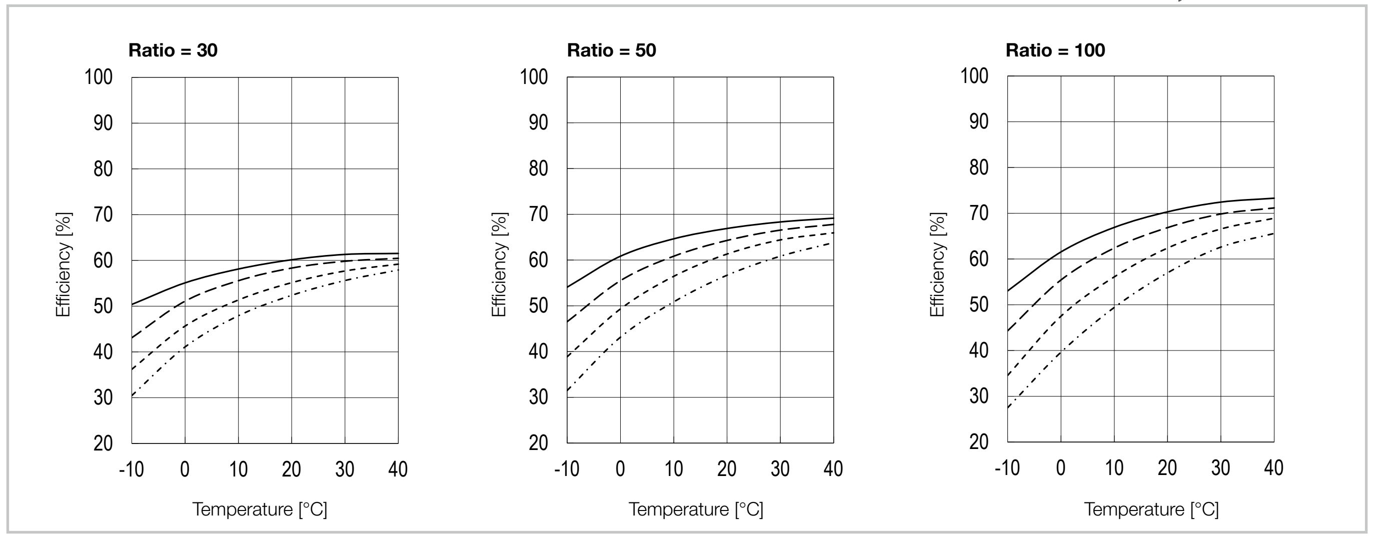


Illustration 2.8.20

CSF-5, all versions



n = 500 rpm — n = 1000 rpm — n = 2000 rpm — n = 3500 rpm — 5000 rpm — n = 10000 rpm

Illustration 2.8.21

CSF-8-1U, -1U-F

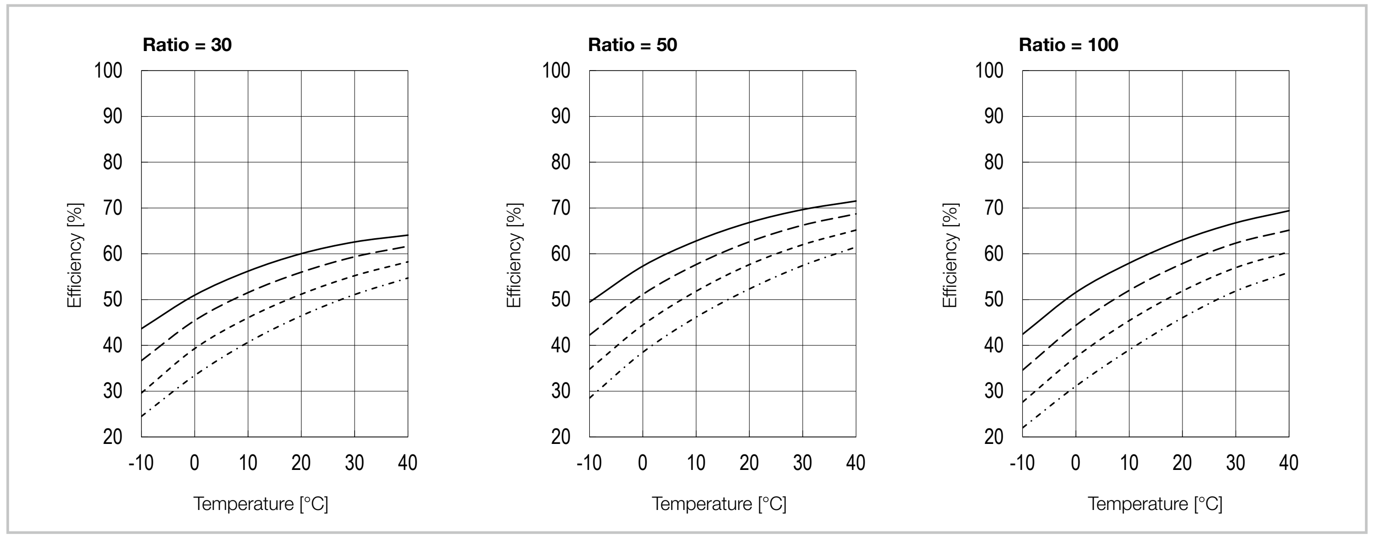


Illustration 2.8.22

CSF-7-2XH-J, -2XH-F

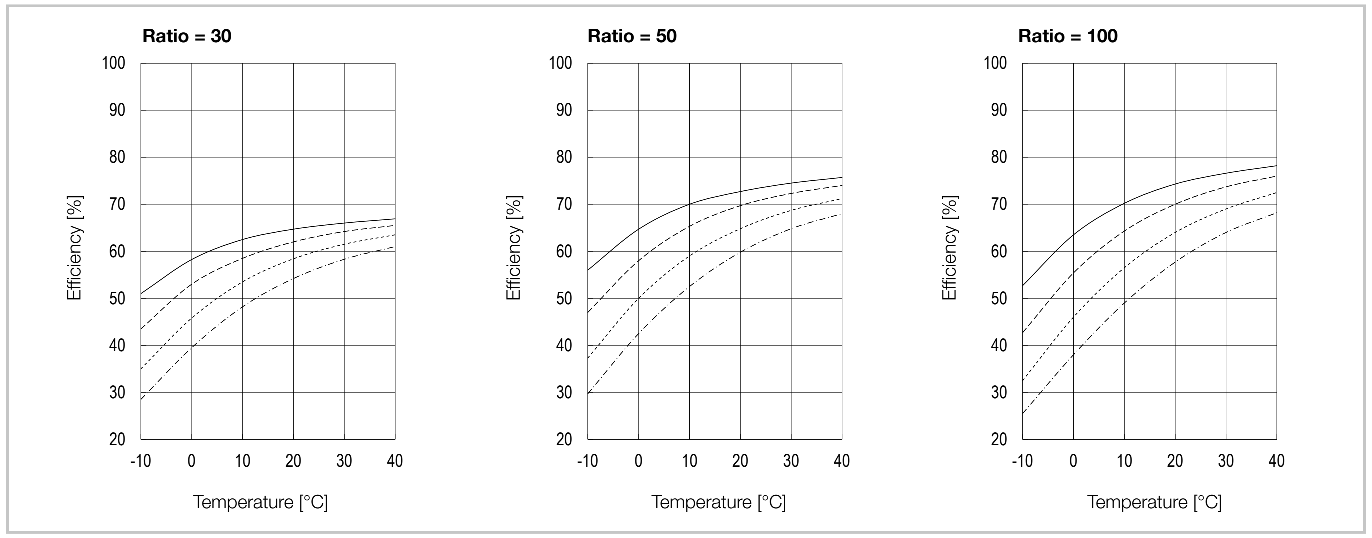
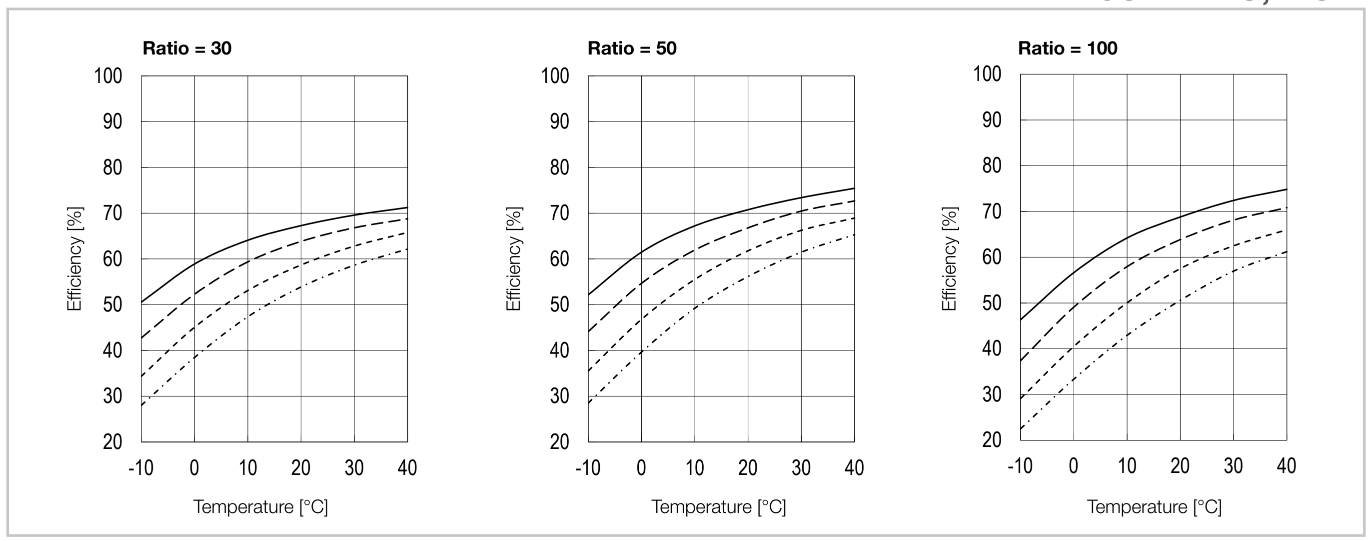


Illustration 2.8.23

CSF-11-1U, -1U-F



n = 500 rpm   n = 1000 rpm   n = 2000 rpm   n = 3500 rpm

Illustration 2.8.24

CSF-11-1U-CC, -2XH-J, -1U-CC-F, -2XH-F

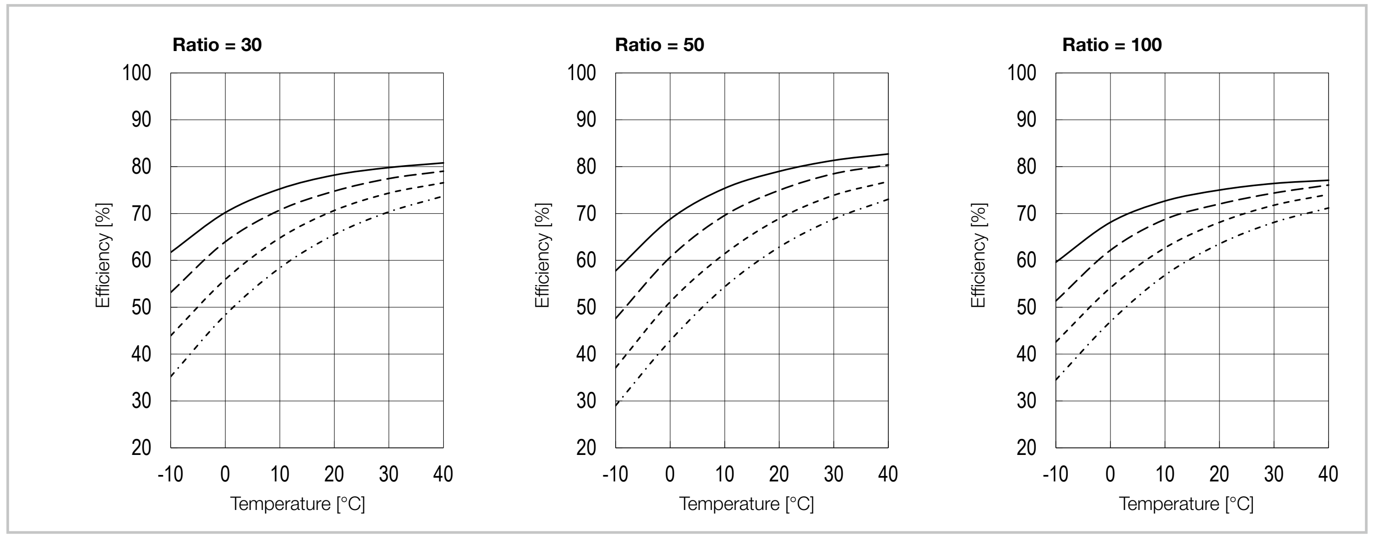


Illustration 2.8.25

CSF-14-1U, -1U-F

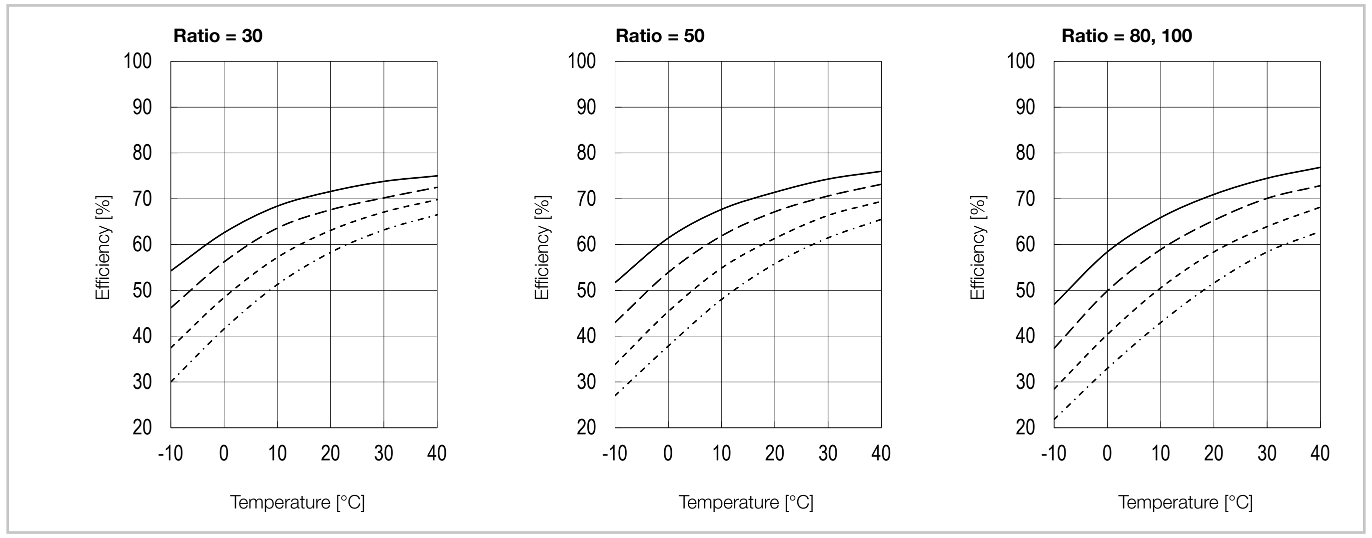
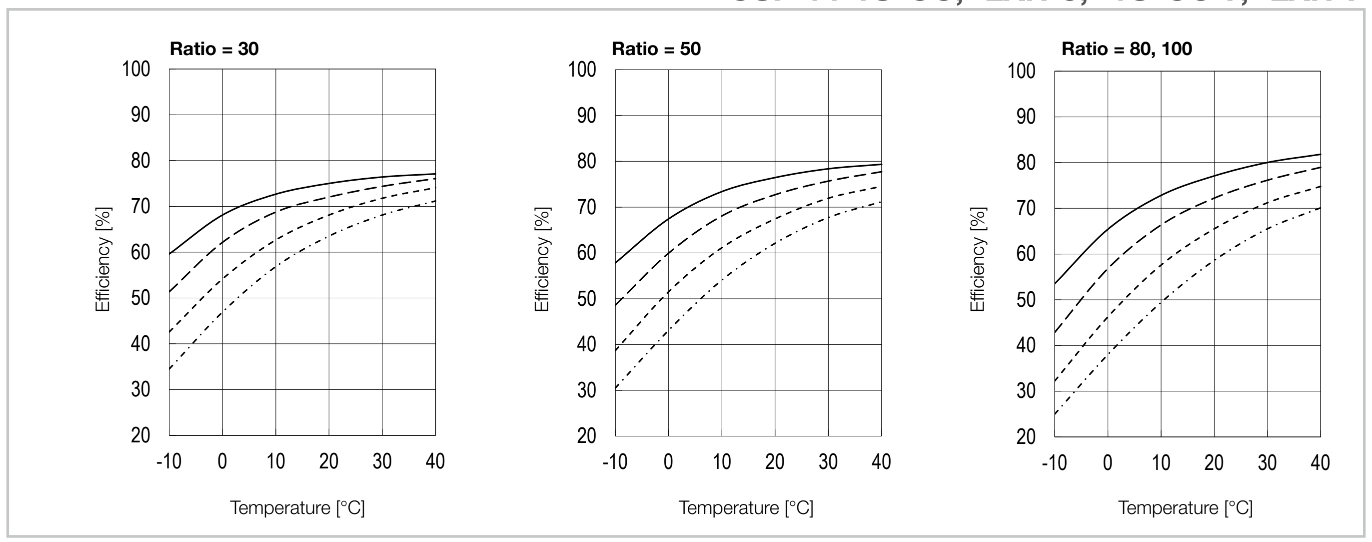


Illustration 2.8.26

CSF-14-1U-CC, -2XH-J, -1U-CC-F, -2XH-F



n = 500 rpm   n = 1000 rpm   n = 2000 rpm   n = 3500 rpm

Efficiency calculation

The efficiency depends on the following parameters: Gear ratio, input speed, load torque, temperature, lubricant and lubricant quantity. If the load torque is lower than the rated torque, the efficiency will be lower than the efficiency indicated in the efficiency curves. The torque specific efficiency is determined by means of the the calculation factor K.

Calculation example

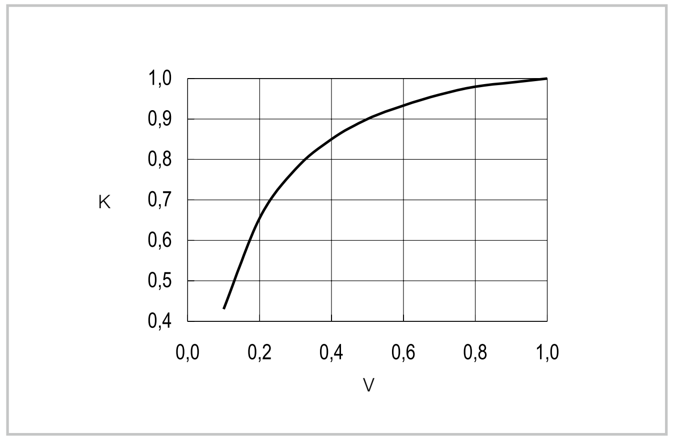
Product: CSF-8-100-2XH

- Input speed: 1000 rpm
- (Average) load torque T_{av}: 2 Nm
- Rated torque T_N (catalogue reference): 2.4 Nm
- Grease lubrication with Harmonic Drive® Grease SK-2, lubricant temperature: 20 °C.

1. Calculation of the torque factor
   $V = T_{av}/T_N = 2/2.4 = 0.83$ (For V > 1 is K = 1)
2. Reading the calculation factor K from diagram Illustration 2.8.27: K = 0.99
3. Reading the efficiency from the efficiency curve Illustration 2.8.22: η = 77 %
4. Calculation of the load dependant efficiency
   $\eta_L = 77 \cdot 0.99 = 76$ %

Illustration 2.8.27

Calculation factor K



Output bearing

Table 2.8.15

	Symbol [Unit]	Size					
		3B	5	7	8	11	14
Bearing type[1]		F	F	F	F	F	F
Pitch circle diameter	d_p [mm]	7.7	13.5	17	20.5	27.5	35
Distance[2]	R [mm]	4.1	4.85	6.0	7.3	9	11.4
Dynamic load rating	C [N]	665	914	1440	2160	3890	6120
Static load rating	C_0 [N]	424	7630	1210	1900	3540	5850
Permissible dynamic tilting moment[3]	M [Nm]	0.27	0.89	1.76	3.46	6.6	13.2
Tilting moment stiffness	K_B [Nm/arcmin]	0.026	0.22	0.44	0.8	2.16	3.9
Permissible axial load[4]	F_a [N]	130	270	140	630	1150	1800
Permissible radial load[4]	F_r [N]	36	90	440	200	300	550

[1] F = Four point contact bearing
[2] Distance between the end face on the output side and the centre of the bearing rolling element, for details see the drawings or the Engineering data chapter
[3] These values are valid for moving gears.
[4] These data are valid for:
F_a: M = 0; F_r = 0
F_r: M = 0; F_a = 0

The permissible radial load refers to the output shaft centre (versions 1U and 2XH-J).

You will find more information on this in the Engineering data chapter.

- Output bearing and housing tolerances

Illustration 2.8.28

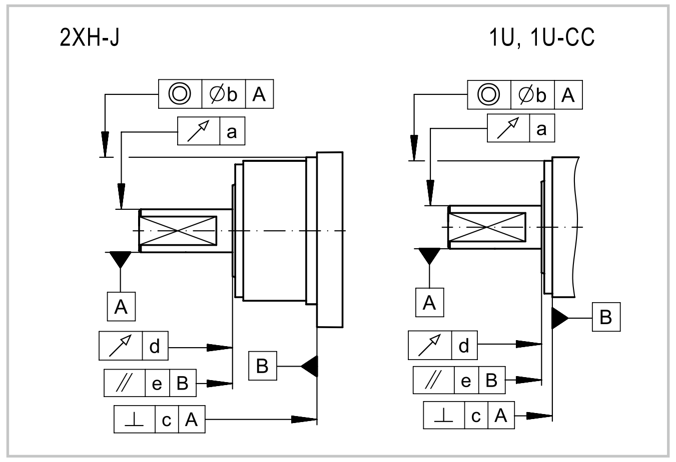


Illustration 2.8.29

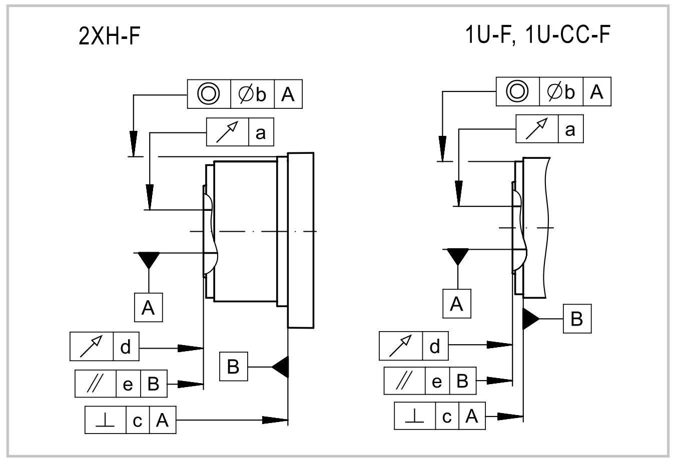


Table 2.8.16

[mm]

	Size/Version										
	3B	5		7		8		11		14	
	1U 1U-CC	1U 1U-CC 2XH-J	1U-F 1U-CC-F 2XH-F	2XH-J	2XH-J	1U 1U-CC 2XH-J	1U-F 1U-CC-F 2XH-F	1U 1U-CC 2XH-J	1U-F 1U-CC-F 2XH-F	1U 1U-CC 2XH-J	1U-F 1U-CC-F 2XH-F
a (radial runout)	0.030	0.030	0.005	0.030	0.005	0.030	0.005	0.030	0.005	0.030	0.005
b	0.020	0.040	0.040	0.040	0.040	0.040	0.040	0.055	0.055	0.055	0.055
c	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.025	0.025	0.025	0.025
d (axial runout)	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
e	0.015	0.015	0.015	0.018	0.018	0.020	0.020	0.030	0.030	0.030	0.030

• Input bearing

The input shaft of the CSF Mini Gears with output bearing is supported by two single row deep groove ball bearings. Illustration 2.8.30 shows the application points of the radial and axial forces shown in Table 2.8.17 and Illustration 2.8.31.

Example: If the input shaft of a CSF-14 Gear with output bearing is preloaded with an axial force of 7.5 N, the maximum permissible radial load is 20.6 N. The technical data shown on this page are valid for an average input speed of 2000 rpm and an average bearing service life of L_{50} = 35000 h.

Table 2.8.17

	Symbol [Unit]	Size					
		3B	5	7*	8	11	14
Distance	B [mm]	5.85	9.25	-	18.00	21.90	24.25
Maximum permissible radial load	F_r [N]	6	8	-	10	20	30

* There is no version with input bearing in this size.

Illustration 2.8.30

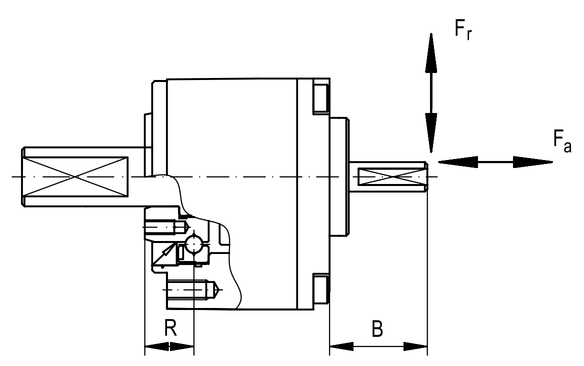
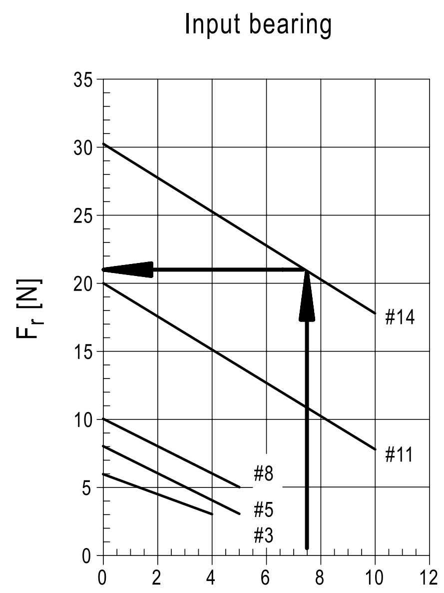


Illustration 2.8.31



Assembly tolerances

The excellent product characteristics of the Harmonic Drive® CSF-1U-CC, -1U-CC-F, -2XH-J and -2XH-F Gears can only be fully utilised if the tolerances according to Table 2.8.18 are considered during assembly.

Illustration 2.8.32

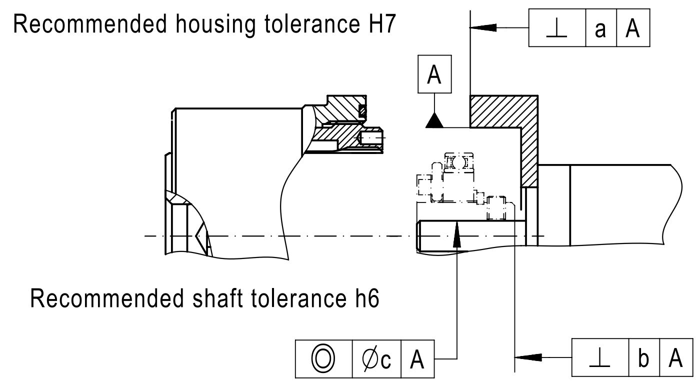


Table 2.8.18 **[mm]**

	Size					
	3B	5	7	8	11	14
a	0.006	0.008	0.008	0.010	0.011	0.011
b	0.004	0.005	0.005	0.012 (0.006)	0.012 (0.007)	0.017 (0.008)
c	0.004	0.005	0.005	0.015 (0.006)	0.015 (0.007)	0.030 (0.016)

The values in brackets are recommended tolerances for a Wave Generator without Oldham coupling. This coupling is used to compensate for eccentricity errors of the motor shaft and is installed in the standard gearbox. In case of a direct coupling of the Wave Generator with the motor shaft without Oldham coupling (option), the motor shaft tolerances should correspond to DIN 42955 R.

• Bore diameter Wave Generator

The Wave Generator can be supplied with the following bore diameters:

Table 2.8.19 **[mm]**

	Size					
	3B	5	7	8	11	14
Wave Generator bore ø H7	2	1.5 ... 6	2 ... 7	2 ... 4 (2 ... 8)	3 ... 7 (3 ... 8)	4 ... 8 (4 ... 10)

- The values in brackets apply to a Wave Generator without Oldham coupling.
- Bore diameters deviating from the standard may have an impact on other Wave Generator components and specifications, e.g. the size of the locking screw, the dimensions of the key, the transmittable torque.

ⓘ You will find more information on this in the Engineering data chapter.

Assembly

• Assembly of the housing flange

Table 2.8.20

	[Unit]	Size									
		3B	5	8	11	14	5	7	8	11	14
Designation		A					A				
Version		1U, 1U-CC, 1U-F, 1U-CC-F					2XH-F, 2XH-J				
Number of screws		4	4	4	4	4	2	2	2	2	2
Size of screws		M1.6	M2	M3	M4	M5	M2	M2.5	M3	M4	M5
Pitch circle diameter	[mm]	15.0	23.0	35.0	46.0	58.0	25.0	31.5	37.5	50.0	62.0
Screw tightening torque	[Nm]	0.26	0.25	0.85	2.00	4.00	0.25	0.49	0.85	2.00	4.00
Torque transmitting capacity[1]	[Nm]	3.0	3.5	12.0	29.0	57.0	2.0	3.8	7.0	16.0	31.0

Illustration 2.8.33 **1U, 1U-CC, 1U-F, 1U-CC-F**

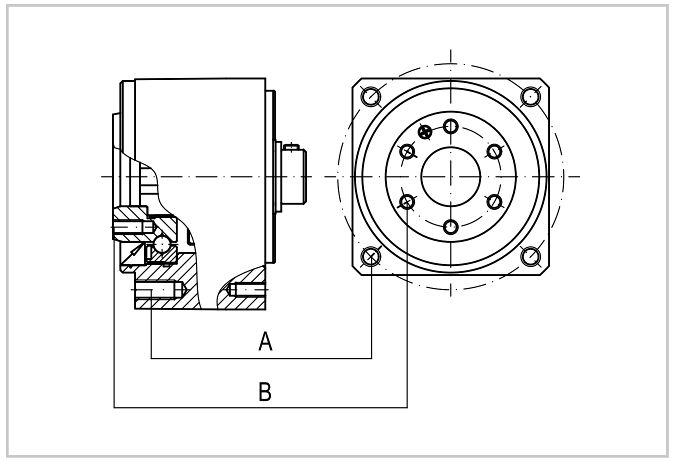
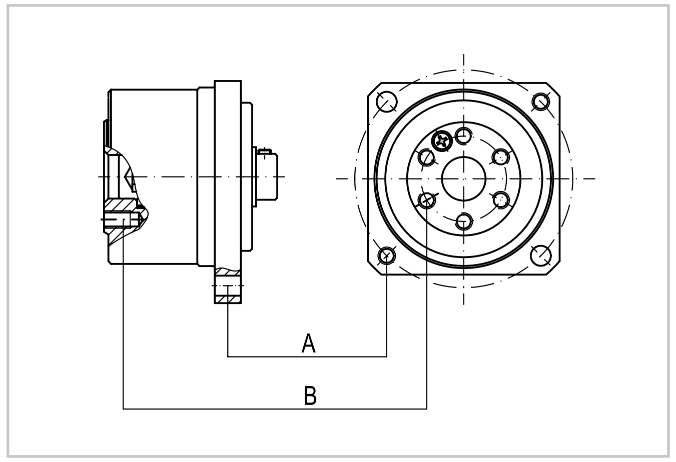


Illustration 2.8.34 **2XH-F, 2XH-J**



• Assembly of the output flange

Table 2.8.21

	[Unit]	Size				
		5	7	8	11	14
Designation		B				
Number of screws		3	4	4	6	6
Size of screws		M2	M2.5	M3	M3	M4
Pitch circle diameter	mm]	9.8	13	15.5	20.5	25.5
Screw tightening torque	[Nm]	0.54	1.1	2.0	2.0	4.6
Torque transmitting capacity[1]	[Nm]	2	7.2	13	26	55

1) Table 2.8.20 and Table 2.8.21 are valid for completely degreased mating surfaces (friction coefficient μk = 0.15) and 12.9 quality screws with metric standard thread according to DIN13 part 13 and head dimensions of cap screws ISO 4762, untreated, oiled, with μ total = 0.12.

• Assembly of the input shaft

Table 2.8.22

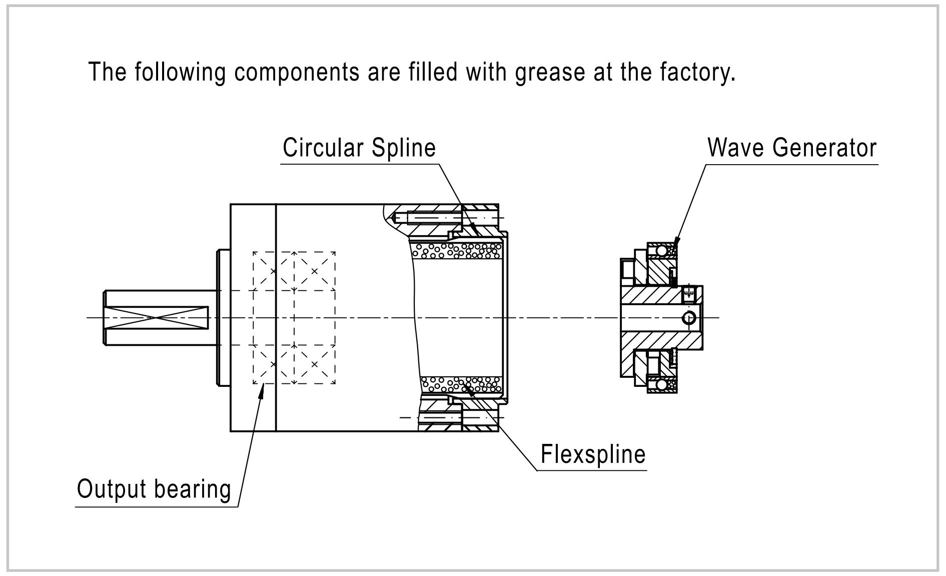
	[Unit]	Size				
		3B	5	8	11	14
Number of screws		1	2	2	2	2
Size of screws		M1.6	M2	M2	M3	M3
Screw tightening torque	[Nm]	0.09	0.19	0.19	0.69	0.69

12.9 quality screws, friction coefficient μ = 0.15

Lubrication

CSF Mini Gears with output bearing are supplied ready for installation. They are provided with a lifetime grease lubrication at the factory, see Illustration 2.8.35. The Harmonic Drive® high performance grease type SK-2 used is adapted to the special requirements of the Harmonic Drive® Gears. It ensures constant accuracy of the gears over the entire service life.
Output bearing grease (#5-14): Designation: Mul temp HL-D, Manufacturer: Kyodo Yushi, Base oil: hydrocarbon complex, Thickener: lithium soap, Consistency (25 °C): 280 [0.1 mm], Drop point: 210 °C, Appearance: whitish.

Illustration 2.8.35



You will find more information on this in the Engineering data chapter.

• Materials and coatings used

Housing: Aluminium, anodised.
Input and output shaft: Bright steel

Product description

Precision gears for low torques

The PMG Series Gears comprise Harmonic Drive® Gear Component Set with an integrated output bearing and an output shaft. The gear input can be designed either with an input shaft or for direct motor mounting. In addition to special corrosion protection, the PMG Series gears are characterised by compact dimensions and low weight.

Features

- Two versions for different assembly situations
- Special corrosion protection
- Integrated output bearing
- Compact dimensions and low weight
- Customised versions possible

Ordering code

Table 2.9.1

Ordering code	PMG	-	8	-	100	-	M	-	SP
Series	PMG								
Size (corresponds to the pitch circle diameter of the Flexspline toothing in inches x 10)			5 8 11 14						
Ratio (in drive configuration: Circular Spline (CS) fixed, Wave Generator (WG) input, Flexspline (FS) output)					50 72 80 88 100 110				
Version Gear for motor mounting Gear with input shaft							M S		
Customised design Standard design (field remains empty) Special design (on request)									[ ] SP

Please refer to the table of possible combinations.

Combinations

Table 2.9.2

		Size			
		5	8	11	14
Ratio	50	●	●	●	●
	72	-	●	●	●
	80	●	-	-	
	88	-	-	-	●
	100	●	●	●	●
	110	-	-	-	●
Version	M	●	●	●	●
	S	●	●	●	●

● available o on request - not available

Technical data

• Performance data

Table 2.9.3

Size	Ratio	Limit for repeated peak torque	Limit for average torque	Rated torque	Limit for momentary peak torque	Rated speed	Max. input speed [rpm]	Limit for average input speed [rpm]	Moment of inertia[2)] Type M	Moment of inertia[2)] Type S	Weight Type M	Weight Type S
		T_R [Nm]	T_A [Nm]	T_N [Nm]	T_M [Nm]	[rpm]	Grease lubrication	Grease lubrication	[x 10^{-4} kgcm²]		[kg]	[kg]
5	50	0.3	0.3	0.2	0.4	4500	10000	4900	2.5	2.5	0.03	0.031
	80	0.45	0.45	0.30	0.60							
	100	0.55	0.55	0.30	0.70							
8	50	1.9	1.9	1.5	2.5	3500	6000	3500	30	30	0.120	0.125
	72	2.4	2.3	2.0	3.1							
	100	2.7	2.7	2.0	3.8							
11	50	5.0	4.7	2.5	6.8	3500	5000	3500	120	140	0.25	0.27
	72	5.6	5.4	4.0	8.8							
	100	7.9	7.6	4.0	10.8							
14	50	9.8	7.0	5.4	14.0	3500	5000	3500	330	340	0.420	0.495
	72	11.8	9.0	7.8	16.0							
	88	12.7	11.0	7.8	18.0							
	100	14.7	11.0	7.8	20.0							
	110	14.7	11.0	7.8	20.0							

You will find more information on this in the Engineering data chapter.

• Dimensions

Version for motor mounting

Illustration 2.9.1 **PMG-5-M [mm]**

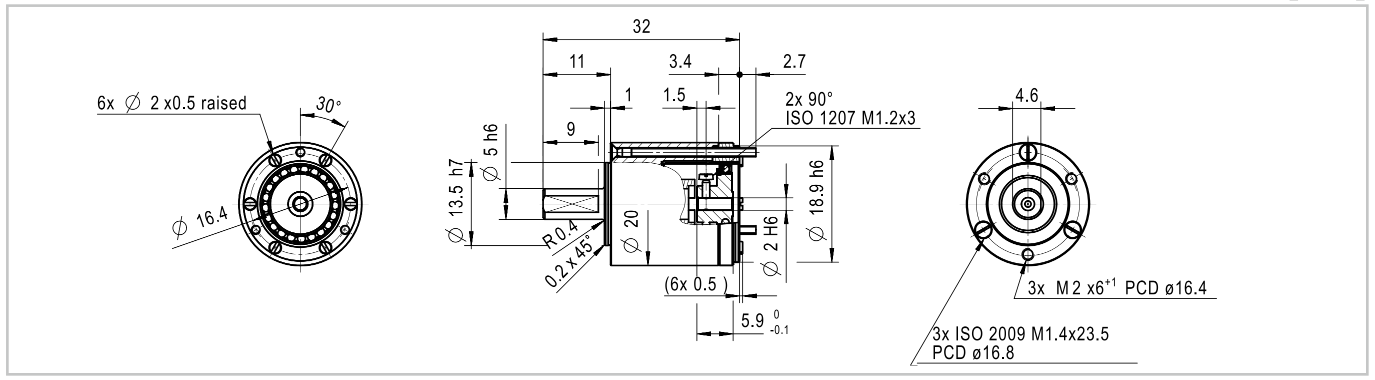


Illustration 2.9.2 **PMG-8-M [mm]**

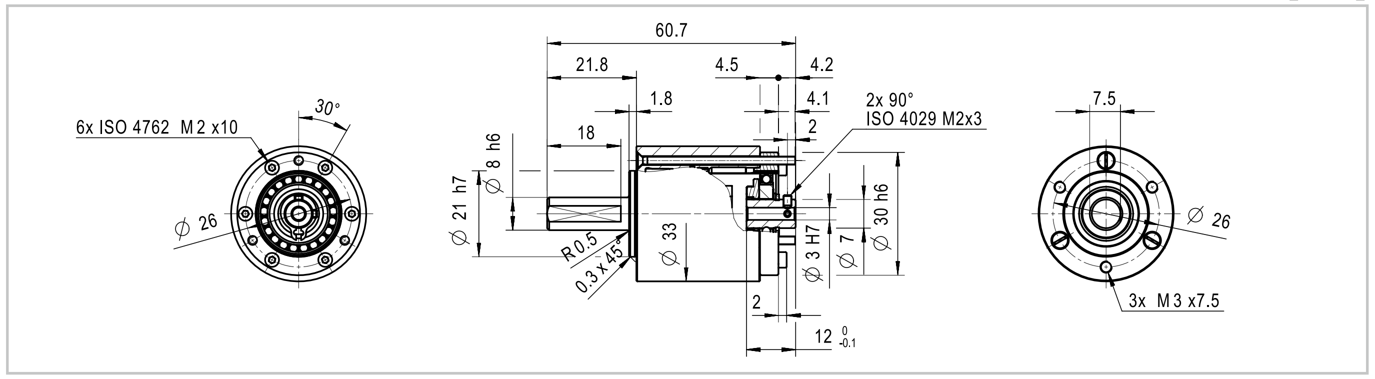


Illustration 2.9.3 **PMG-11-M [mm]**

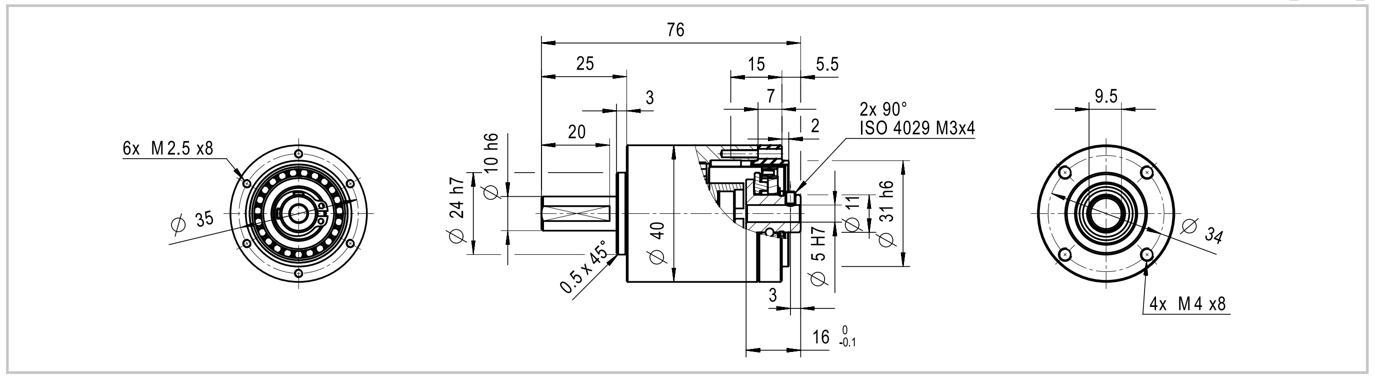
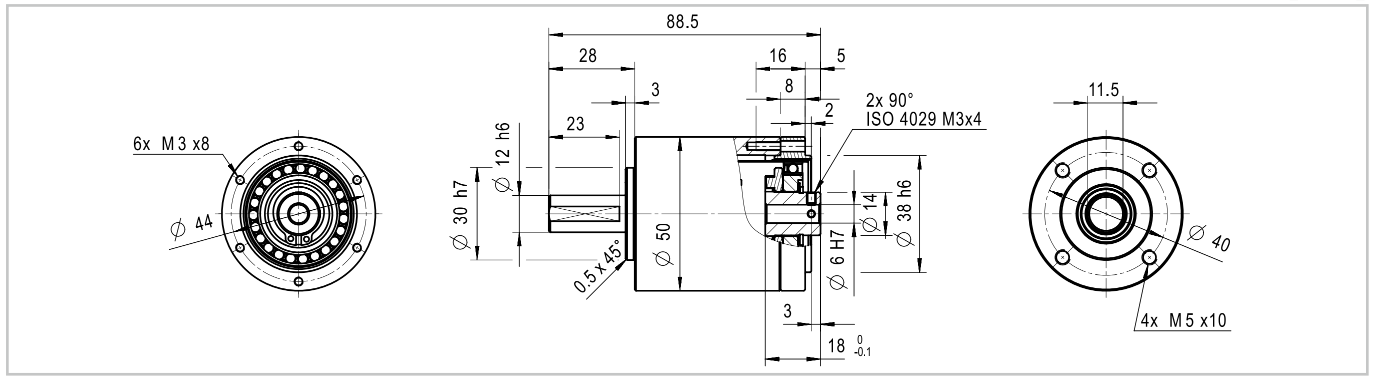


Illustration 2.9.4 **PMG-14-M [mm]**



CAD drawings for download: www.harmonicdrive.co.uk

Version with input shaft

Illustration 2.9.5

PMG-5-S [mm]

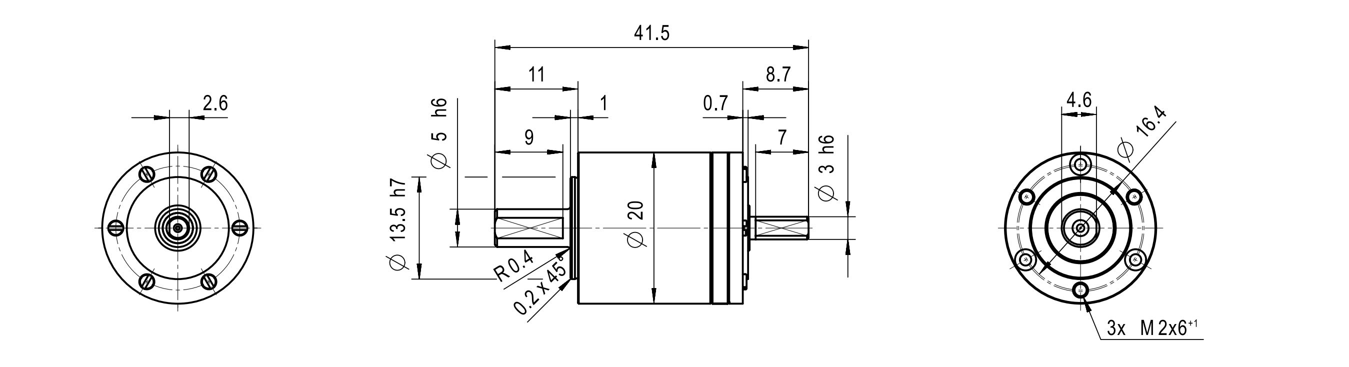


Illustration 2.9.6

PMG-8-S [mm]

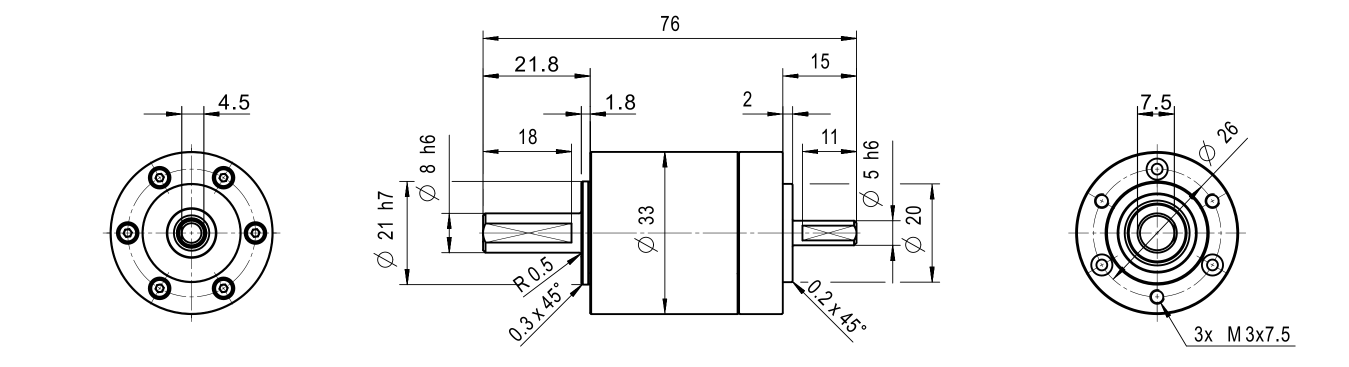


Illustration 2.9.7

PMG-11-S [mm]

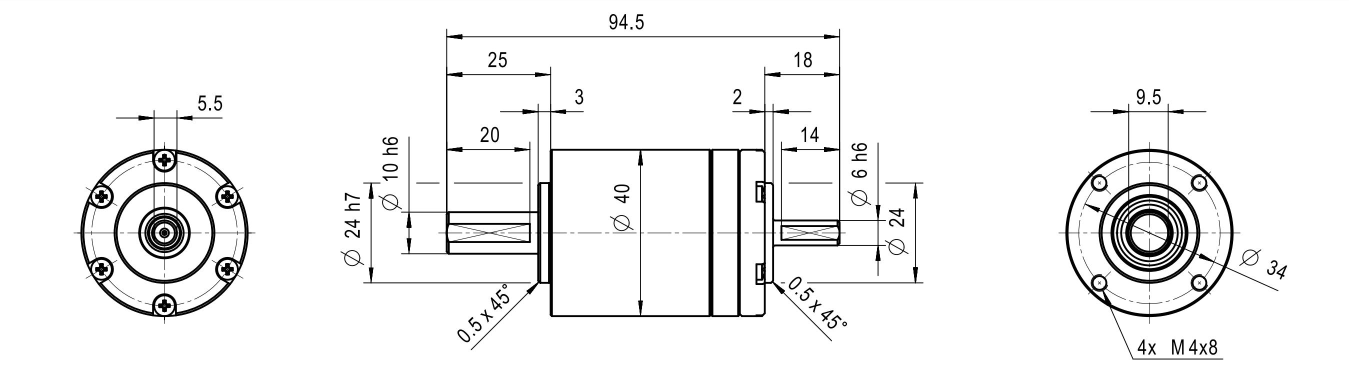
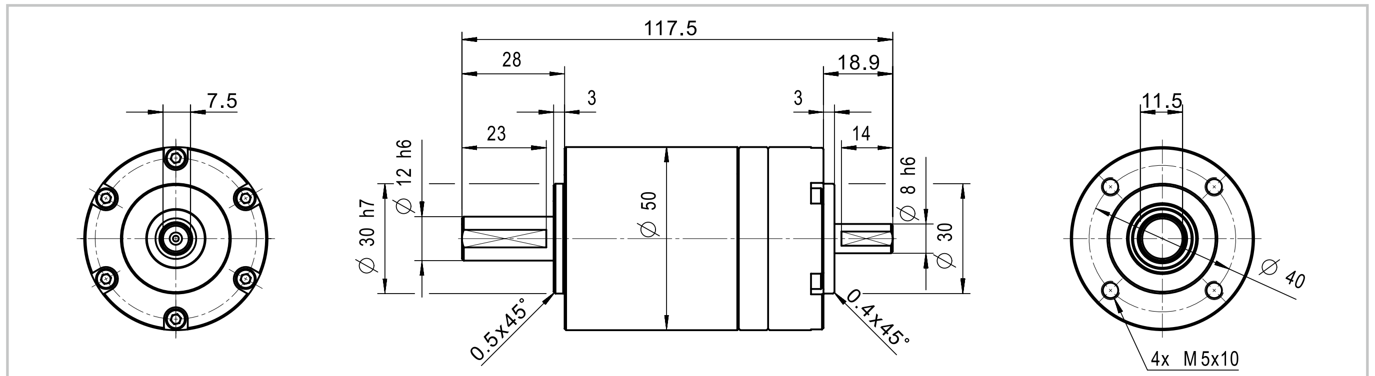


Illustration 2.9.8

PMG-14-S [mm]



CAD drawings for download: www.harmonicdrive.co.uk

- Accuracy

Table 2.9.4 **[arcmin]**

	Size			
	5	8	11	14
Transmission accuracy	< 4.5	< 3.0	< 2.0	< 2.0
Lost motion	< 4.0	< 1.0	< 1.0	< 1.0
Repeatability	< ± 1.5	< ± 1.0	< ± 1.0	< ± 1.0

- Torsional stiffness

Table 2.9.5

	Symbol [Unit]	Size			
		5	8	11	14
Limit torques	T_1 [Nm]	0.05	0.30	0.80	1.90
	T_2 [Nm]	0.19	1.50	3.40	6.80
i = 50	K_2 [Nm/rad]	55	389	1160	2250
	K_1 [Nm/rad]	24	246	622	1320
i > 50	K_3 [Nm/rad]	100	690	1400	4270
	K_2 [Nm/rad]	60	500	1320	3300
	K_1 [Nm/rad]	30	380	770	1710

- No load starting torque

Table 2.9.6 **[Ncm]**

Ratio	Size			
	5	8	11	14
50	0.4	0.8	1.6	2.3
72, 80, 88	0.3	0.7	1.3	1.9
100, 110	0.3	0.6	1.1	1.6

- No load back driving torque

Table 2.9.7 **[Nm]**

Ratio	Size			
	5	8	11	14
50	0.18	0.50	0.90	1.30
72, 80, 88	0.2	0.6	1.0	1.6
100, 110	0.3	0.7	1.1	1.8

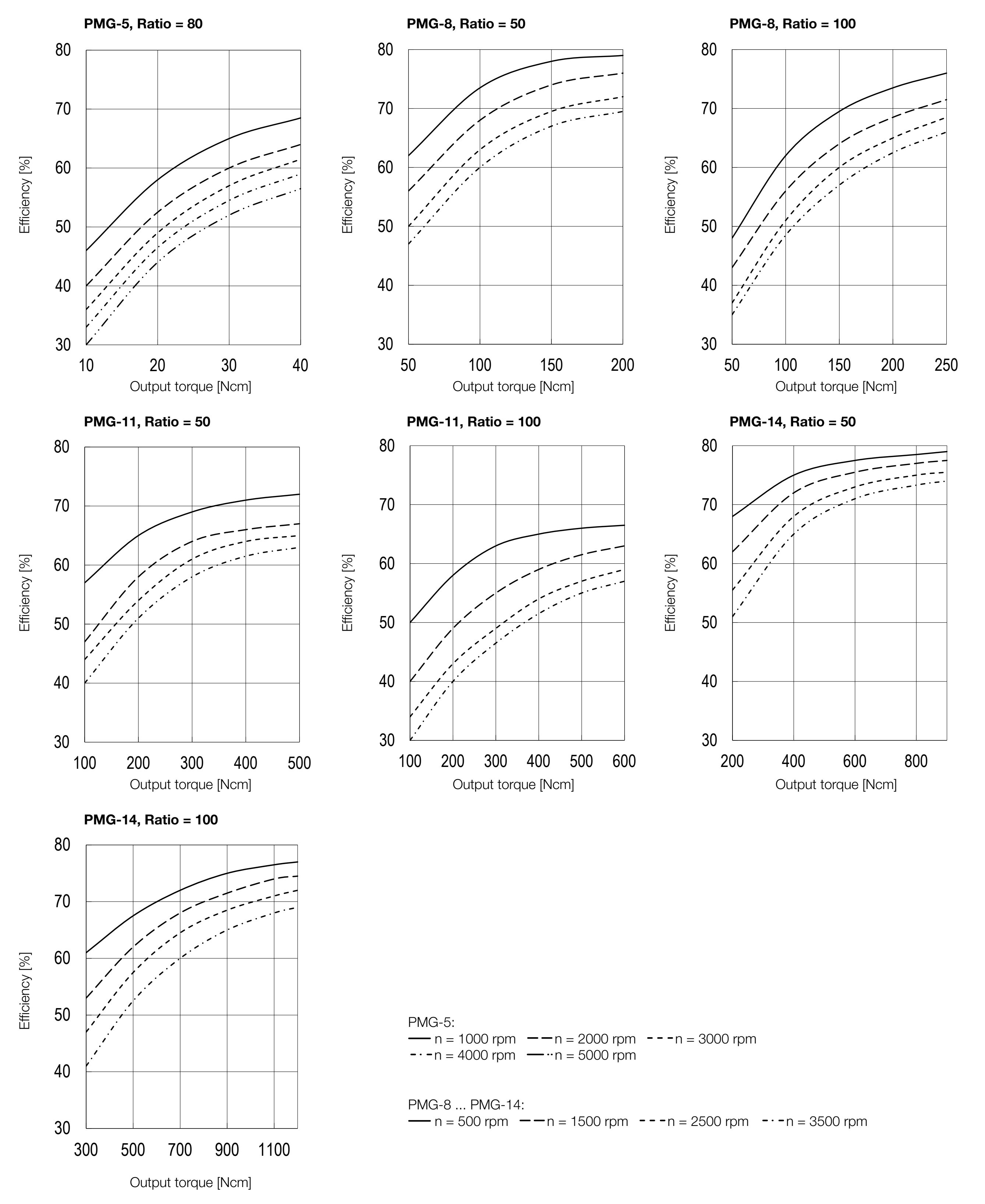
You will find more information on this in the Engineering data chapter.

Efficiency

Efficiency for grease lubrication at rated torque

The diagrams apply to Harmonic Drive® Grease SK-2.

Illustration 2.9.9



Output bearing

Table 2.9.8

[N]

		Symbol [Unit]	Size 5	8	11	14
Output bearing	Permissible radial load[1]	F_r [N]	59	196	245	392
	Permissible axial load	F_a [N]	29	98	196	392
Input bearing	Permissible radial load[1]	F_r [N]	8	10	20	29
	Permissible axial load	F_a [N]	5	5	10	10

[1] The load refers to the centre of the shaft.

Output bearing and housing tolerances

Illustration 2.9.10

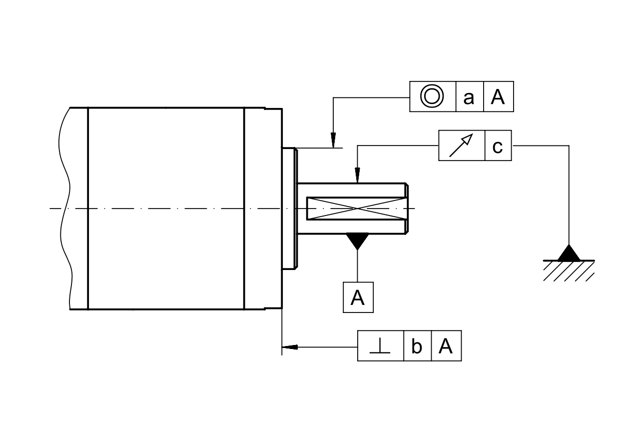


Table 2.9.9

[mm]

Symbol	Size 5	8	11	14
a	0.04	0.04	0.04	0.04
b	0.04	0.04	0.04	0.04
c (radial runout)	0.02	0.02	0.02	0.02

Materials and coatings used

Housing: Aluminium, anodised. Exception: Centering collar on the output side
Input and output shaft: Chrome steel, corrosion resistant
Circular Spline (outside): Nickel plated

Optional materials and coatings are available on request.

Assembly

• Assembly tolerances

Illustration 2.9.11

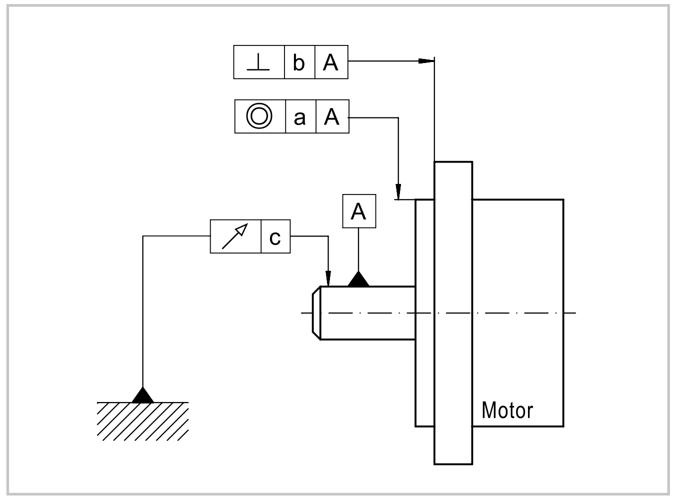
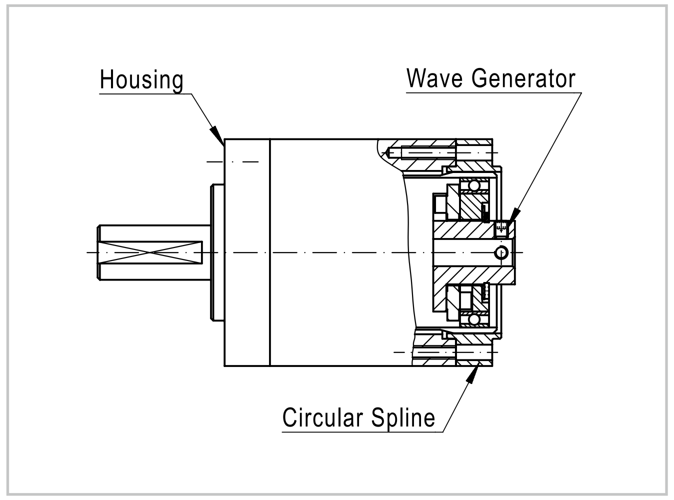


Table 2.9.10 **[mm]**

Symbol	Size			
	5	8	11	14
a	0.015	0.025	0.030	0.030
b	0.015	0.025	0.030	0.030
c	0.010	0.015	0.015	0.015

• Assembly of the output and housing flange

Illustration 2.9.12



• Assembly on the Circular Spline

Table 2.9.11

	[Unit]	Size			
		5	8	11	14
Size of screws		M1.4	M2	M2.5	M3
Screw tightening torque	[Nm]	0.21	0.65	1.3	2.3

12.9 quality screws, friction coefficient μ = 0.15

• Assembly on the housing

Table 2.9.12

	[Unit]	Size			
		5	8	11	14
Size of screws		M2	M3	M4	M5
Screw tightening torque	[Nm]	0.65	2.3	5.3	10.5

12.9 quality screws, friction coefficient μ = 0.15

• Assembly on the Wave Generator

Table 2.9.13

	[Unit]	Size			
		5	8	11	14
Number of screws		1	1	1	1
Threaded pin size		M1.2	M2	M3	M3
Tightening torque of the screw	[Nm]	0.06	0.38	1.34	1.34

12.9 quality screws, friction coefficient μ = 0.15

Lubrication

PMG Gears with output bearing are designed for grease lubrication. Oil lubrication is not provided for these products.

• Grease lubrication

PMG Gears with output bearing are supplied with lifetime lubrication. For lubrication we recommend the specially developed Harmonic Drive® Grease SK-2.

You will find more information on this in the Engineering data chapter.

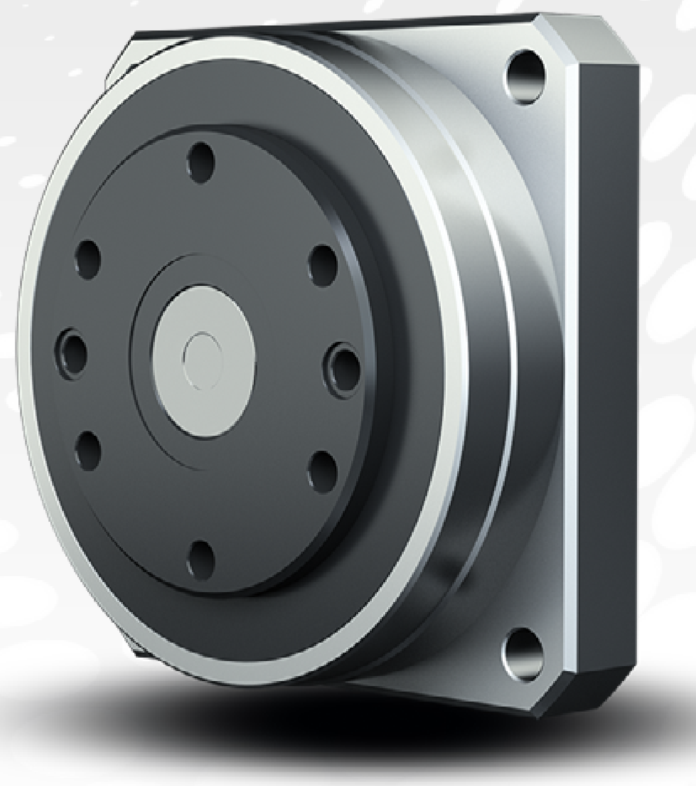
Product description

Short gear for direct motor mount with high capacity tilt resistant output bearing

The CSF-2UP Series Gears consist of an HFUC Gear Component Set and a tilt resistant output bearing. They are suitable for direct motor mounting in precision applications with low torque requirements.

Features

- Integrated tilt resistant output bearing
- Direct motor attachment possible
- For precise applications in small torque ranges
- Short design



Ordering code

Table 2.10.1

Ordering code	CSF	-	11	-	50	-	2UP	-	SP
Series									
Size (corresponds to the pitch circle diameter of the Flexspline toothing in inches x 10)			8 11 14						
Ratio (in drive configuration: Circular Spline (CS) fixed, Wave Generator (WG) input, Flexspline (FS) output					30 50 100				
Version Gears for motor mounting							2UP		
Customised design Standard design (field remains empty) Special design (on request)									[ ] SP

Please refer to the table of possible combinations.

Combinations

Table 2.10.2

		Size		
		8	11	14
Ratio	30	•	•	•
	50	•	•	•
	100	•	•	•

• available o on request - not available

Technical data

• Rating table

Table 2.10.3

Size	Ratio	Limit for repeated peak torque	Limit for average torque	Rated torque at rated speed 2000 rpm	Limit for momentary peak torque	Max. input speed [rpm]	Limit for average input speed [rpm]	Moment of inertia	Weight
	i	T_R [Nm]	T_A [Nm]	T_N [Nm]	T_M [Nm]	Grease lubrication	Grease lubrication	[kgm²]	[kg]
8	30	1.8	1.4	0.9	3.3	8500	3500	$40x10^{-6}$	0.20
	50	3.3	2.3	1.8	6.6				
	100	4.8	3.3	2.4	9.0				
11	30	4.5	3.4	2.2	8.5	8500	3500	$150x10^{-6}$	0.33
	50	8.3	5.5	3.5	17.0				
	100	11.0	8.9	5.0	25.0				
14	30	9.0	6.8	4.0	17.0	8500	3500	$400x10^{-6}$	0.62
	50	18.0	6.9	5.4	35.0				
	100	28.0	11.0	7.8	54.0				

You will find more information on this in the Engineering data chapter.

• Dimensions

Illustration 2.10.1 [mm]

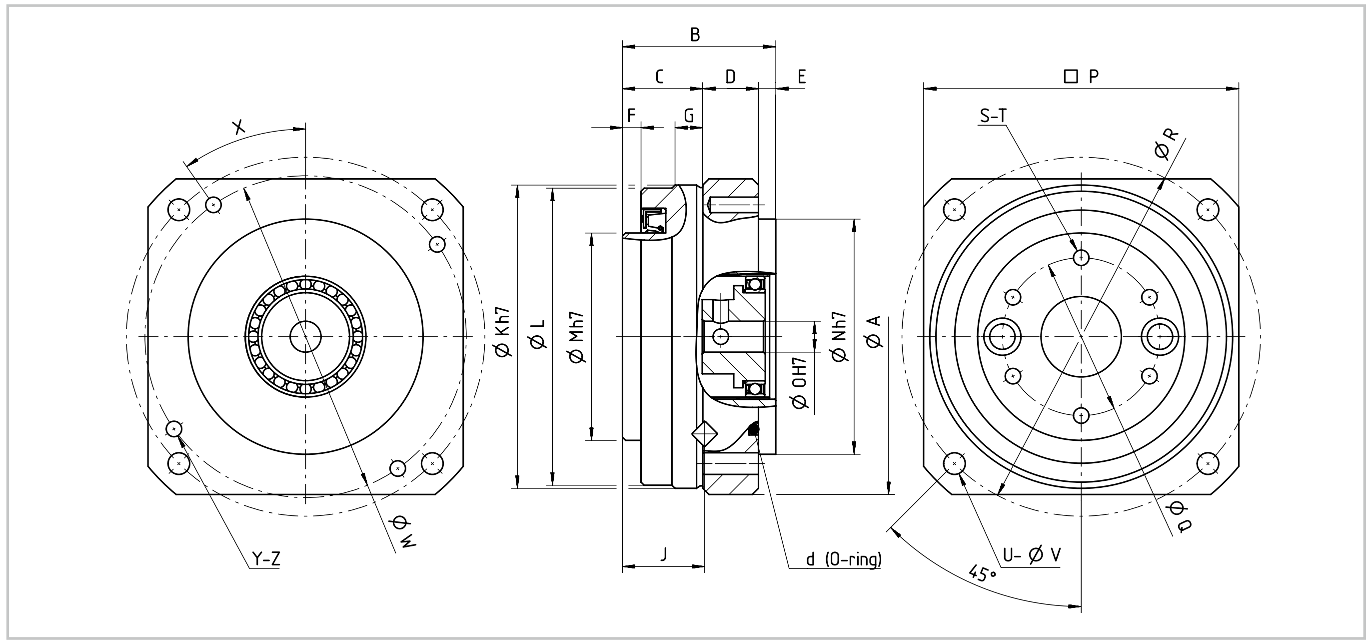


Table 2.10.4 [mm]

Symbol	Size 8	11	14
ØA	66	80	100
B	24.8	27.0	34.0
C	13.0	13.5	18.5
D	9.0	11.5	12.0
E	2.8	2.0	3.0
F	3.0	3.5	3.5
G	5	5	8
H*	$1.1^{0}_{-0.3}$	$1.6^{0}_{-0.7}$	$3.5^{0}_{-0.8}$
I	7.2	8.3	10.5
J	12.9	14.0	14.0
ØK h7	49	59	74
ØL	48	58	73
ØM h7	33.5	41.0	52.5
ØN h7	30	44	52
ØO h7	5	5	8
□P	50 ±1	60 ±1	75 ±1
ØQ	25.5	33.0	44.0
ØR	58	70	88
S	6	6	6
T	M3x6	M4x5	M5x7
U	4	4	4
ØV	3.5	4.5	5.5
ØW	52.00	63.00	70.71
X	35.0°	33.5°	55.0°
Y	4	4	4
Z	M3x5	M3x6	M4x8

* Dimension H is the Wave Generator setting dimension. Observe the tolerances given in the table.

Illustration 2.10.2 [mm]

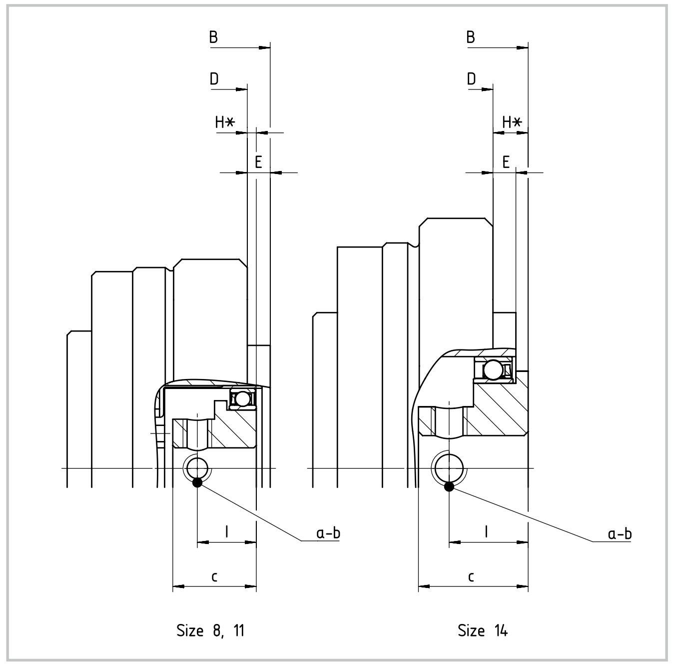


Table 2.10.5 [mm]

Symbol	Size 8	11	14
a	2	2	2
b	M3x4	M3x4	M4x4
c	10.2	11.3	14.0
d	Ø29.8x0.8	Ø54.0x1.2	Ø58.4x1.3

CAD drawings for download: www.harmonicdrive.co.uk

Accuracy

Table 2.10.6 **[arcmin]**

	Size						
	8		11		14		
Ratio	30	≥50	30	≥50	30	≥50	100
Transmission accuracy	<2.0		<2.0	<1.5	<2.0	<1.5	
Hysteresis loss	<3.0	<2.0	<3.0	<2.0	<3.0	<2.0	<1.0

Torsional stiffness

Table 2.10.7

	Symbol [Unit]	Size		
		8	11	14
Limit torques	T_1 [Nm]	0.29	0.80	2.00
	T_2 [Nm]	0.75	2.00	6.90
i = 30	K_3 [x 10^4 Nm/rad]	0.054	0.158	0.355
	K_2 [x 10^4 Nm/rad]	0.044	0.124	0.235
	K_1 [x 10^4 Nm/rad]	0.034	0.084	0.188
i = 50	K_3 [x 10^4 Nm/rad]	0.084	0.320	0.568
	K_2 [x 10^4 Nm/rad]	0.067	0.300	0.468
	K_1 [x 10^4 Nm/rad]	0.044	0.221	0.335
i = 100	K_3 [x 10^4 Nm/rad]	0.120	0.432	0.700
	K_2 [x 10^4 Nm/rad]	0.104	0.333	0.601
	K_1 [x 10^4 Nm/rad]	0.090	0.267	0.468

No load starting torque

Table 2.10.8 **[Ncm]**

Ratio	Size		
	8	11	14
30	1.50	3.40	4.60
50	0.92	2.00	3.50
100	0.65	1.50	2.20

No load back driving torque

Table 2.10.9 **[Nm]**

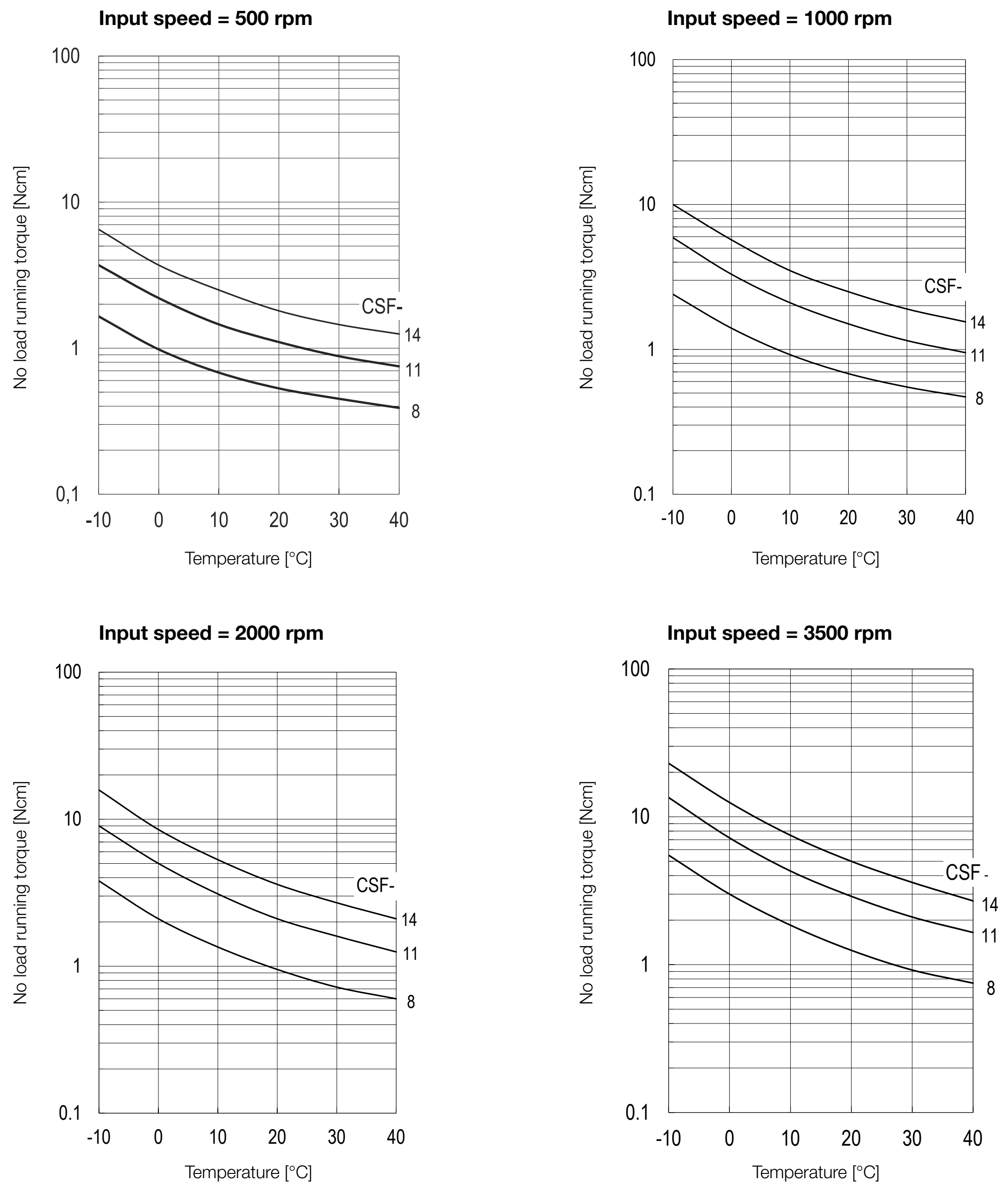
Ratio	Size		
	8	11	14
30	0.70	1.70	2.40
50	0.55	1.20	1.60
100	0.75	1.50	1.80

You will find more information on this in the Engineering data chapter.

No load running torque

The diagrams apply to Harmonic Drive® Grease SK-2 (size 8 ... 14).

Illustration 2.10.3



Compensation values for no load running torque

When using gears with ratios other than i=100 please apply the compensation values for the table to the values taken from the curves.

Table 2.10.10 **[Ncm]**

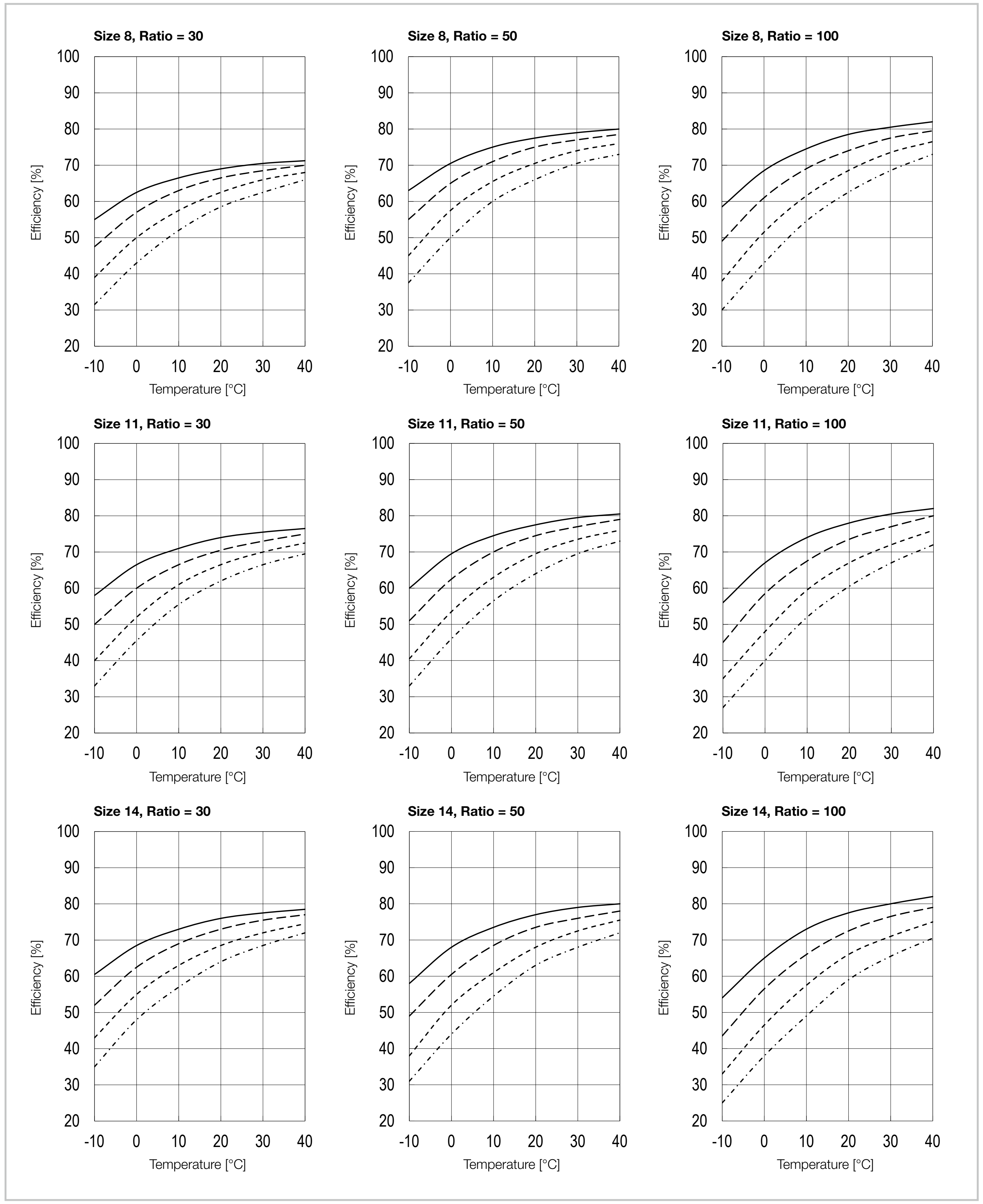
Ratio	Size		
	8	11	14
30	0.49	0.81	1.25
50	0.22	0.36	0.55

Efficiency

Efficiency for grease lubrication at rated torque

The diagrams apply to Harmonic Drive® Grease SK-2 (sizes 8 ... 14).

Illustration 2.10.4



n = 500 rpm
n = 1000 rpm
n = 2000 rpm
n = 3500 rpm

You will find more information on this in the Engineering data chapter.

Efficiency calculation

The efficiency depends on the following parameters: Gear ratio, input speed, load torque, temperature, lubricant and lubricant quantity. If the load torque is lower than the rated torque, the efficiency will be lower than the efficiency than that indicated in the efficiency curves. The torque specific efficiency is determined by means of the the calculation factor K.

Calculation example

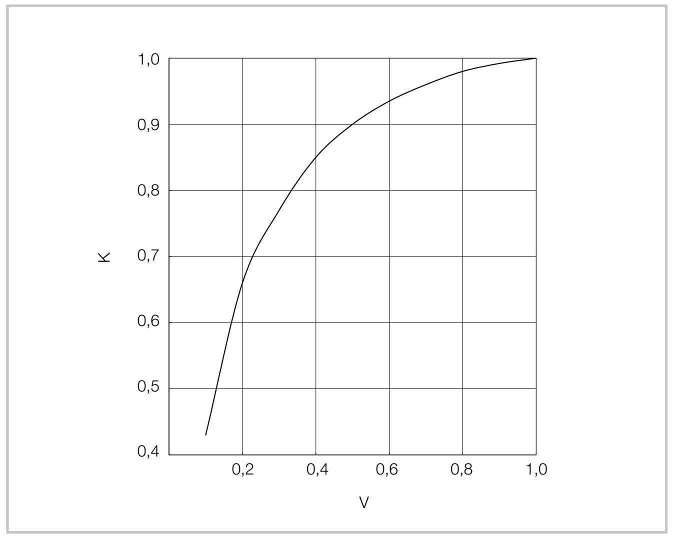
Product: CSF-11-50-2UP

- Input speed: 1000 rpm
- (Average) load torque T_{av}: 2 Nm
- Rated torque T_N (catalogue reference): 3.5 Nm
- Grease lubrication with Harmonic Drive® Grease SK-1A, lubricant temperature: 20 °C.

1. Calculation of the torque factor
   $V = T_{av}/T_N = 2/3.5 = 0.57$ (For V > 1 is K = 1)
2. Reading the calculation factor K from diagram Illustration 2.10.5: K = 0.93
3. Reading the efficiency from the efficiency curve Illustration 2.10.4: η = 74 %
4. Calculation of the load dependant efficiency
   η_L = 74 % · 0.93 = 69 %

Illustration 2.10.5

Calculation factor K



Output bearing

The CSF-2UP Gears are equipped with a heavy duty cross roller bearing at the output.

Rating table

Table 2.10.11

	Symbol [Unit]	Size 8	11	14
Bearing type[1]		C	C	C
Pitch circle diameter	d_p [m]	0.0350	0.0425	0.0540
Distance[2]	R [m]	0.0129	0.0140	0.0140
Dynamic load rating	C [N]	5800	5600	7400
Static load rating	C_0 [N]	8000	9900	12800
Permissible dynamic tilting moment[3,4]	M [Nm]	15	40	75
Tilting moment stiffness	K_B [Nm/arcmin]	5.8	11.6	23.3
Permissible axial load[4]	F_a [N]	1239	1389	1581
Permissible radial load[4]	F_r [N]	830	930	1059

1) Bearing type C = Cross roller bearing; F = Four point contact bearing
2) Distance between the centre of the rolling bearing and the screw mounting surface on the output side, see chapter Gear dimensioning.
3) These values are valid for moving gears. They are not based on the equation for lifetime of the output bearing but on the maximum allowable deflection of the Harmonic Drive® Gear Component Set. The values indicated in the table must not be exceeded even if the lifetime equation of the bearing permits higher values.
4) These data are valid for **M**: $F_a = 0, F_r = 0$ I **F_a**: $M = 0, F_r = 0$ I **F_r**: $M = 0, F_a = 0$
5) The value of tilting moment stiffness is the average value (± 20 %).

Output bearing and housing tolerances

Data applies to rotating output flange.

Illustration 2.10.6

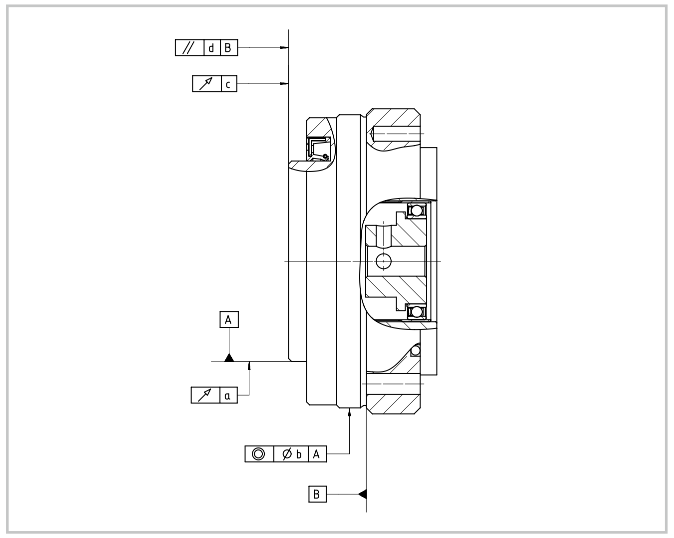


Table 2.10.12 [mm]

Symbol	Size 8	Size 11	Size 14
a (radial runout)	0.010		
b	0.040		
c (axial runout)	0.010		
d	0.040		

Assembly

Assembly tolerances

Illustration 2.10.7

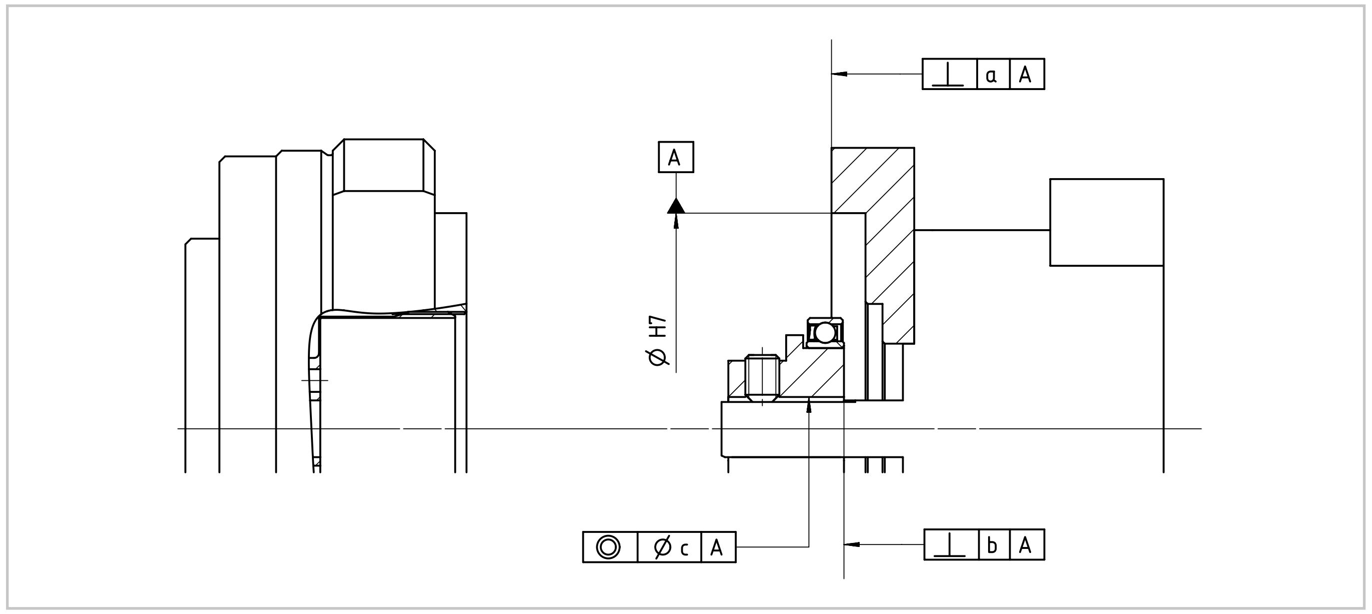


Table 2.10.13 [mm]

Symbol	Recommended tolerance shaft/bore of the connection components	Size 8	Size 11	Size 14
a		0.010	0.011	0.011
b		0.006	0.007	0.008
Øc	h6	0.006	0.007	0.016

You will find more information on this in the Engineering data chapter.

Bore diameter Wave Generator

The Wave Generator can be supplied with the following bore diameters.

Table 2.10.14 [mm]

	Size 8	Size 11	Size 14
Ø0H7	2 to 8	3 to 8	4 to 10

All bore diameter changes are special specifications. Please contact Harmonic Drive SE for details.

Screw connection

Illustration 2.10.8

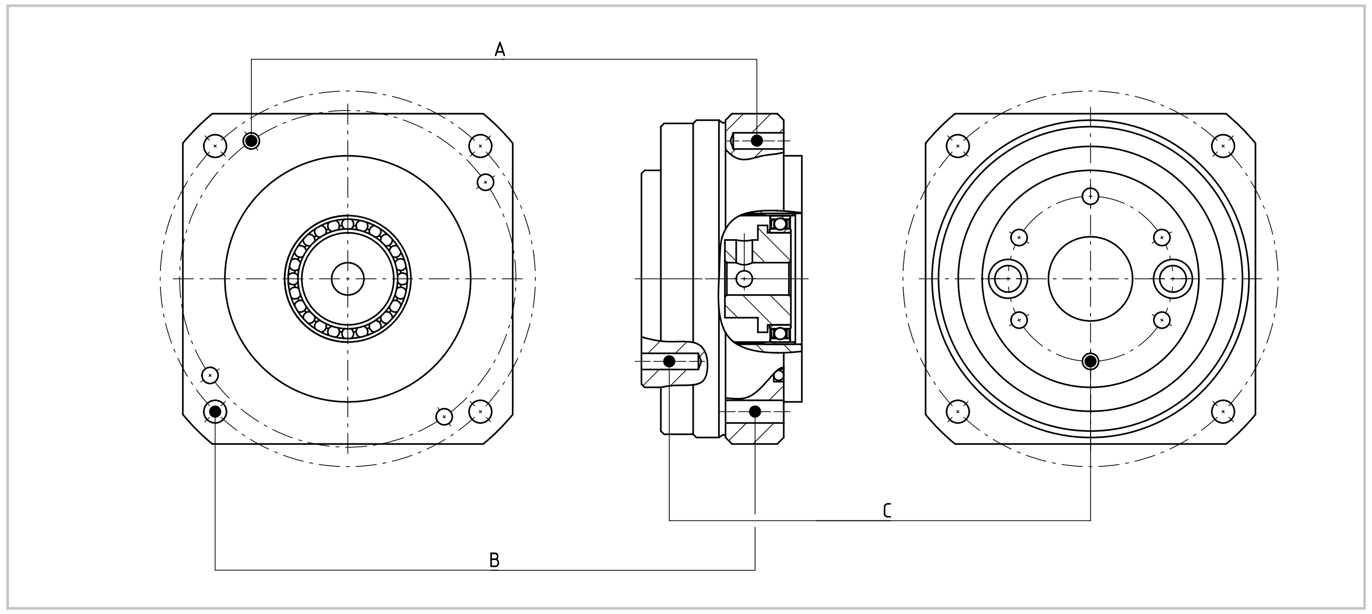


Table 2.10.15

	[Unit]	Screw connection A Adapter flange			Screw connection B Housing flange			Screw connection C Output flange		
Size		8	11	14	8	11	11	8	11	14
Number of screws		4	4	4	4	4	4	6	6	6
Size of screws		M3	M3	M4	M3	M4	M5	M3	M4	M5
Pitch circle diameter	[mm]	52.00	63.00	70.71	58.00	70.00	88.00	25.50	33.00	44.00
Screw tightening torque	[Nm]	0.85	0.85	2.00	1.20	2.70	5.40	2.00	4.50	9.00
Torque transmitting capacity	[Nm]	18.0	22.0	44.0	29.0	59.1	119.0	31.9	69.6	184.0
Recommended minimum screw depth	[mm]	3.6	3.6	4.8	3.6	4.8	6.0	3.6	4.8	6.0

12.9 quality screws, friction coefficient μ = 0,15

Materials and coatings used

Material:
Output bearing: bright steel
Circular Spline: bright grey cast iron
Flexspline: bright steel
Wave Generator: bright steel

Optional materials and coatings are available on request from Harmonic Drive SE.

Lubrication

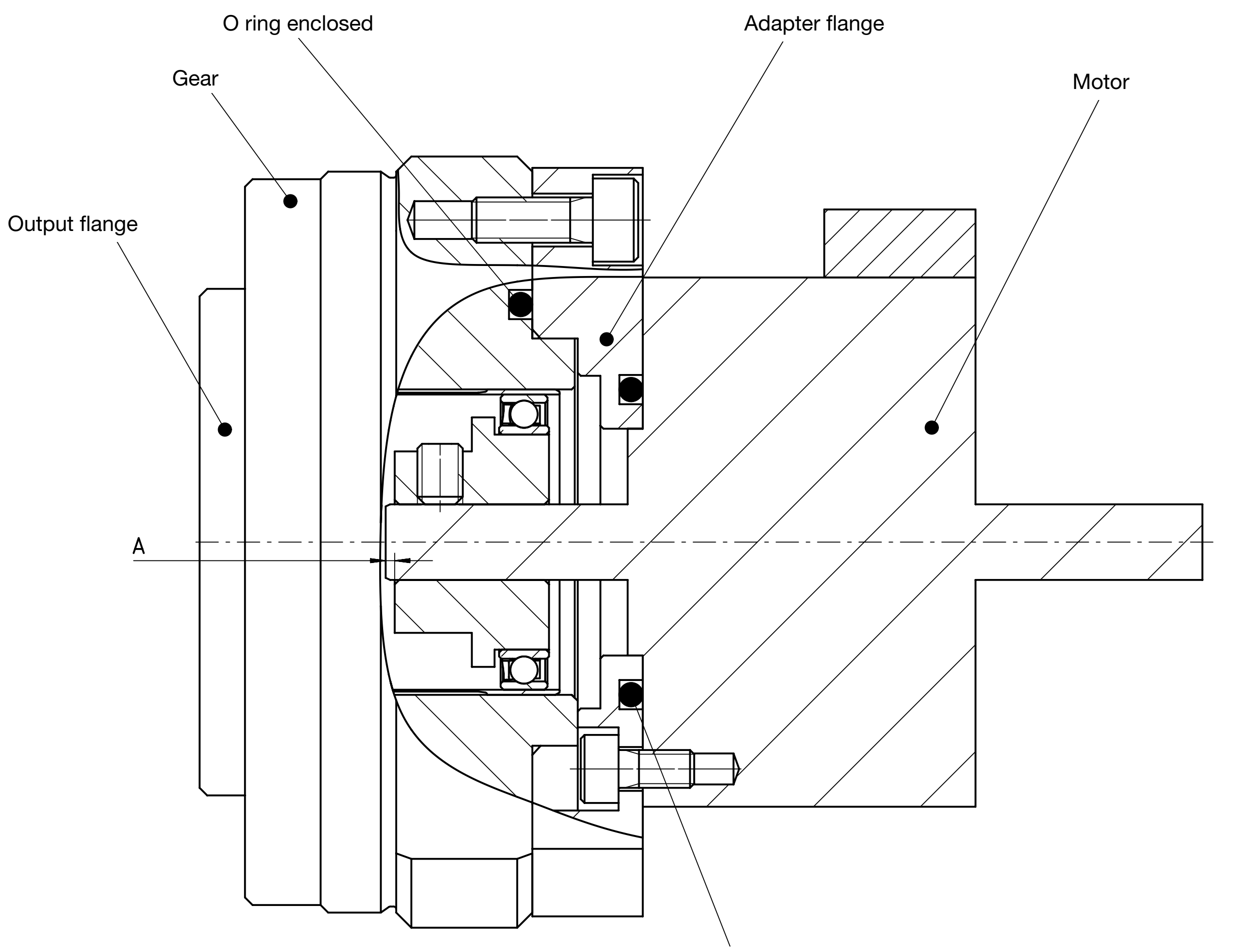
CSF-2UP Gears are supplied ready for installation. They are delivered with Harmonic Drive® SK-2 high performance grease which provides lifetime lubrication direct from the factory and no additional grease is required during assembly.

You will find more information on this in the Engineering data chapter.

Application example

The following illustration shows the installation of the gearbox with output bearing.

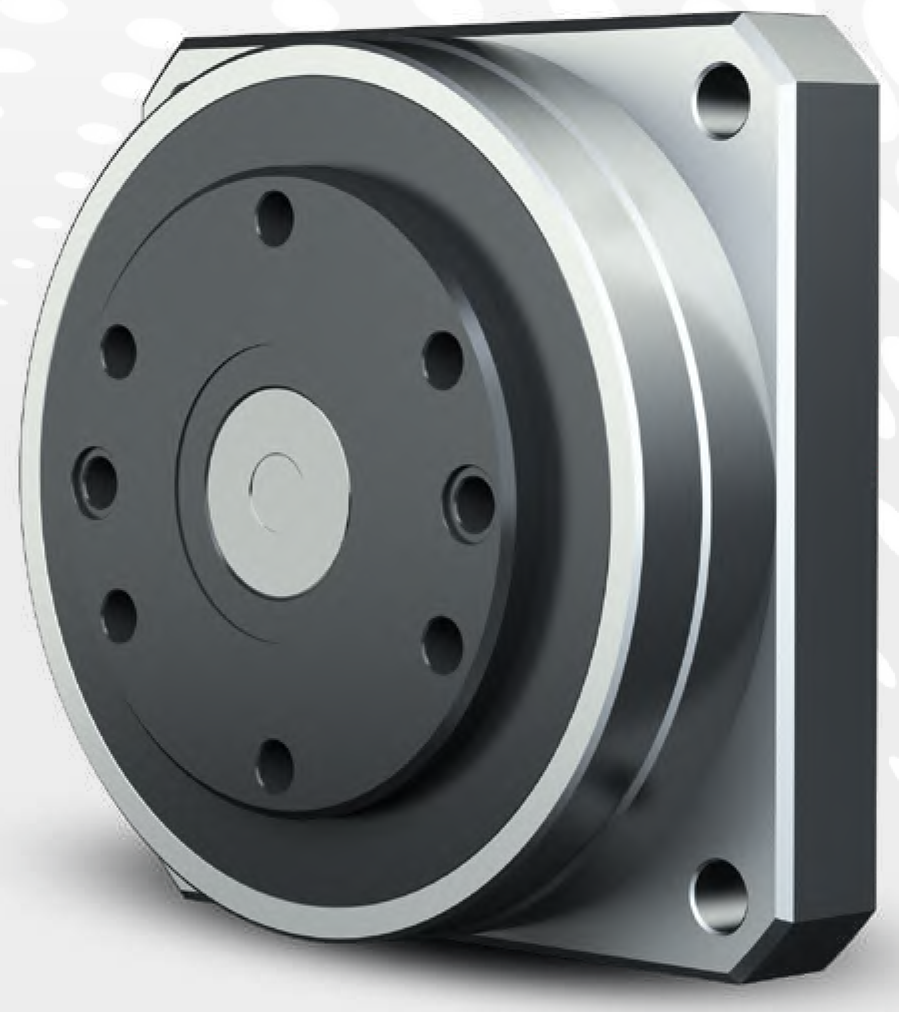
Illustration 2.10.9



Please ensure that length A is shorter than the values in the table below.

Table 2.10.16 [mm]

	Size		
	8	11	14
A	2.5	4.5	6.0



Product description

Largest hollow shaft with smallest outer diameter

The gears with output bearing of the FBS-2UH Series are characterised by the largest hollow shaft with a small outer diameter at the same time. The large hollow shaft is the ideal solution for robots and machine tools that require a central cable feed through the rotary axis. By avoiding cable loops, the machine design can therefore be simplified. Based on the new gear technology of the gear component set of the FBS Series, an increased torque, a high torsional stiffness as well as an extended service life are achieved.

Features

- Large central hollow shaft for cable bushings
- Maximum hollow shaft with minimum outer diameter
- Compact and space saving design
- Integrated output bearing
- High corrosion protection

Ordering code

Table 2.11.1

Ordering code	FBS	-	25	-	100	-	2UH	-	SP
Series									
Size (corresponds to the pitch circle diameter of the Flexspline toothing in inches x 10)			25 32						
Ratio (in drive configuration: Circular Spline (CS) fixed, Wave Generator (WG) input, Flexspline (FS) output					30 50				
Version Open hollow shaft gear with input bearing							2UH		
Customised design Standard design (field remains empty) Special design (on request)									[ ] SP

Please refer to the table of possible combinations.

Combinations

Table 2.11.2

		Size 25	Size 32
Ratio	30	●	●
	50	●	●

● available o on request - not available

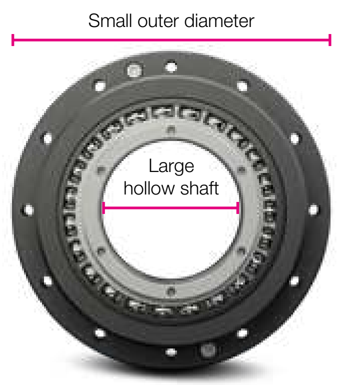


Table 2.11.3

	[Unit]	Size 25	Size 32
Hollow shaft	[mm]	41.0	55.1
Outer diameter	[mm]	93	113
Relation	[%]	44	49

Technical data

• Rating table

Table 2.11.4

Size	Ratio	Limit for repeated peak torque	Limit for average torque	Rated torque at rated speed 2000 rpm	Limit for momentary peak torque	Max. input speed [rpm]	Limit for average input speed [rpm]	Moment of inertia	Weight
	i	T_R [Nm]	T_A [Nm]	T_N [Nm]	T_M [Nm]	Grease lubrication	Grease lubrication	[kgm²]	[kg]
25	30	25	24	15	50	3600	2500	1.0×10^{-4}	1.3
	50	47	35	22	93				
32	30	48	48	30	96	3600	2300	3.3×10^{-4}	2.2
	50	92	67	43	151				

You will find more information on this in the Engineering data chapter.

• Dimensions

Illustration 2.11.1 [mm]

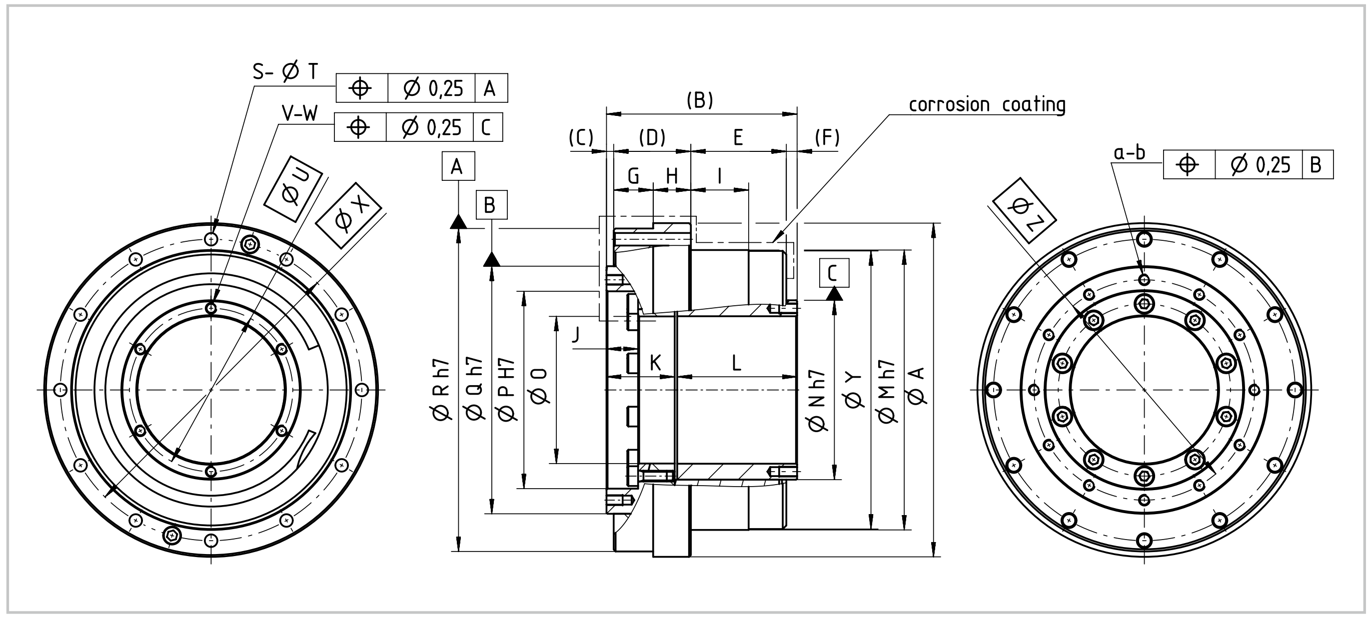


Table 2.11.5 [mm]

	Size	
	25	32
ØA	93	113
B	53.1	62.5
C	2	2
D	21.5	25.2
E	26.6	32.3
F	3	3
G	11.0	13.7
H	10.5	11.5
I	16.1	20.0
J	8.8	7.5
K	19.0	21.7
L	33.40	39.97
ØM h7	78	96
ØN h7	50	65
ØO	41.0	55.1
ØP H7	55	69
ØQ h7	69	84
ØR h7	90	110
S	12	12
ØT	3.5	4.5
ØU	45.5	60.0
V	M3	M3
W	5	6
ØX	84	102
ØY	77.5	95.5
ØZ	61.4	77.0
a	M3	M4
b	4.5	6.0

CAD drawings for download: www.harmonicdrive.co.uk

Accuracy

Table 2.11.6 **[arcmin]**

	Size			
	25		32	
Ratio	30	50	30	50
Transmission accuracy	<3	<2	<3	<2
Hysteresis loss	<3	<2	<3	<2

Torsional stiffness

Table 2.11.7

		Size	
		25	32
Limit torques	T_1 [Nm]	7.4	16.0
	T_2 [Nm]	26.0	55.0
i = 30	K_3 [x 10^4 Nm/rad]	1.6	2.9
	K_2 [x 10^4 Nm/rad]	1.3	2.4
	K_1 [x 10^4 Nm/rad]	1.3	2.1
i = 50	K_3 [x 10^4 Nm/rad]	2.3	4.3
	K_2 [x 10^4 Nm/rad]	2.0	3.7
	K_1 [x 10^4 Nm/rad]	1.9	3.5

No load starting torque

Table 2.11.8 **[Ncm]**

Ratio	Size	
	25	32
30	25	54
50	15	31

No load back driving torque

Table 2.11.9 **[Nm]**

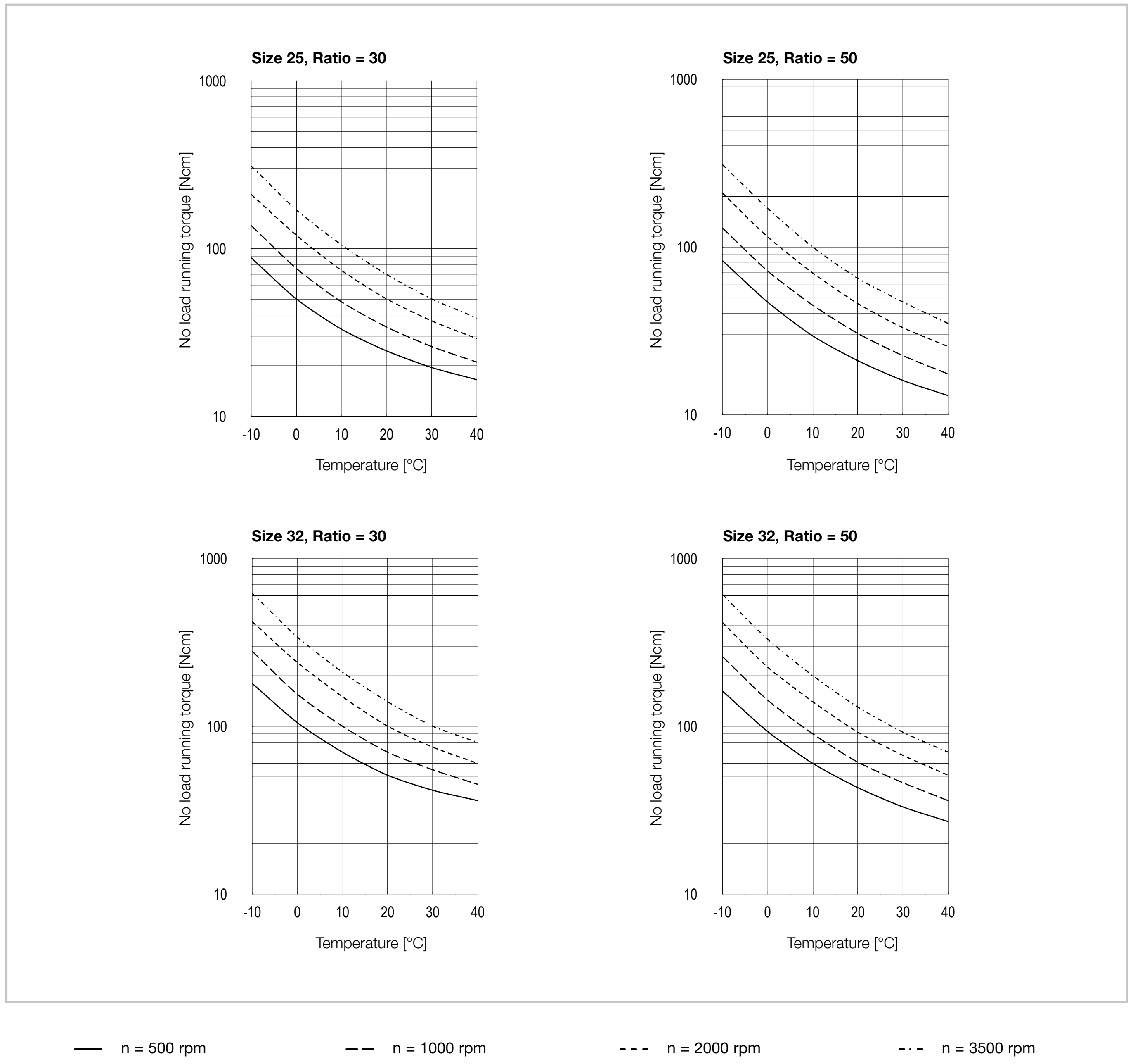
Ratio	Size	
	25	32
30	11	23
50	9	18

You will find more information on this in the Engineering data chapter.

No load running torque

The diagrams apply to Harmonic Drive® Grease SK-1A.

Illustration 2.11.2

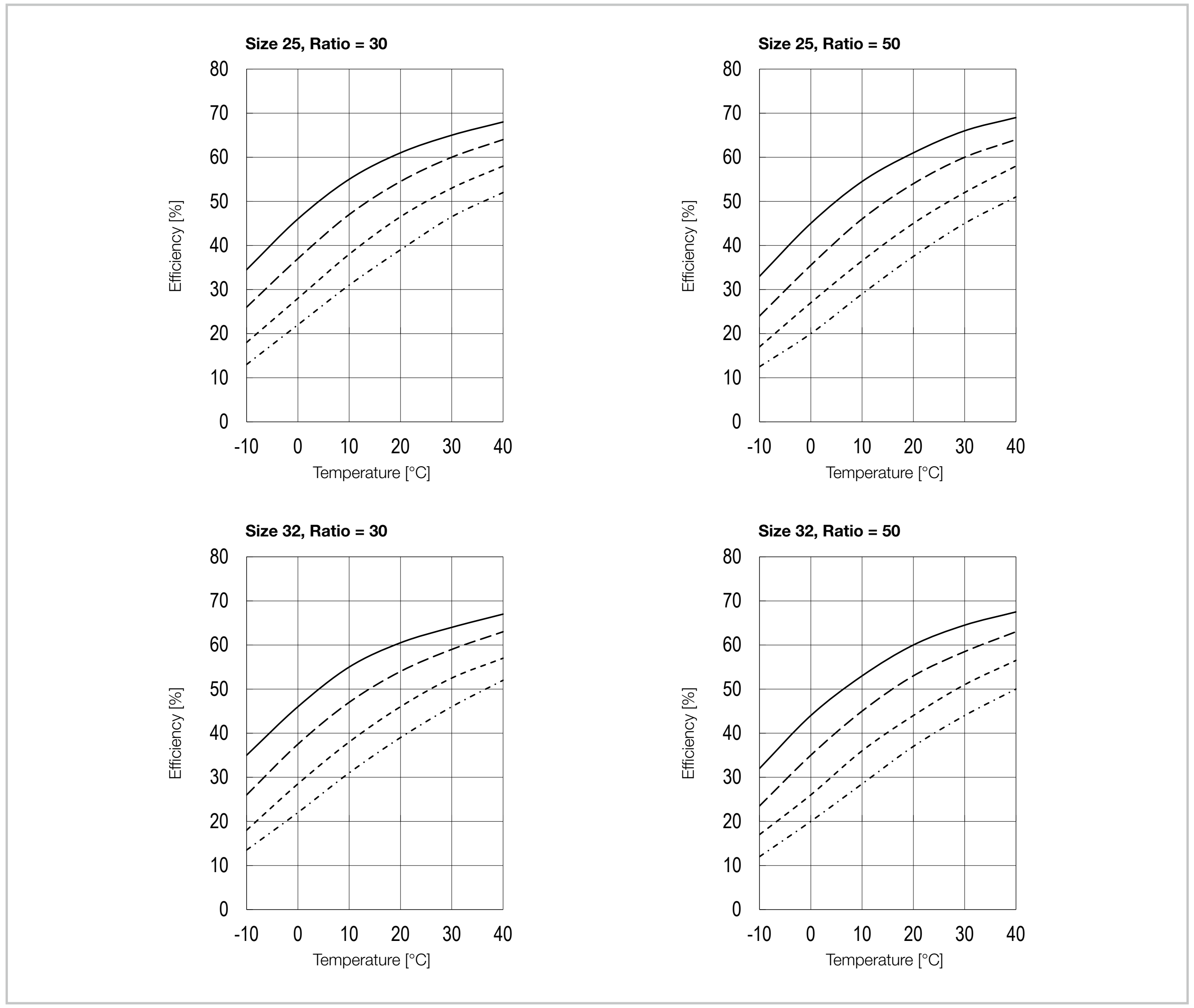


• Efficiency

Efficiency for grease lubrication at rated torque

The diagrams apply to Harmonic Drive® Grease SK-1A.

Illustration 2.11.3



—— n = 500 rpm   — — n = 1000 rpm   - - - n = 2000 rpm   -·- n = 3500 rpm

You will find more information on this in the Engineering data chapter.

Efficiency calculation

The efficiency depends on the following parameters: Gear ratio, input speed, load torque, temperature, lubricant and lubricant quantity. If the load torque is lower than the rated torque, the efficiency will be lower than the efficiency than that indicated in the efficiency curves. The torque specific efficiency is determined by means of the the calculation factor K.

Calculation example

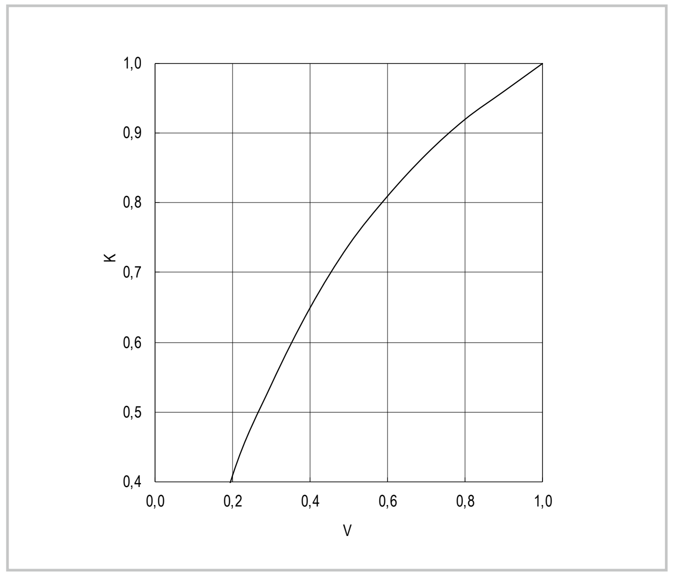
Product: FBS-25-50-2UH

- Input speed: 1000 rpm
- (Average) load torque T_{av}: 2 Nm
- Rated torque T_N (catalogue reference): 22 Nm
- Grease lubrication with Harmonic Drive® Grease SK-1A, lubricant temperature: 20 °C.

1. Calculation of the torque factor
   $V = T_{av}/T_N = 20/22 = 0{,}91$ (For V > 1 is K = 1)
2. Reading the calculation factor K from diagram Illustration 2.11.4: K = 0.98
3. Reading the efficiency from the efficiency curve Illustration 2.11.3: η = 54 %
4. Calculation of the load dependant efficiency
   $\eta_L = 74\ \% \cdot 0.98 = 53\ \%$

Illustration 2.11.4

Calculation factor K



Output bearing

The FBS-2UH Gear is equipped with a heavy duty cross roller bearing at the output.

• Rating table

Table 2.11.10

	Symbol [Unit]	Size	
		25	32
Bearing type[1]		C	C
Pitch circle diameter	d_P [m]	0.070	0.086
Distance[2]	R [m]	0.0110	0.0121
Dynamic load rating	C [N]	7300	10900
Static load rating	C_O [N]	11000	17900
Permissible dynamic tilting moment[3,4]	M [Nm]	93	129
Tilting moment stiffness[5]	K_B [Nm/arcmin]	61	90
Permissible axial load[4]	F_a [N]	1560	2329
Permissible radial load[4]	F_r [N]	1045	1560

1) Bearing type C = Cross roller bearing; F = Four point contact bearing
2) Distance between the centre of the rolling bearing and the screw mounting surface on the output side, see chapter Gear dimensioning.
3) These values are valid for moving gears. They are not based on the equation for lifetime of the output bearing but on the maximum allowable deflection of the Harmonic Drive® Gear Component Set. The values indicated in the table must not be exceeded even if the lifetime equation of the bearing permits higher values.
4) These data are valid for **M**: $F_a = 0$, $F_r = 0$ I **F_a**: $M = 0$, $F_r = 0$ I **F_r**: $M = 0$, $F_a = 0$
5) The value of tilting moment stiffness is the average value (± 20 %).

• Output bearing and housing tolerances

Data applies to rotating output flange.

Illustration 2.11.5

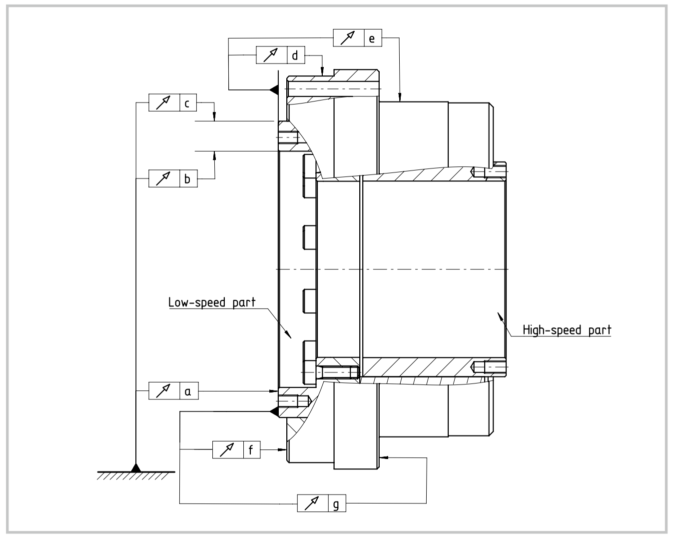


Table 2.11.11 **[mm]**

Symbol	Size	
	25	32
a (axial runout)	0.015	0.015
b (radial runout)	0.010	0.010
c (radial runout)	0.010	0.010
d	0.010	0.013
e	0.070	0.073
f	0.010	0.010
g	0.018	0.024

Input bearing

• Axial bearing tolerance of the input shaft

The bearing of the gear input is subject to backlash. Table 2.11.12 shows the axial backlash. If the bearing tolerance is to be eliminated, this must be done by the customer.

Illustration 2.11.6

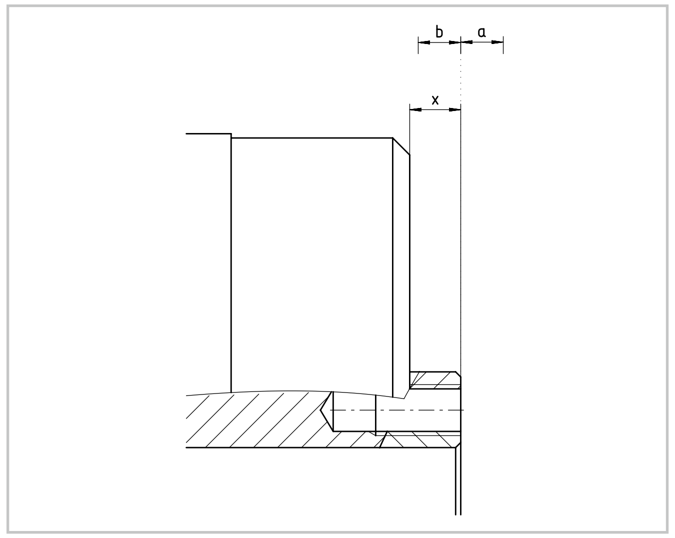


Table 2.11.12 **[mm]**

		Axial backlash	
Size	x	a	b
25	3	0.1 ... 0.7	0.0 ... 0.6
32	3	0.2 ... 0.8	0.1 ... 0.7

Design guidelines

• Load capacity of the input shaft

The hollow shaft of the FBS-2UH is supported by roller bearings. Illustration 2.11.7 shows the force application points of the maximum radial and axial forces shown in Illustration 2.11.8. The maximum values are valid for an average input speed of 2000 rpm and an average service life of L_{10} 5000 hrs.

Illustration 2.11.7

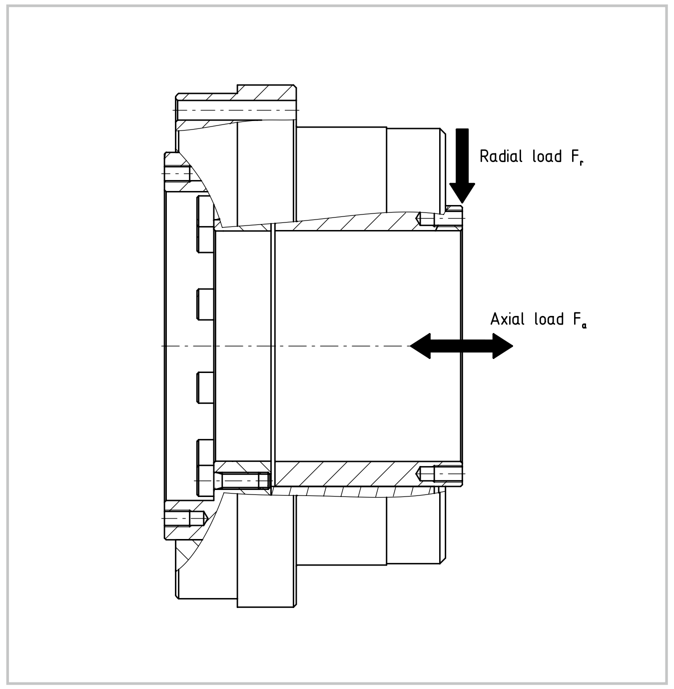
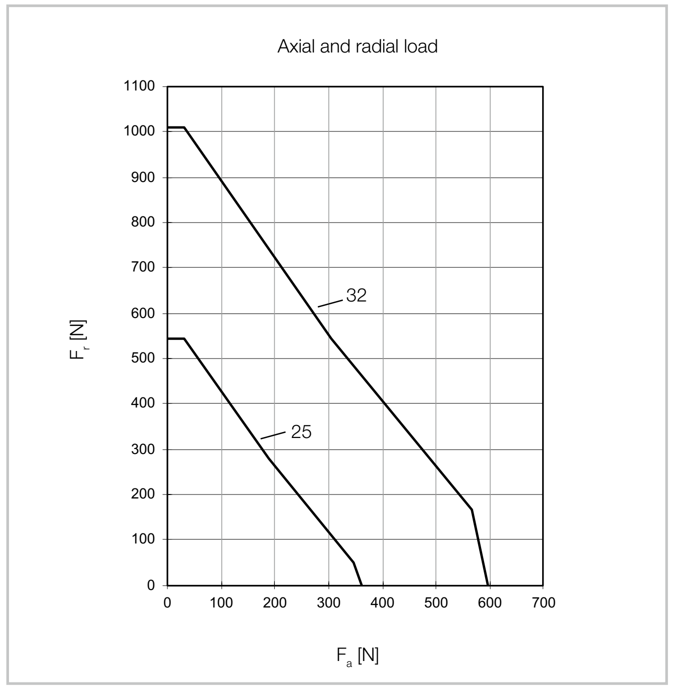


Illustration 2.11.8



• Housing detail

We recommend the following undercut on the customer flange.

Illustration 2.11.9

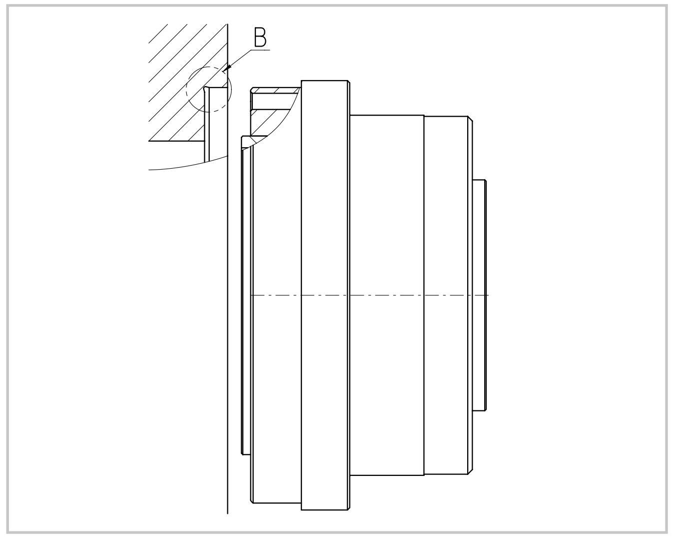
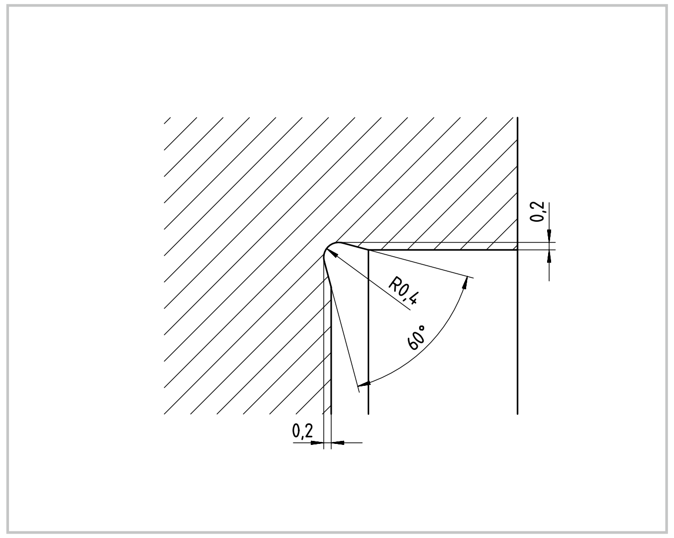


Illustration 2.11.10



- Materials and coatings used

Material:
Output bearing: Steel corrosion protected
Circular Spline (housing): Cast iron corrosion protected
Flexspline: bright steel
Wave Generator (hollow shaft): bright steel

Optional materials and coatings are available on request from Harmonic Drive SE.

Assembly

- Screw connection

Illustration 2.11.11

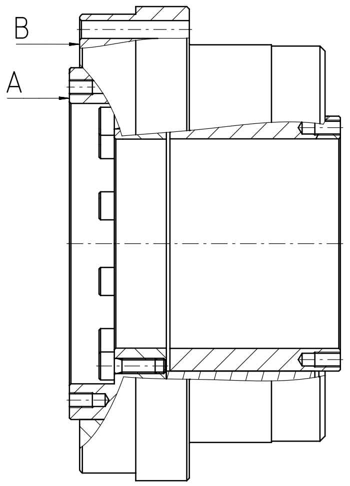


Table 2.11.13

	[Unit]	Screw connection A input flange		Screw connection B housing flange	
Size		25	32	25	32
Number of screws		12	12	12	12
Size of screws		M3	M4	M3	M4
Pitch circle diameter	[mm]	61.4	77.0	84.0	102.0
Screw tightening torque	[Nm]	2.0	4.5	2.0	4.5
Torque transmitting capacity	[Nm]	154	324	210	431

12.9 quality screws, friction coefficient μ = 0,15

Screw connection on the Wave Generator

Table 2.11.14

	[Unit]	Size	
		25	32
Number of screws		6	6
Size of screws		M3	M3
Pitch circle diameter	[mm]	45.5	60.0
Screw tightening torque	[Nm]	2.3	2.3
Torque transmitting capacity	[Nm]	51	64

Lubrication

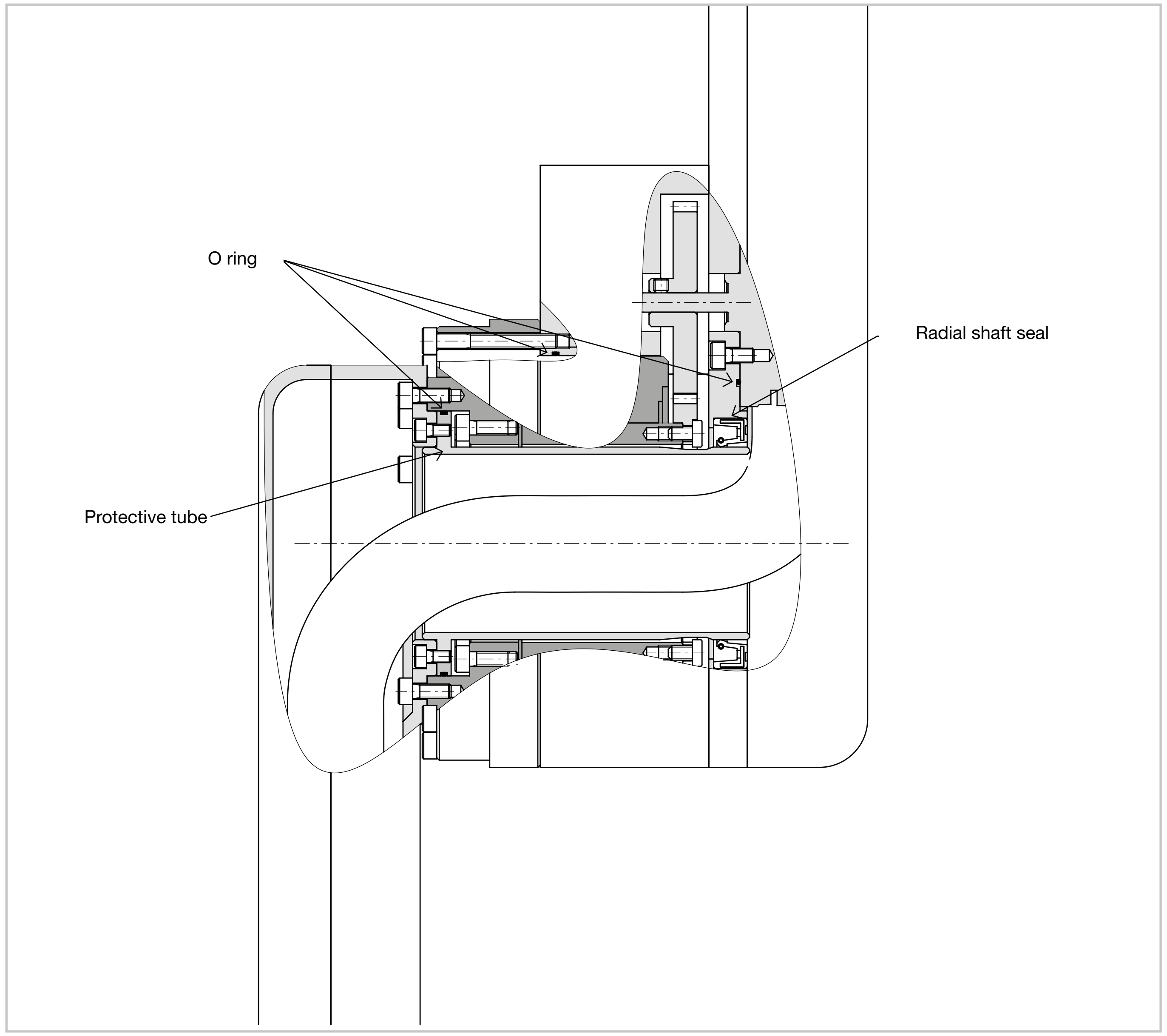
Grease lubrication is standard for the FBS-2UH Gears. They are supplied fully greased. Additional grease is not required during assembly. Harmonic Drive® SK-1A is used as lubricant. The cross roller bearing is greased with Harmonic Drive® 4BNo.2.

You will find more information on this in the Engineering data chapter.

Application example

The FBS-2UH Gear has no seal on the input side. The illustration shows an application example with integrated protective tube to protect the cable bushing. The rotary shaft seal runs on the slowly rotating protective tube and seals the gearbox to the housing. This reduces friction losses to a minimum. Please continue to provide O rings or surface sealants for static sealing of the gear.

Illustration 2.11.12



Engineering data
Harmonic Drive® Gears

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

Content

General

Notes for the user
At the beginning of the engineering process of your drive project with Harmonic Drive® Products we would like to point out general technical boundary conditions and special safety instructions as well as give recommendations for the design. You will also find a glossary explaining the technical parameters of our products.

This documentation is intended for planners and project engineers of the machine manufacturers. It can assist in the selection and calculation of gears, servo actuators and systems as well as accessories.

Notes on storage
Please keep this document for the entire life of the product, up to its disposal. Please hand over the documentation when reselling the product.

Additional documentation
Engineering data documentation for our drive systems will also be required. Harmonic Drive SE provides the complete documentation for its products on its website in PDF format.

www.harmonicdrive.co.uk

Third party systems
Documentation for parts supplied by third party suppliers, associated with Harmonic Drive® Components, is not included in our standard documentation and should be requested directly from these manufacturers.

Before commissioning gearboxes from Harmonic Drive SE with servo motors, we advise you to obtain the relevant documents for each device.

Safety Instructions

Please take note of the information and instructions in this document. Customised products may differ in technical detail. If in doubt, we recommend to contact the manufacturer, giving the type designation and serial number for clarification.

⚠ ATTENTION

The surface temperature of products exceed 55 °C. The hot surfaces should not be touched.

⚠ WARNING

Injury caused by moving or ejected parts:
Contact with moving parts or output elements and the ejection of loose parts (e.g. feather keys) can result in severe injury or death.
- Remove or carefully secure any loose parts
- Do not touch any moving parts
- Protect against all moving parts using the appropriate safety guards

⚠ ATTENTION

Use suitable lifting equipment to move and lift products with a weight > 20 kg.

INFO

Special versions of products may differ in the specification from the standard. Further applicable data from data sheets, catalogues and offers of the special version have to be considered.

• Intended use

Harmonic Drive® Products are intended for industrial or commercial applications.

Typical areas of application are robotics and handling, machine tools, semiconductor, medical equipment, wood working machines, mobile systems, packaging and food machines and similar machines.

The products may only be operated within the operating ranges and environmental conditions shown in the documentation (altitude, degree of protection, temperature range, etc).

Before commissioning of systems and machines including Harmonic Drive® Products, compliance with the Machinery Directive must be established.

• Improper use

The use of products outside the areas of application mentioned above or beyond the operating areas or environmental conditions described in the documentation is considered as improper use.

If incorrect products are installed or used in safety relevant applications, unintended operating states may occur in the application that can injure persons and/or cause material damage. The product may only be used in safety relevant applications if this use is explicitly specified in the product documentation. Harmonic Drive SE accepts no responsibility for damage caused by unintended use. The risks of improper use are solely with the user.

• Use in special application areas

The use of the products in one of the following application areas requires a risk assessment and approval by Harmonic Drive SE.

- Aerospace
- Areas at risk of explosion
- Machines specially constructed or used for a nuclear purpose whose breakdown might lead to the emission of radio activity
- Vacuum
- Household devices
- Medical equipment
- Devices which interact directly with the human body
- Machines or equipment for transporting or lifting people
- Special devices for use in fairgrounds or amusement parks

Declaration of conformity

In the sense of the EC Machine Directive Harmonic Drive® Gears are not partially completed machines but components, which do not fall under the scope of the EC Machine directive.

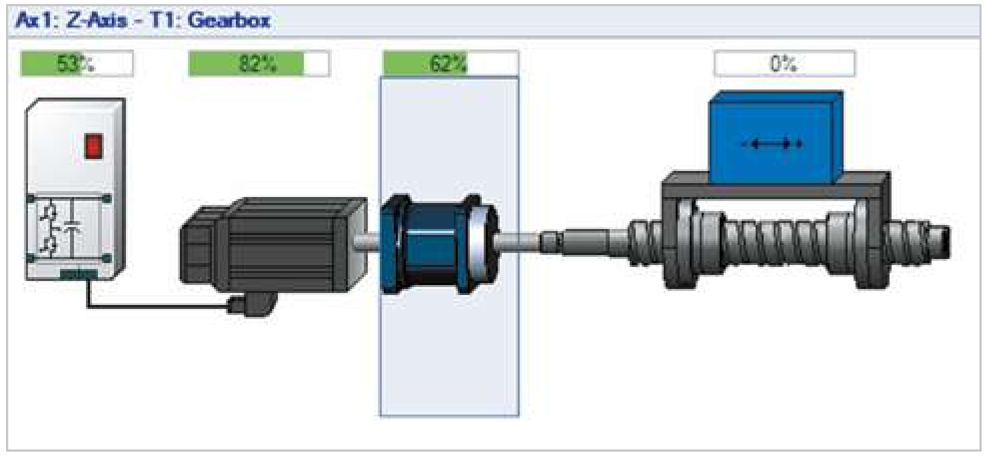
Essential health and safety requirements were considered in the design and manufacture of these gear component sets. This simplifies the implementation of the Machinery Directive by the end user for the machinery or the partly completed machinery. Commissioning of the machine or partly completed machine is prohibited until the end product conforms to the EC Machinery Directive.

Gear dimensioning

• Gear dimensioning via SERVOsoft®

For an optimal design of Harmonic Drive® Strain Wave Gears and Servo Actuators, our sales and project engineers use the SERVOsoft® actuator dimensioning program.

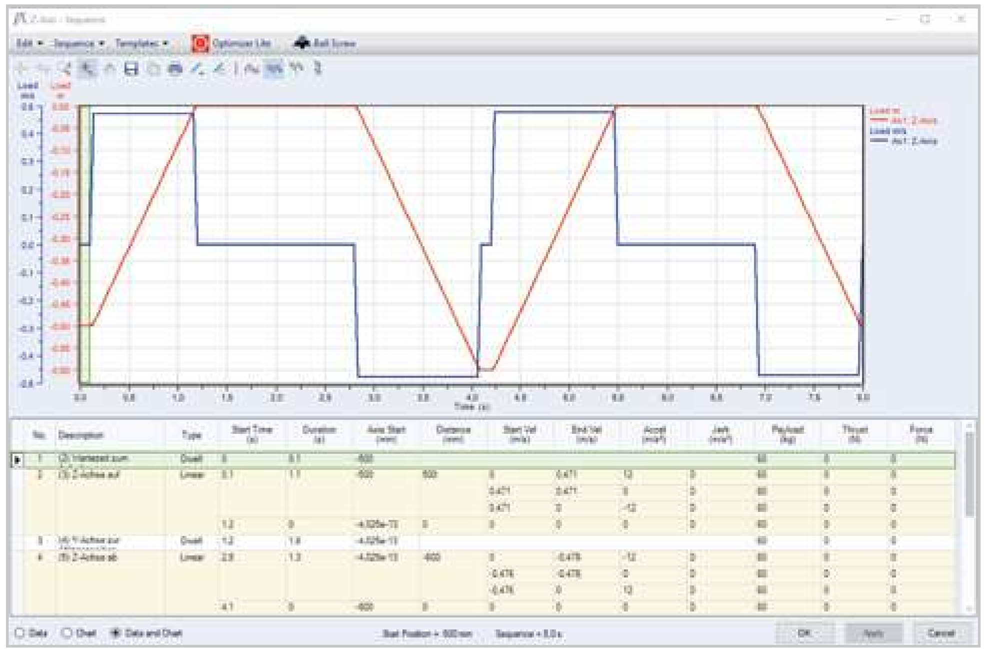
Illustration 3.1



The calculation with SERVOsoft® ensures that all components are correctly designed with regard to mechanical load and also all electrical data. For this purpose, a database was created with all relevant data of our gearboxes, motors, servo actuators and controllers.
Calculated margins are displayed in a way that is easy to understand in critcal applications.
Within the drive design SERVOsoft® helps to ensure your system is designed with sufficient safety margins on the one hand, but is also sensibly utilised and works efficiently on the other, taking into account all the load data and motion cycles entered. We create the load cycle of your machine for you according to your specification. Alternatively, do you have the load profile of your machine available as an Excel file or as a csv file? We will be able to integrate your load profile quickly and accurately into our simulation.

On request, you will receive a detailed list of all calculation results as well as the parts list of the selected drive components for your application.

Illustration 3.2



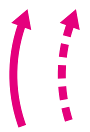
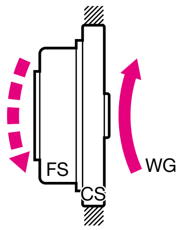
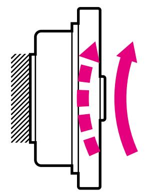
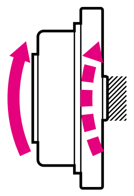
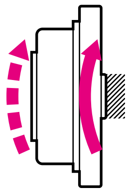
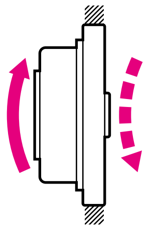
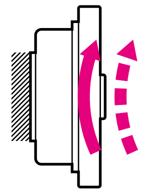
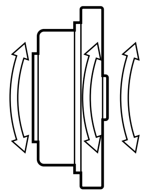
• Driving arrangements

Cup Type Gear

Harmonic Drive® Strain Wave Gears can be operated in various driving arrangements, resulting in different gear ratios.

Cup Type Gears are:
HFUC-2A, CSG-2A, CPL-2A, CSD-2A, HFUC-2UH, CSG-2UH, CPU, CSF Mini, CSF-2UP, CSF-ULW, CSD-2UH/2UF, PMG

Illustration 3.3

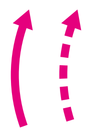
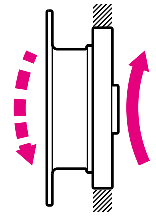
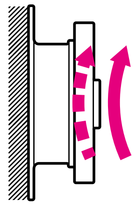
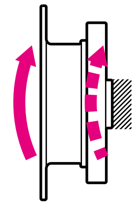
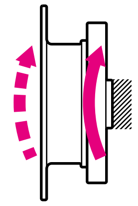
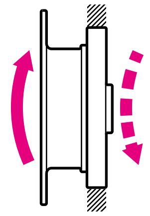
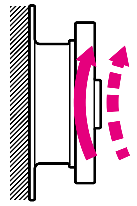
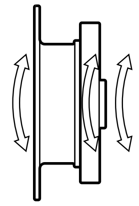
 **Input** **Output** i = Ratio according to technical data	 **(1) Speed reducer gear** Input: Wave Generator Output: Flexspline Fixed: Circular Spline	 **(2) Speed reducer gear** Input: Wave Generator Output: Circular Spline Fixed: Flexspline	 **(3) Speed reducer gear** Input: Flexspline Output: Circular Spline Fixed: Wave Generator
Ratio = $\frac{\text{Input speed}}{\text{Output speed}}$	Ratio = $-\frac{1}{i}$	Ratio = i + 1	Ratio = $\frac{i+1}{i}$
 **(4) Speed increaser gear** Input: Circular Spline Output: Flexspline Fixed: Wave Generator	 **(5) Speed increaser gear** Input: Flexspline Output: Wave Generator Fixed: Circular Spline	 **(6) Speed increaser gear** Input: Circular Spline Output: Wave Generator Fixed: Flexspline	 **(7) Differential gear** When the Wave Generator, Flexspline and Circular Spline rotate, combinations of (1) to (6) are possible.
Ratio = $\frac{i}{i+1}$	Ratio = $-\frac{1}{i}$	Ratio = $\frac{1}{i+1}$	

Silk Hat Type Gear

Harmonic Drive® Strain Wave Gears can be operated in various input configurations, resulting in different gear ratios.

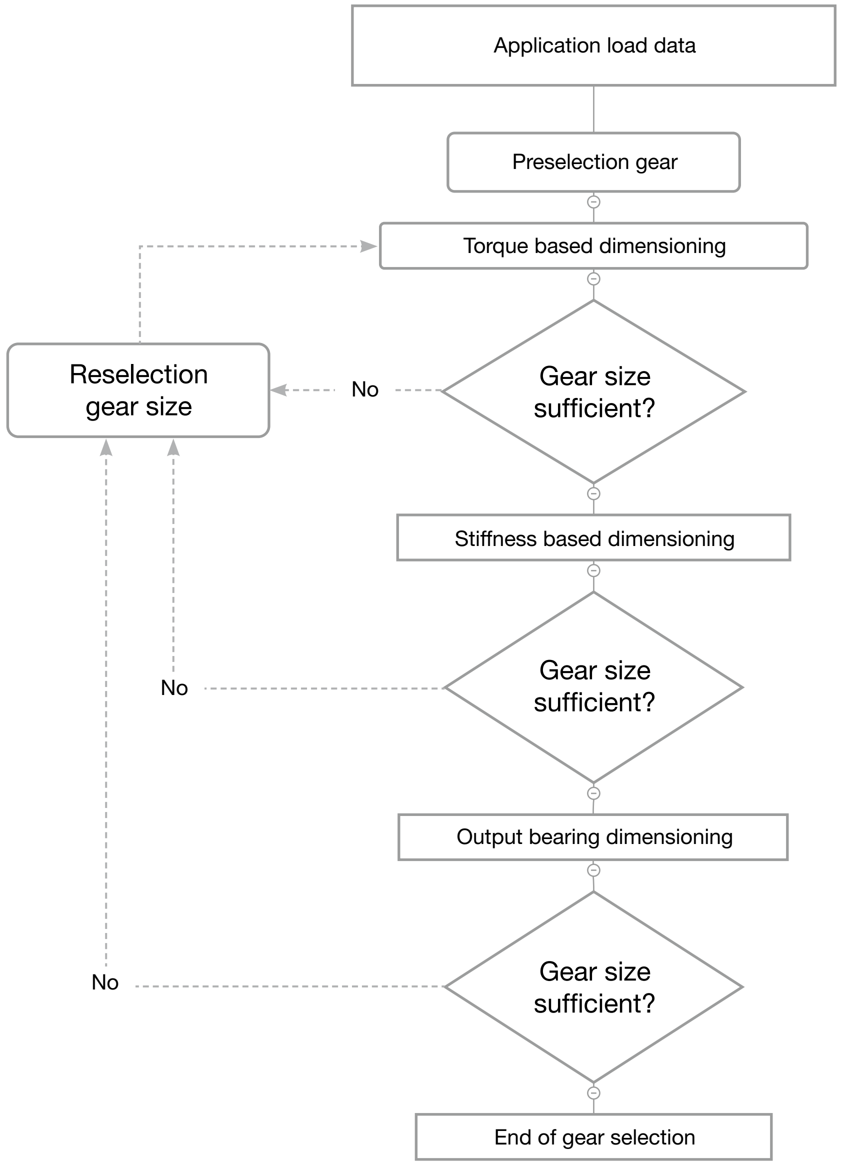
Silk Hat Type Gears are:
SHG-2A, SHG-2UH/2SO/2SH, SHD-2SH, HFUS-2A, HFUS-2UH/2SO/2SH

Illustration 3.4

 **Input** **Output** i = Ratio according to technical data	 **(1) Speed reducer gear** Input: Wave Generator Output: Flexspline Fixed: Circular Spline	 **(2) Speed reducer gear** Input: Wave Generator Output: Circular Spline Fixed: Flexspline	 **(3) Speed reducer gear** Input: Flexspline Output: Circular Spline Fixed: Wave Generator
Ratio = $\frac{\text{Input speed}}{\text{Output speed}}$	Ratio = $-\frac{1}{i}$	Ratio = i + 1	Ratio = $\frac{i+1}{i}$
 **(4) Speed increaser gear** Input: Circular Spline Output: Flexspline Fixed: Wave Generator	 **(5) Speed increaser gear** Input: Flexspline Output: Wave Generator Fixed: Circular Spline	 **(6) Speed increaser gear** Input: Circular Spline Output: Wave Generator Fixed: Flexspline	 **(7) Differential gear** When the Wave Generator, Flexspline and Circular Spline rotate, combinations of (1) to (6) are possible.
Ratio = $\frac{i}{i+1}$	Ratio = $-\frac{1}{i}$	Ratio = $\frac{1}{i+1}$	

• Dimensioning diagram

In principle, both torque and stiffness requirements should be taken into account in the design. For example, in robotics applications, the required torques are more decisive for the gear size, the torsional stiffness necessary for the process is often decisive in machine tool constructions. In addition, both the service life and the static safety of the output bearing should be calculated for the output bearings. We therefore recommend that the design is carried out according to the following diagram.



• Torque based dimensioning

Checking the permissible loads

Table 3.1 **Application load data**

	Symbol	[Unit]
Torque (Stage 1 ... n)	$T_1 ... T_n$	[Nm]
Duty time (Stage 1 ... n)	$t_1 ... t_n$	[s]
Dwell time	t_p	[s]
Output speed (Stage 1 ... n)	$n_1 ... n_n$	[rpm]
Maximum torque	T_{max}	[Nm]
Average torque	T_{av}	[Nm]
Maximum output speed	$n_{out\,max}$	[rpm]
Maximum Input speed	$n_{in\,max}$	[rpm]
Average output speed	$n_{out\,av}$	[rpm]
Average input speed	$n_{in\,av}$	[rpm]
Overload torque	T_k	[Nm]
Output speed at overload	n_k	[rpm]
Load time in case of overload	t_k	[s]

Illustration 3.5

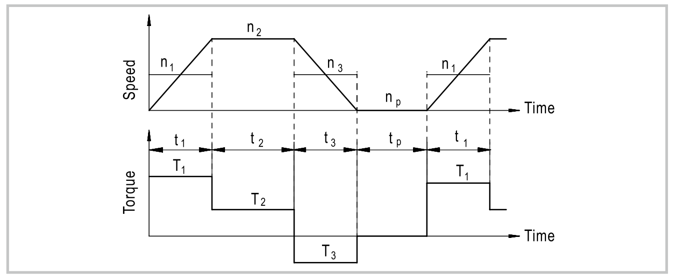


Table 3.2 **Permissible load of the gear**

	Symbol	[Unit]
Permissible average torque	T_A	[Nm]
Permissible repeated peak torque	T_R	[Nm]
Permissible momentary peak torque	T_M	[Nm]
Permissible average input speed	$n_{av\,(max)}$	[rpm]
Permissible maximum input speed	$n_{in\,(max)}$	[rpm]

Equation 3.1

Preselection of a gear under the condition
$T_{av} \leq T_A$

Equation 3.2

Calculation of the average output torque

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

Equation 3.3

Checking the permissible average Input speed
$n_{in\,av} \leq n_{av\,(max)}$

Equation 3.4

Calculation of the average output speed

$$n_{out\,av} = \frac{|n_1| \cdot t_1 + |n_2| \cdot t_2 + ... + |n_n| \cdot t_n}{t_1 + t_2 + ... + t_n + t_p}$$

Equation 3.5

Calculation of the average input speed

$$n_{in\,av} = i \cdot n_{out\,av}$$

Equation 3.6

Checking the permissible maximum input speed
$n_{in\,max} \leq n_{in\,(max)}$

Determination of the maximum input speed from load cycle

Equation 3.7

Checking the permissible repeated peak torque
$T_{max} \leq T_R$

Determination of the maximum torque from load cycle

Equation 3.8

Checking the permissible momentary peak torque
$T_K \leq T_M$

Determination of the overload torque from load cycle

Equation 3.9

Checking the allowed numbers of momentary peak torques
$N_K < 10^4$

Equation 3.10

Determining the number of momentary peak torques

$$N_K = \frac{10^4}{2 \cdot \frac{n_k}{60} \cdot i \cdot t_k}$$

Equation 3.11

Checking the Wave Generator bearing lifetime
Calculated lifetime L_{10h} > required lifetime $L_{10\,req.}$

$$L_{10} = L_n \cdot \frac{n_N}{n_{in\,av}} \cdot \left(\frac{T_N}{T_{av}}\right)^3$$

Table 3.3

Nominal lifetime and rated speed

Harmonic Drive® Series	Nominal lifetime L_n [h]	Rated speed n_N [rpm]
HFUC, HFUS, CPL, CSD, CPU, CSF Mini, SHD, CSF-2UP, CSF-ULW	7000	2000
CSG, SHG	10000	2000
FBS-2UH	5000	2000
PMG-5	3000	4500
PMG-8/ 11/ 14	3000	3500

Calculation example

The torque based dimensioning should be based on a reference cycle representing a typical load situation of the gear including acceleration and deceleration phases. The emergency stop torque can be estimated either from known application data in case of overload (e.g. emergency stop event) or using the nominal load and an overload factor.

Application load data

T_1 = 400 Nm	t_1 = 0.3 s	n_1 = 7 rpm
T_2 = 320 Nm	t_2 = 3.0 s	n_2 = 14 rpm
T_3 = 200 Nm	t_3 = 0.4 s	n_3 = 7 rpm
T_k = 1000 Nm	t_k = 0.15 s	n_k = 14 rpm
	t_p = 0.2 s	n_p = 0 rpm

required lifetime $L_{10\ req.}$ = 15000 h

Permissible load of the gear

Preselected gear	CSG-40-120-2A-GR
Rated torque	T_N = 382 Nm
Rated speed	n_N = 2000 rpm
Permissible average torque	T_A = 586 Nm
Permissible repeated peak torque	T_R = 802 Nm
Permissible momentary peak torque	T_M = 1530 Nm
Permissible average input speed	$n_{av\ (max)}$ = 3000 rpm
Permissible maximum Input speed	$n_{in\ (max)}$ = 4000 rpm

Preselection of the gear according to average output torque CSG-40-120-2A-GR

T_{av} = 319 Nm ≤ T_A = 586 Nm ✓

Determination of the average output torque

$$T_{av} = \sqrt[3]{\frac{7\text{ rpm} \cdot (400\text{ Nm})^3 \cdot 0.3\text{ s} + 14\text{ rpm} \cdot (320\text{ Nm})^3 \cdot 3\text{ s} + 7\text{ rpm} \cdot (200\text{ Nm})^3 \cdot 0.4\text{ s}}{7\text{ rpm} \cdot 0.3\text{ s} + 14\text{ rpm} \cdot 3\text{ s} + 7\text{ rpm} \cdot 0.4\text{ s}}}$$

T_{av} = 319 Nm

Checking the permissible average input speed

$n_{in\ av}$ = 1440 rpm ≤ $n_{av\ (max)}$ = 3000 rpm ✓

Determination of the average output speed

$$n_{out\ av} = \frac{7\text{ rpm} \cdot 0.3\text{ s} + 14\text{ rpm} \cdot 3\text{ s} + 7\text{ rpm} \cdot 0.4\text{ s}}{0.3\text{ s} + 3\text{ s} + 0.4\text{ s} + 0.2\text{ s}} = 12\text{ rpm}$$

Determination of the average input speed

$n_{in\ av}$ = 120 · 12 rpm = 1440 rpm

Checking the permissible maximum input speed

$n_{in\ max}$ = 1680 rpm ≤ $n_{in\ (max)}$ = 4000 rpm ✓

Determination of the maximum input speed from the load cycle

$n_{in\ max} = n_2 \cdot i$ = 14 rpm · 120 = 1680 rpm

Checking the permissible momentary peak torque

T_K = 1000 Nm ≤ T_M = 1530 Nm ✓

Determination of the overload torque from the load cycle

T_K = 1000 Nm

Checking the allowed numbers of momentary peak torques

N = 1190 ≤ $N_{k\ zul}$ = 10^4 ✓

Determination of the numbers of momentary peak torques

$$N_K = \frac{10^4}{2 \cdot \frac{14 \cdot 120}{60} \cdot 0.15} = 1190$$

Checking the Wave Generator Bearing lifetime

L_{10} = 23850 h > $L_{10\ req.}$ = 15000 h ✓

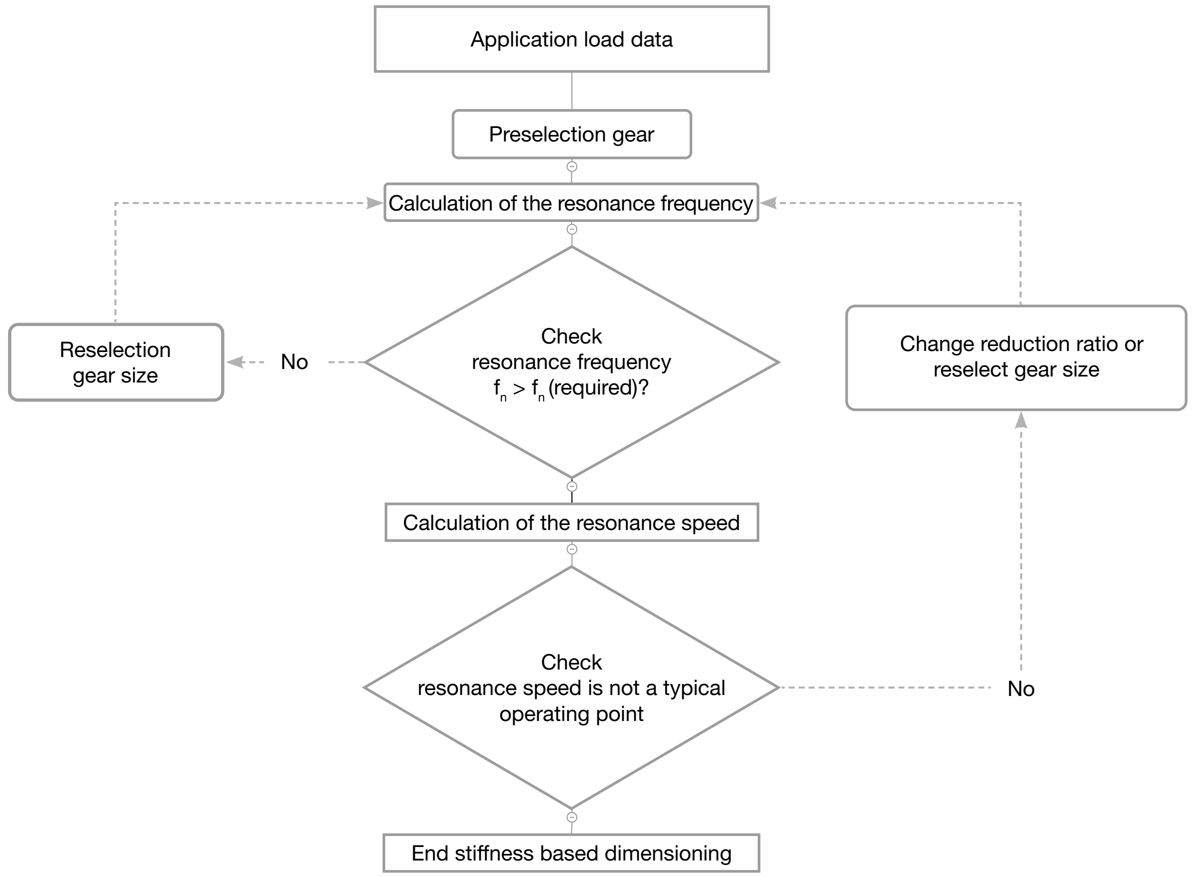
Determination of the Wave Generator Bearing lifetime

$$L_{10} = \frac{10000\text{ h} \cdot 2000\text{ rpm}}{1440\text{ rpm}} \cdot \left(\frac{382\text{ Nm}}{319\text{ Nm}}\right)^3$$

• Stiffness based dimensioning

Selection procedure

In addition to the "torque based dimensioning" selection procedure, we recommend performing a stiffness based dimensioning, which evaluates the ratio of the load moment of inertia to the stiffness of the gear and compares it to the application requirements.



Calculation of the resonance frequency

Assuming that the stiffness of the housing structure adapted to the gear is high compared to the gear stiffness, the resonance frequency of the system can be estimated with the following equation.**

Equation 3.12

$$f_n = \frac{1}{2\pi}\sqrt{\frac{K_1}{J}}$$

Table 3.4

Symbol	[Unit]	Designation	Note
f_n	[Hz]	Resonance frequency	
K_1	[Nm/rad]	Torsional stiffness gear K_1	See corresponding product chapter „Torsional stiffness"
J	[kgm²]	Load moment of inertia	From application

To reduce vibration of the system, the calculated resonance frequency should not fall below the following recommended minimum resonance frequencies depending on the application.

** If the stiffness of the housing structure adapted to the gear has a not negligible influence on the vibration behaviour, or if the load moment of inertia is variable over time (e.g. with mechanically coupled axles), please contact your Harmonic Drive SE sales contact. With the help of the multiple body simulation, these influences on the vibration behaviour of your drive solution can be mapped.

Table 3.5

Application	Recommended minimum resonance frequency f_n [Hz]
Slowly rotating turntables, base axes of slow moving welding robots (not laser welding), slowly rotating welding turntables, gantry robot axes	≥ 4
Base axes of revolute robots, hand axes of revolute robots with low requirements regarding dynamic performance, tool revolvers, tool magazines, swivelling and positioning axes in medical and measuring devices	≥ 8
Standard applications in general mechanical engineering, tilting axes, palette changers, high dynamic tool changers, -revolvers and -magazines, hand axes of revolute robots, scara robots, gantry robots, polishing robots, dynamic welding turntables, base axes of welding robots (laser welding), swivelling and positioning axes of medical equipment	≥ 15
B / C axes in 5 axis grinding machines, welding robot hand axes (laser welding), milling heads for plastics machining	≥ 20
C axes in turning machines, milling heads light metal machining, milling heads wood machining (chipboards etc.)	≥ 25
Milling heads for woodworking (hardwood etc.)	≥ 30

Calculation of the resonance speed

The resonance frequency of the drive system is the frequency at which the system tends to oscillate. The Harmonic Drive® Gear itself causes two amplitudes of vibration at each Wave Generator revolution. With this, the resonance speed of the system can be calculated.

Equation 3.13

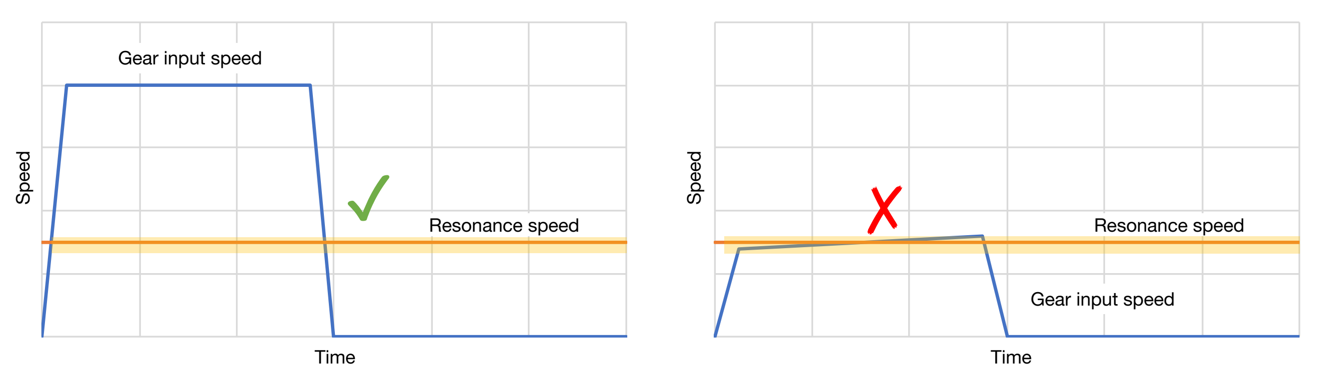
$$n_n\,[\text{rpm}] = \frac{f_n\,[\text{Hz}]}{2} \cdot 60$$

Table 3.6

Symbol	[Unit]	Description
n_n	[rpm]	Resonance speed
f_n	[Hz]	Resonance frequency

The resonance speed should either not be exceeded during operation, or it should be run through quickly, see Illustration 3.6. If possible, operating points of the system in the resonance speed range should be avoided. The resonance speed can be influenced with the help of the gear reduction ratio or the gear size.

Illustration 3.6



Selection example

The following is a selection example for a milling head application in woodworking.

Table 3.7

Preselected gear (Torque based dimensioning)	CSG-40-120-2A-GR
Torsional stiffness K_3 of the gear	130 · 10³ Nm/rad
Planned application	Milling head woodworking
Output side moment of inertia	7 kgm²
Recommended min. resonance frequency (from Table 3.5)	30 Hz

Equation 3.14

$$f_n = \frac{1}{2\pi}\sqrt{\frac{130 \cdot 10^3\,\text{Nm/rad}}{7\,\text{kgm}^2}} = 21.7\ \text{Hz}$$

According to stiffness based dimensioning, this size is too small for the application. Selecting the larger gear CSG-50-120-2A-GR results in the following resonance frequency.

Equation 3.15

$$f_n = \frac{1}{2\pi}\sqrt{\frac{250 \cdot 10^3\,\text{Nm/rad}}{7\,\text{kgm}^2}} = 30.1\ \text{Hz}$$

Due to the stiffness based dimensioning, the CSG-50-120-2A-GR gear is recommended.

The resonance speed at the gear input (motor side) is:

Equation 3.16

$$n_n\,[\text{rpm}] = \frac{30.1}{2} \cdot 60 = 903\ \text{rpm}$$

This speed should be passed through quickly during acceleration and deceleration or be outside the used speed range.

- ## Calculation of the torsional angle

The torsional angle of the gear under load can be calculated as follows:

Equation 3.17

For $T \leq T_1$:

$$\varphi = \frac{T}{K_1}$$

Equation 3.18

For $T_1 < T \leq T_2$

$$\varphi = \frac{T_1}{K_1} + \frac{T - T_1}{K_2}$$

Equation 3.19

For $T > T_2$:

$$\phi = \frac{T_1}{K_1} + \frac{T_2 - T_1}{K_2} + \frac{T - T_2}{K_3}$$

Table 3.8

Symbol	[Unit]	Designation	Note
φ	[rad]	Angle	
T	[Nm]	Load torque	
T_1	[rpm]	Limit torque 1	See chapter "Torsional stiffness" of corresponding product
T_2	[rpm]	Limit torque 2	See chapter "Torsional stiffness" of corresponding product
K_1	[Nm/rad]	Torsional stiffness until limit torque T_1	See chapter "Torsional stiffness" of corresponding product
K_2	[Nm/rad]	Torsional stiffness until limit torque T_2	See chapter "Torsional stiffness" of corresponding product
K_3	[Nm/rad]	Torsional stiffness above limit torque T_2	See chapter "Torsional stiffness" of corresponding product

Calculation example

Table 3.9

Gear	CSG-32-100-2UH
Load torque T	60 Nm
T_1	29 Nm
T_2	108 Nm
K_1	$67 \cdot 10^3$ Nm/rad
K_2	$110 \cdot 10^3$ Nm/rad
K_3	$120 \cdot 10^3$ Nm/rad

Equation 3.20

For $T_1 < T \leq T_2$:

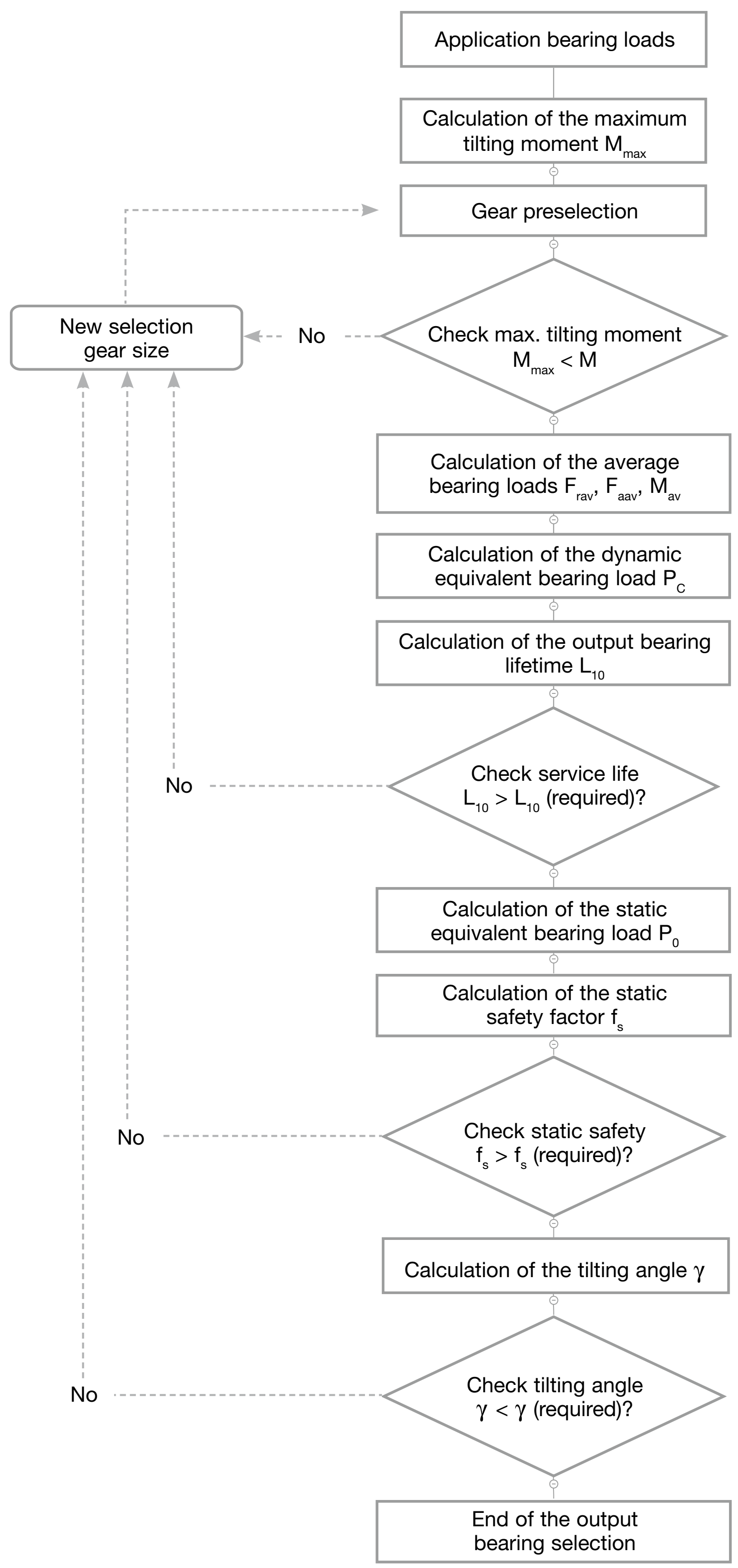
$$\varphi = \frac{29\ \text{Nm}}{67 \cdot 10^3\ \text{Nm/rad}} + \frac{60\ \text{Nm} - 29\ \text{Nm}}{110 \cdot 10^3\ \text{Nm/rad}} = 7.15 \cdot 10^{-4}\ \text{rad} = 2.5\ \text{arcmin}$$

with

$$\varphi\ [\text{arcmin}] = \varphi\ [\text{rad}]\ \frac{180}{\pi} \cdot 60$$

- ## Selection of the output bearing

Selection procedure



Dynamic load capacity

Calculation of the maximum tilting moment

The tilting moment is calculated from the radial force and the axial force acting on the output bearing. The permissible dynamic tilting moment of the bearing results from the permissible tilting angle of the gear component set in operation.

Illustration 3.7

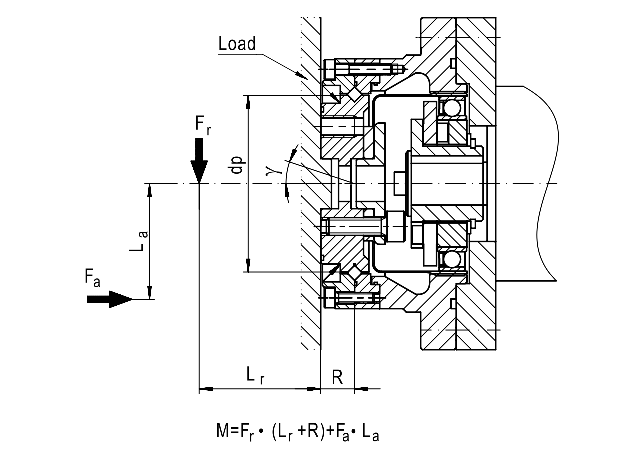


Table 3.10

Symbol	[Unit]	Designation
M_{max}		Max. dynamic tilting moment
$F_{r\,max}$	[N]	Max. dynamic radial force
$F_{a\,max}$	[N]	Max. dynamic axial force
L_r, L_a	[mm]	Distances according to Illustration 3.7
R	[mm]	Distance bearing centre / output flange, See chapter „Output bearing“

Equation 3.21

$$M_{max} = F_{r\,max} \cdot (L_r + R) + F_{a\,max} \cdot L_a$$

Calculation of the average bearing loads

Illustration 3.8

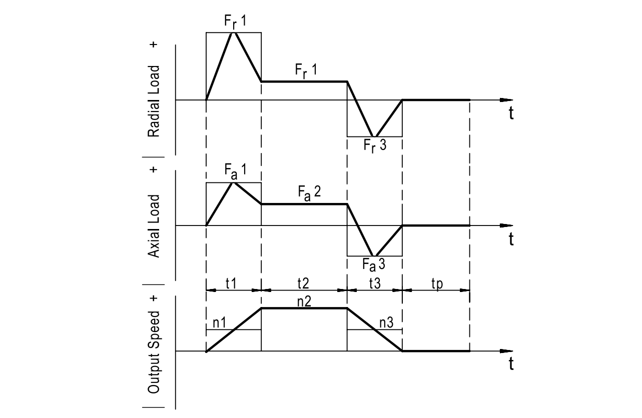


Table 3.11

Symbol	[Unit]	Designation
$F_{r\,av}$	[N]	Average radial force
$F_{a\,av}$	[N]	Average axial force
M_{av}	[Nm]	Average tilting moment
$t_{1...n}$	[s]	Duration of phase 1…n
$F_{r\,1...n}$	[N]	Radial load in phase 1 … n
$F_{a\,1...n}$	[N]	Axial load in phase 1 … n
$n_{1...n}$	[rpm]	Speed in phase 1…n

Determination of the average radial force

Equation 3.22

$$F_{r\,av} = \left(\frac{|n_1| \cdot t_1 (|F_{r1}|)^B + |n_2| \cdot t_2 (|F_{r2}|)^B + \ldots + |n_n| \cdot t_n (|F_{rn}|)^B}{|n_1| \cdot t_1 + |n_2| \cdot t_2 + \ldots + |n_n| \cdot t_n} \right)^{\frac{1}{B}}$$

Determination of the average axial force

Equation 3.23

$$F_{a\,av} = \left(\frac{|n_1| \cdot t_1 (|F_{a1}|)^B + |n_2| \cdot t_2 (|F_{a2}|)^B + \ldots + |n_n| \cdot t_n (|F_{an}|)^B}{|n_1| \cdot t_1 + |n_2| \cdot t_2 + \ldots + |n_n| \cdot t_n} \right)^{\frac{1}{B}}$$

Determination of the average tilting moment

Equation 3.24

$$M_{av} = \left(\frac{|n_1| \cdot t_1 (|M_1|)^B + |n_2| \cdot t_2 (|M_2|)^B + \ldots + |n_n| \cdot t_n (|M_n|)^B}{|n_1| \cdot t_1 + |n_2| \cdot t_2 + \ldots + |n_n| \cdot t_n} \right)^{\frac{1}{B}}$$

Determination of the average output speed

Equation 3.25

$$n_{av} = \frac{|n_1| \cdot t_1 + |n_2| \cdot t_2 + \ldots + |n_n| \cdot t_n}{t_1 + t_2 + \ldots + t_n + t_p}$$

Calculation of the dynamic equivalent bearing load

Axial and radial force factors

The axial and radial force factors evaluate the influence of the axial force on the bearing load.

Table 3.12

Symbol	x	y
$\frac{F_{a\,av}}{F_{r\,av} + 2 \cdot M_{av}/d_p} \leq 1.5$	1	0,45
$\frac{F_{a\,av}}{F_{r\,av} + 2 \cdot M_{av}/d_p} > 1.5$	0,67	0,67

Table 3.13

Symbol	[Unit]	Designation	Note
$F_{r\,av}$	[N]	Average radial force	See chapter “Calculation of the average bearing loads“
$F_{a\,av}$	[N]	Average axial force	See chapter “Calculation of the average bearing loads“
M_{av}	[Nm]	Average tilting moment	See chapter “Calculation of the average bearing loads“
d_p	[mm]	Pitch circle diameter output bearing	See corresponding product chapter, “Output bearing“

Dynamic equivalent bearing load

A composite radial, axial and tilting moment load is replaced by the dynamic equivalent bearing load, which causes the same stress in the bearing.

Equation 3.26

$$P_C = x \cdot \left(F_{r\,av} + \frac{2M_{av}}{d_p} \right) + y \cdot F_{a\,av}$$

Table 3.14

Symbol	[Unit]	Designation	Note
P_C	[N]	Dynamic equivalent bearing load	See Equation
$F_{r\,av}$	[N]	Average radial force	See chapter „Calculation of the average bearing loads“
$F_{a\,av}$	[N]	Average axial force	See chapter “Calculation of the average bearing loads“
M_{av}	[Nm]	Average tilting moment	See chapter “Calculation of the average bearing loads“
d_p	[mm]	Pitch circle diameter output bearing	See corresponding product chapter, “Output bearing“

Calculation of output bearing life

Lifetime at continuous operation

At continuous operation, but also at dynamic cycles where the dynamic bearing loads have been converted to an average bearing load, the following equation can be used to calculate the life of the output bearing.

Equation 3.27

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

Table 3.15

Symbol	[Unit]	Designation	Note
L_{10}	[h]	Calculated lifetime of the output bearing for 10 % failure probability	See Equation 3.27
n_{av}	[N]	Average output speed	From application
C	[N]	Dynamic load rating	See corresponding product chapter "Output bearing"
f_w	-	Operating factor	See Table 3.17
P_C	[N]	Equivalent dynamic bearing load	See Equation 3.26
B	-	Bearing type exponent	See Table 3.18

Calculation at the output bearing lifetime

Lifetime at oscillating motion
At oscillating motion with an constant oscillating cycle, the following equation can be used.

Equation 3.28

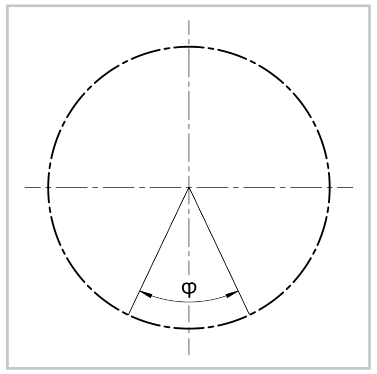
$$L_{10} = \frac{10^6}{60 \cdot n_1} \cdot \frac{180}{\varphi} \cdot \left(\frac{C}{f_w \cdot P_c}\right)^B$$

Table 3.16

Symbol	[Unit]	Designation	Note
L_{10}	[h]	Calculated lifetime of the output bearing for 10% failure probability	See Equation 3.28
n_1	[N]	Number of oscillations per minute	From application
φ	[°]	Oscillating angle	From application
C	[N]	Dynamic load rating	See corresponding product chapter "Output bearing"
f_w	-	Operating factor	See Table 3.17
P_c	[N]	Dynamic equivalent load	See Equation 3.27
B	-	Bearing type exponent	See Table 3.18

Oscillating angle
At oscillating angles < 5° fretting corrosion may occur due to insufficient lubrication. In this case please contact our sales engineer for countermeasures.

Illustration 3.9



Operating factor
The operating factor takes into account the influence of the load conditions on the bearing lifetime.

Table 3.17

Load conditions	Operating factor f_w [ ]
No impact loads or vibrations	1.0 … 1.2
Normal loads	1.2 … 1.5
Impact loads or vibrations	1.5 … 3.0

Bearing type exponent
The bearing type exponent takes into account the type of output bearing on the bearing life.

Table 3.18

Bearing type	Bearing type exponent B [ ]
Cross roller bearing	$\frac{10}{3}$
Four point contact bearing	3

Static load capacity
In the case of a static load on the output bearing or to evaluate overload cases with a stationary or slowly rotating load, the static safety factor is calculated with the following equation:

Equation 3.29

$$f_s = \frac{C_0}{P_0}$$

Table 3.19

Symbol	[Unit]	Designation	Note
f_s	-	Static safety factor	See Table 3.21
C_0	[N]	Static load rating	See corresponding product chapter "Output bearing"
P_0	[N]	Static equivalent bearing load	See Equation 3.30

Equation 3.30

$$P_0 = F_{r\,max} + \frac{2M_{max}}{d_p} + 0.44\, F_{a\,max}$$

Table 3.20

Symbol	[Unit]	Designation	Note
P_0	[N]	Static equivalent bearing load	See Equation 3.27
$F_{r\,max}$	[N]	Static radial force	From application
M_{max}	[Nm]	Static tilting moment	From application
d_p	[m]	Pitch circle diameter output bearing	See corresponding product chapter "Output bearing"
$F_{a\,max}$	[N]	Static axial force	From application

Table 3.21

Operating conditions of the bearing	Recommended static safety factor f_S [ ]
Normal operating conditions	≥1.5
In case vibrations or impacts	≥2
For the highest demands on transmission accuracy	≥3

Tilting angle at the loaded output bearing
The output bearing can tilt under the influence of a tilting moment. The requirements of the application may result in a limit value for the permissible tilting. In these cases, the expected tilting angle should be calculated. If the expected tilting angle is too high for the application, a larger gear size with higher output bearing tilting stiffness should be selected.

Equation 3.31

$$\gamma = \frac{M}{K_B}$$

Table 3.22

Symbol	[Unit]	Designation	Note
γ	[arcmin]	Tilting angle at the loaded output bearing	See Equation 3.31
M	[Nm]	Tilting moment on the output bearing	From application
K_B	[Nm/arcmin]	Tilting stiffness of the output bearing	See corresponding product chapter "Output bearing"

Design guidelines

• Design integration

We recommend observing the following notes on the design integration of the components Wave Generator (WG), Circular Spline (CS) and Flexspline (FS) of the gear component set.

Illustration 3.10

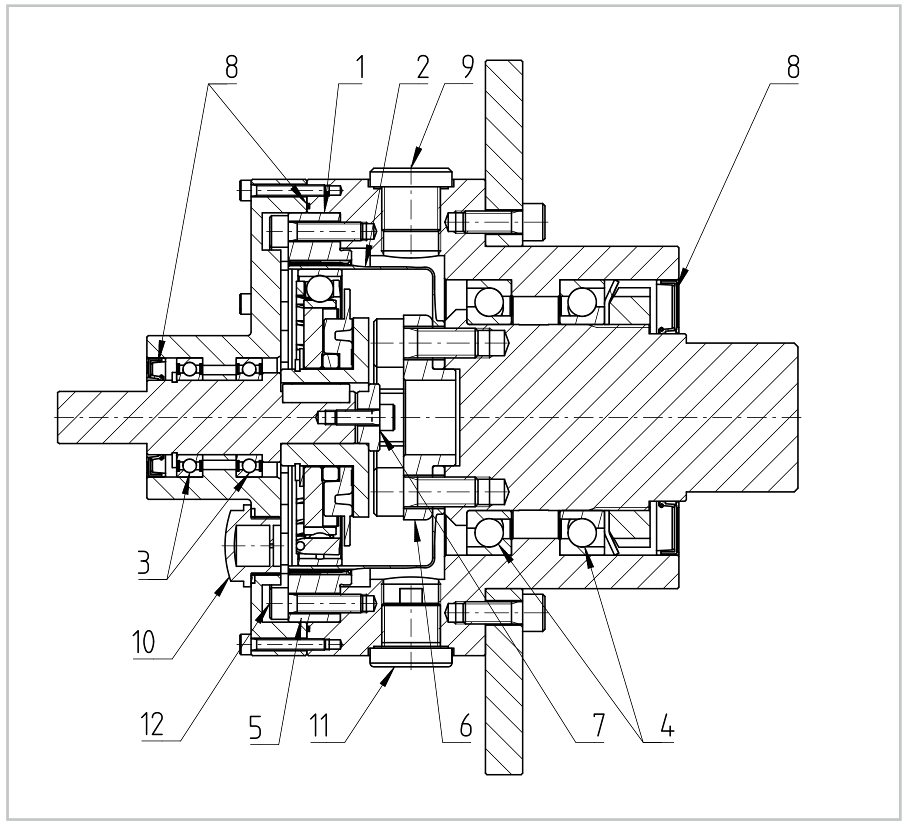
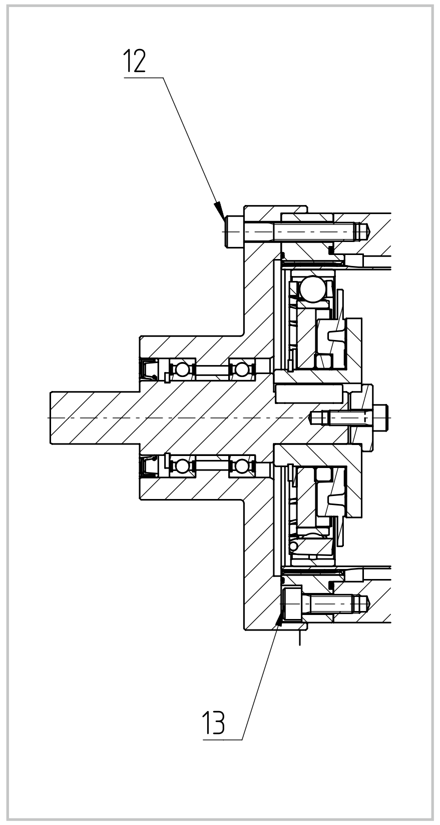


Illustration 3.11



Accuracy of the housing components and adapter flanges

(1) Concentric alignment of the components input shaft, WG, CS, FS, output shaft and housing, taking into account the assembly tolerances specified in the product chapters.
Recommendation: The bearing seats, centering diameters and end faces relevant for the assembly tolerances should preferably be manufactured in a single setup, i.e. without reclamping the respective component.

Housing dimensions

(2) During operation, the flexible part of the Flexspline is radially and axially deformed. The minimum housing clearance (MHC) given in the confirmation drawing should be taken into account for the design.

Bearing of the input and output shaft

(3) Double bearing of the input shaft.
Note: The input shaft must be supported independently. The Wave Generator bearing must not be used as support for the input shaft.

(4) Backlash free preloaded bearing setup of the output shaft.
For Harmonic Drive® Gear Component Sets, the output shaft bearing support must be provided by the customer. Harmonic Drive® Gears with output bearing have a tilt resistant cross roller or four point contact bearing which serves both for the aligned guidance of the Flexspline, as well as for the support of external forces and tilting moments.

Assembly sequence and screw connections

The assembly sequence of the gear components must already be planned during the design process. It must be taken into account that the gear components WG and FS induce a radial force on the CS in the assembled state. This radial force causes an elliptical deformation of the CS which impacts the transmission accuracy if the CS is not already firmly screwed to the housing at the time of WG assembly. Therefore, the CS should already be fixed to the housing by means of screws during the joining of FS and WG.

Circular Spline

(5) In the design shown in Illustration 3.10, the CS is already completely fixed by means of the screws (12) before the FS and WG are assembled.
Illustration 3.11 shows an alternative design with smaller outer diameter. Here, the CS is preassembled by means of four screws (13) in countersunk holes. Then the FS and WG are mounted. Finally, the unit consisting of the preassembled input flange, input bearing and WG is joined and fastened by means of screws (12). While the screws (12) transmit the gear torque, the screws (13) are used for CS preassembly.

If none of the above methods of installation is possible for design reasons, please contact Harmonic Drive SE for alternatives.

Flexspline, clamping ring

(6) For most cup type gear component sets we recommend the use of a clamping ring with rounded edges, consider the respective product chapter. Clamping ring, bolt heads or any washers must not hinder the deformation of the Flexspline base during operation.

Wave Generator

(7) During operation, axial forces act on the Wave Generator (as well as on the Flexspline). For interlocking shaft hub connections, such as keys or splined shafts, we recommend axial clamping of the Wave Generator against a shaft shoulder or similar, to prevent wear in the interlocking connection. Please note that the housing volume behind the Wave Generator should be kept compact so that the grease is available for lubricating the gear.

Sealing

(8) We recommend sealing with O rings and radial shaft seals, regardless of the lubricant selected. If necessary, surface sealants should be applied on the flange surfaces. For alternative sealing solutions, please consult Harmonic Drive SE.

Oil lubrication

In case of oil lubrication, inlet screw (9), oil sight glass (10), and (magnetic) drain screw (11) should be applied.

• Axial loads on Wave Generator and Flexspline

The deformation of the Flexspline generates an axial force on the Wave Generator acting in the direction of the Flexspline flange when a Harmonic Drive® Gear is used in reduction operation (torque input via the Wave Generator). In reverse operation, e.g. during deceleration of moments of inertia on the output side, the axial force acts in the opposite direction. The corresponding reaction force acts on the Flexspline.

In any case, the axial force must be supported by the bearing of the input shaft (or the motor shaft). The Wave Generator must therefore be fixed on the input shaft in axial direction. At closed Harmonic Drive® Gears with input bearing, the axial force is supported internally.

Illustration 3.12

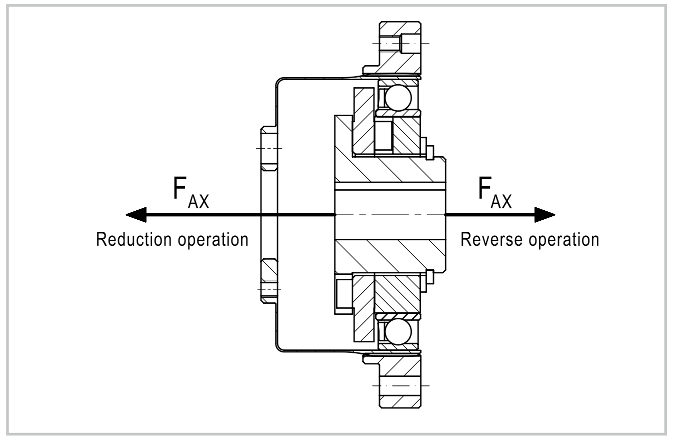


Table 3.23

Ratio		
30	$F_{AX} = 2 \cdot \frac{T}{D} \cdot \mu \cdot \tan 32°$	Equation 3.32
50	$F_{AX} = 2 \cdot \frac{T}{D} \cdot \mu \cdot \tan 30° + 2\mu PF$	Equation 3.33
80 … 160	$F_{AX} = 2 \cdot \frac{T}{D} \cdot \mu \cdot \tan 20° + 2\mu PF$	Equation 3.34

with:

Table 3.24

Symbol	[Unit]	Designation
F_{AX}	[N]	Axial force
D	[m]	Pitch circle diameter of the toothing (Size) · 0.00254
T	[Nm]	Output torque
μ	[ ]	0.07; Friction coefficient
2μPF	[N]	Additional force (only CSD and SHD)

Table 3.25

[N]

Series	Factor 2μPF						
	14	17	20	25	32	40	50
CSD-2A, -2UH, -2UF	2.1	4.1	5.6	9.8	16.0	24.0	39.0
SHD-2SH	1.2	3.3	5.6	9.3	16.0	24.0	-
All other Series				0			

Example

Size 32 (CSD-32-50)
Output torque = 151 Nm
Friction coefficient μ = 0.07

$$F_{AX} = \frac{151\ \text{Nm}}{(32 \cdot 0.00254)\ \text{m}} \cdot 0.07 \cdot \tan 30° + 16\ \text{N}$$

$F_{AX} = 166$ N

• Bearing support of input and output shafts

Both the input and output shaft of the Harmonic Drive® Gear Component Sets must be carefully supported to take up all axial and radial loads that may occur. On the input side, the radial play of the bearings used should not exceed the ISO standard of classes “C2” or “normal”. When mounting the Wave Generator on a motor shaft, please observe the information on motor shaft tolerances in the chapter “Assembly tolerances” of the respective product chapter. To make full use of the gear accuracy, we recommend an axially and radially preloaded and stiff bearing support design of the output shaft. The following illustrations show examples of correct bearing arrangements for the Wave Generator (WG), Flexspline (FS) and Circular Spline (CS) components. See also the notes in the respective product chapter “Assembly tolerances”.

1. WG: gear input, FS: output, CS: fixed to the housing. The left WG support bearing is in side the Flexspline cup. Inner ring of the left WG support bearing is rotating.
2. WG: gear input, FS: output, CS: fixed to the housing. The left WG support bearing is in the Flexspline cup. Outer ring of the left WG support bearing is rotating.
3. WG: gear input, FS: output, CS: fixed to the housing. The left WG support bearing is located outside the actual gear space.
4. WG: gear input, FS: output, CS: fixed to the housing. Example of typical connection of a motor.
5. WG: gear input, FS: fixed to the housing. CS: output. Input shaft passed through FS flange.
6. WG: gear input, FS rotatably mounted, CS: output. This design can be used, for example, for a creed/rapid mode solution (with integrated coupling/brake). When the WG is connected to the FS via a clutch (not shown), the CS rotates as a gear output with WG speed (i = 1). If the clutch is released and the FS is connected to the housing instead by means of a brake, the CS acts as a gear output in reduction operation.
7. Example of an application as differential gear. WG: phase adjustment, FS: input, CS: output. Note: for design reasons, Harmonic Drive® Flat Gears are also very suitable for differential applications.

Illustration 3.13

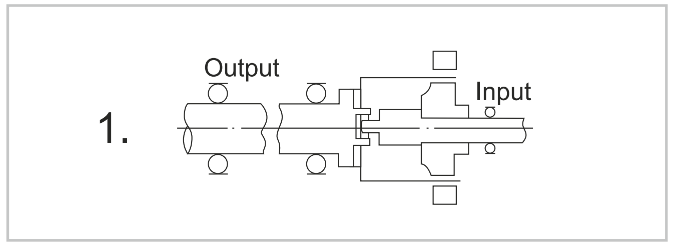


Illustration 3.14

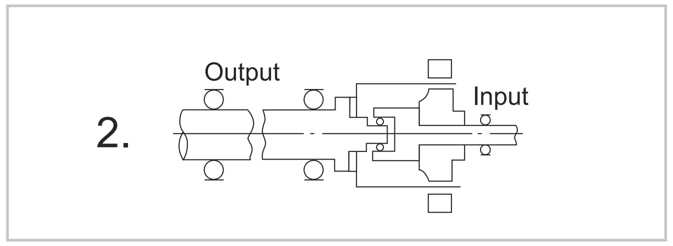


Illustration 3.15

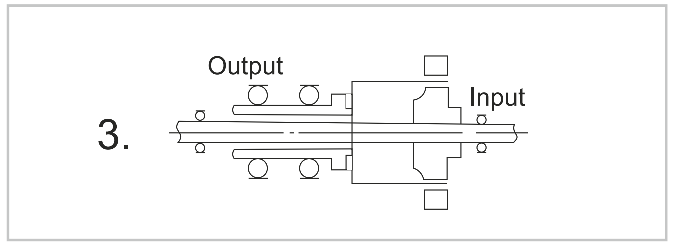


Illustration 3.16

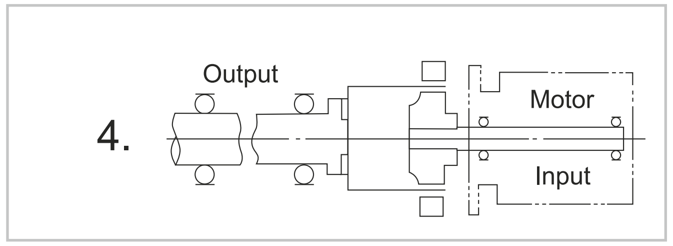


Illustration 3.17

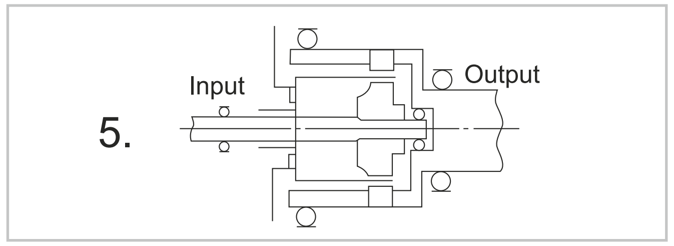


Illustration 3.18

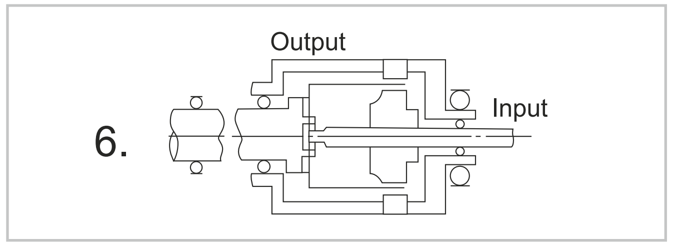
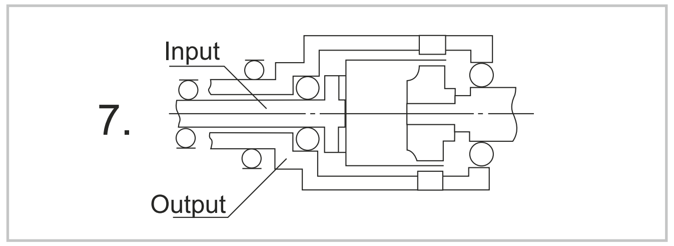


Illustration 3.19



Screw connections

The high torque capacity of a Harmonic Drive® Gear requires a secure screw connection of the Flexspline and the Circular Spline. The following points should be considered:

- The calculation of screw connections should be based on VDI directive 2230.
- The above mentioned directive states, among other things:
  - Output shaft and nut thread must have sufficient strength.
  - The flange material must withstand the contact pressure of the screw heads.
  - The roughness of the flange surfaces should be as low as possible to minimise settling losses.
  - The clamping length ratio (thickness of the connecting flange/diameter of the screws) should be as large as possible.
- The screws should be quality 12.9, unless the screw calculation allows other qualities.
- Unless otherwise stated, the transmittable torques of the Circular Spline and Flexspline connections given in the product chapters apply to metric socket head screws with standard thread according to ISO 4762, uncoated, oiled, with $\mu_{tot.}$ = 0.12 with completely cleaned, degreased and dried contact surfaces (friction coefficient μ_k = 0.15).
- The screws should be tightened with suitable tools such as torque wrench or similar (tightening factor 1.4).
- Washers, wedge lock washers or similar should generally not be used. However, they may be used if confirmed by the screw calculation.
- Toothed lock washers, spring washers or similar should not be used.
- Friction shims can be used to increase friction. Please consult Harmonic Drive SE if necessary.
- All screw connections should be secured against loosening, for example with threadlocker.

Wave Generator

The Wave Generator is the input element of Harmonic Drive® Strain Wave Gears. For gears without integrated input bearing, the Wave Generator is supplied as a separate element in the packaging. Depending on the size and design of the Wave Generator, it is connected to the input or motor shaft by means of a set screw, clamping set, keyway or axial screw connection. Customised connections such as spline profiles are also possible.

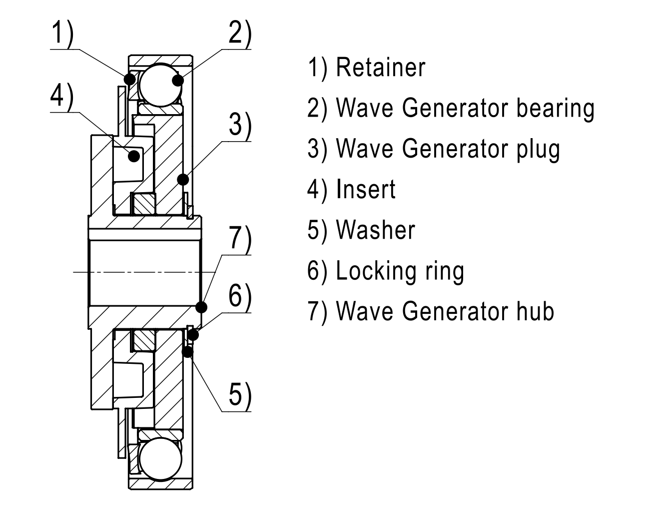
The Wave Generator can be supplied with an integrated Oldham coupling or as a Solid Wave Generator without an integrated Oldham coupling. If available, the Wave Generator variant with Oldham coupling is shown in the variable drawings of the catalogue. However, all products can also be designed with a Solid Wave Generator, see chapter “Modifications of the Wave Generator”. The design with Solid Wave Generator can bring a cost advantage, especially for higher quantities. Please consult Harmonic Drive SE.

Wave Generator with Oldham coupling

The Oldham coupling is used to compensate for coaxiality and angular errors at the gear input. Therefore, when using a Wave Generator with Oldham coupling, the requirements on the accuracy of the customer’s housing components are lower than when using Solid Wave Generators, see the respective product chapter “Assembly tolerances”.

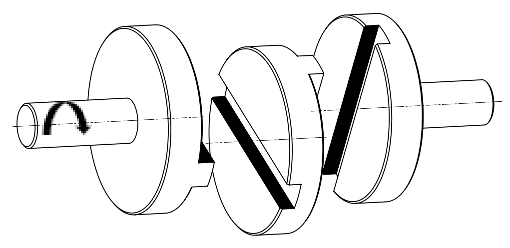
Wave Generator with Oldham coupling

Illustration 3.20



Principle of an Oldham coupling

Illustration 3.21



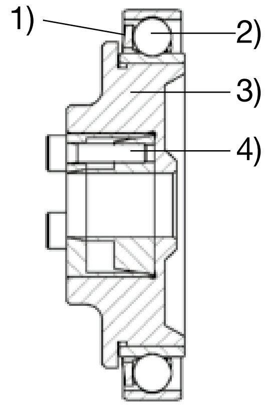
Solid Wave Generator

The Solid Wave Generator is directly connected to the input shaft without a compensating element. When using a Solid Wave Generator, the requirements on the accuracy of the customer’s housing components are higher than when using a Wave Generator with Oldham coupling, see the respective product chapter “Assembly tolerances”. The use of a Solid Wave Generator can be useful in the following situations:

- „Large“ input shaft diameter
- Higher quantities (cost reduction by saving the Oldham coupling)
- Need for input solutions that are completely backlash free, e.g. when using stepper motors

Illustration 3.22

Solid Wave Generator



1) Retainer
2) Wave Generator bearing
3) Wave Generator plug
4) Clamping set (optionally included in the scope of delivery), alternatively also e.g. keyway connection

Modifications of the Wave Generator

The following table gives an overview of the Wave Generator versions of Harmonic Drive® Strain Wave Gears with a customised Wave Generator design shown in the catalogue. All products shown in the catalogue "with Oldham coupling" can also be supplied with customised Solid Wave Generator.

You will find further design options for the Wave Generator in the chapter "Individual solutions".

Bore diameter

The following Illustration 3.23 and Table 3.26 show the possible bore diameters of the Wave Generator.

Possible shapes: Round, with keyway, splined hub

Illustration 3.23

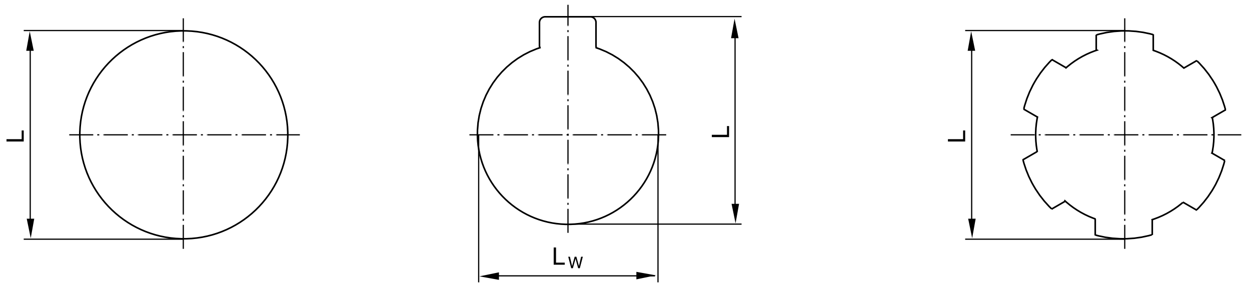


Table 3.26 **[mm]**

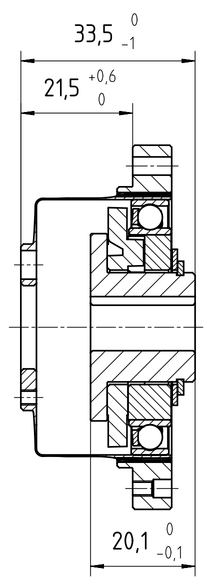
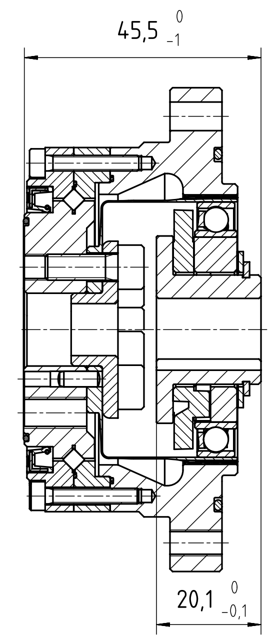
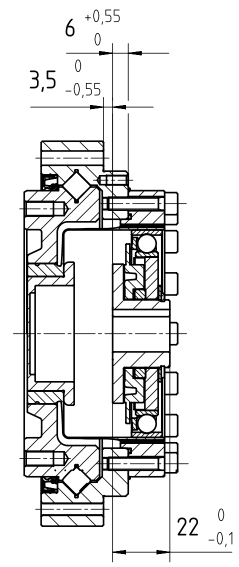
		Size															
		3	5	8	11	14	17	20	25	32	40	45	50	58	65	80	90
Wave Generator with Oldham coupling	L max.	-	-	-	-	8	10	13	15	15	20	20	20	25	30	35	37
	L, L_W 1) Catalogue vers.	-	-	3	5	6	8	9	11	14	14	19	19	22	24	28	28
Solid Wave Generator	L max.	2.5	6	10	12	17	20	23	28	36	42	47	52	60	67	72	84
	L_W 1) max.	-	-	8	10	12	13	17	22	28	34	39	44	50	56	61	73

1) Keyway DIN 6885 T1

Axial position of the Wave Generator

The Wave Generator must be mounted at a defined axial position relative to the Flexspline. This position can be defined by a shaft shoulder on the gearbox input shaft. In case of a shaft shoulder that is defined by the motor shaft, the prescribed axial position of the Wave Generator is ensured by adjusting the thickness of the adapter flange and/or the length of the Wave Generator (customised Wave Generator). For the positioning of the Wave Generator on a shaft shoulder, the shoulder must have a sufficient height, considering the components chamfers. As due to tolerance chains the axial position of the shaft should may vary, the axial position of the Wave Generator in assembled state has to be checked and eventually be corrected with the help of shims. If the Wave Generator is mounted on the input shaft (motor shaft), e.g. by means of a clamping set and without an axial stop or shaft shoulder, the axial position should be carefully checked. The tolerance of the axial position always points in the direction of the Flexspline flange, see the following examples for dimensioning. We recommend setting the axial position of the Wave Generator to the centre dimension.

Table 3.27 **[mm]**

Gear component set	Gear with output bearing	Gear with output bearing Special case CPU-M
		

Example: Gear component set
In the example shown, the prescribed distance between the end surfaces of the Flexspline flange and Wave Generator is 33.5 0/-1 mm (centre dimension = 33 ±0.5 mm). In addition, the distance between the end faces of the Flexspline flange and the Circular Spline, in the example 21.5 +0.6/0 mm (centre dimension = 21.8 ±0.3 mm). The length of the Wave Generator is 20.1 0/-0.1 mm.

Example: Gear with output bearing
In the example shown, the prescribed distance between the end faces of the output flange and Wave Generator is 45.5 0/-1 mm (centre dimension = 45 ±0.5 mm). The length of the Wave Generator is 20.1 0/-0.1 mm. For some gearboxes with output bearings, the axial position of the Wave Generator is also specified relative to the face of the Circular Spline.

Example: Gear with output bearing, Special case Series CPU-M
In this series, the dimensions L and M take into account the axial position of the Wave Generator, see the corresponding drawing in the product chapter. As in the examples shown above, the direction of the tolerance points in the direction of the Flexspline flange. In the example shown, the prescribed distance between the end faces of the housing flange and Wave Generator is 3.5 0/-0.55 mm (centre dimension = 3.225 ±0.275 mm) or 6 +0.55/0 mm (centre dimension = 6.275±0.275 mm), depending on the selected adapter flange type or reference surface on the housing. The length of the Wave Generator is 22 0/-0.1 mm.

• Assembly

When using a clamping set as a Wave Generator fixation, the screws of the clamping set should be tightened crosswise in approx. five steps up to the torque indicated on the Harmonic Drive® confirmation drawing. Illustration 3.24 shows two possible clamping set designs.

Illustration 3.24

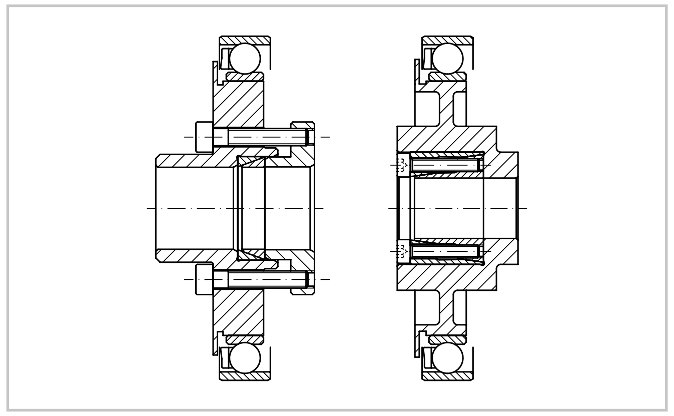
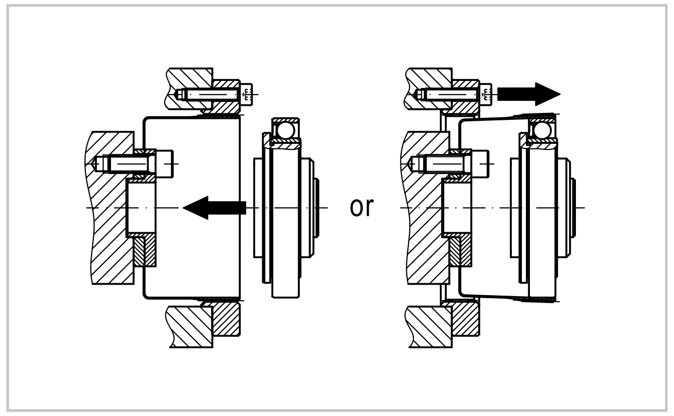


Illustration 3.25



Assembly of the gear component set

We recommend that the assembly of the gear component set is preferably carried out according to the scheme shown in Illustration 3.25. The illustration on the right shows an alternative method. For further instructions, see also chapter "Design integration".

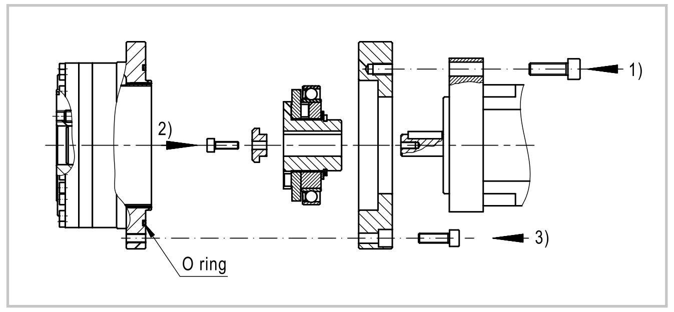
Motor assembly

If the centering diameter of the motor is smaller than the diameter of the Wave Generator's major axis shown in Table 3.28, the assembly must be carried out according to Illustration 3.26. Otherwise, the assembly can also be carried out according to Illustration 3.27.

Table 3.28 **[mm]**

	Size														
	5	8	11	14	17	20	25	32	40	45	50	58	65	80	90
Approx. Ø Wave Generator main axis	14	21	28	36	43	50	63	82	100	114	125	146	164	202	227

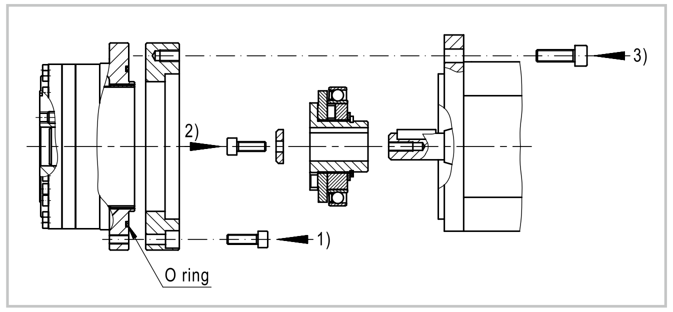
Illustration 3.26



Assembly steps according to Illustration 3.26:

1) Mounting the adapter flange to the motor
2) Mounting the Wave Generator to the motor shaft
3) Mounting of the adapter flange including motor to the gear with output bearing.

Illustration 3.27



Assembly steps according to Illustration 3.27:

1) Mounting the adapter flange to the gears with output bearing.
2) Mounting the Wave Generator to the motor shaft.
3) Mounting the motor to the adapter flange.

• Lubrication

Influence of the lubricant on the performance data

Harmonic Drive® Products achieve the specified performance data and properties with the lubricants named in the catalogue in the standard ambient temperature range (0 °C to 40 °C). Harmonic Drive SE can only guarantee the data mentioned in the catalogue if the Harmonic Drive® Greases or the mineral oils mentioned are used which have been approved for the respective product. Lubricants and lubricant quantities other than those recommended by Harmonic Drive SE should be qualified by means of prototype tests if required.
When using lubricants that are not recommended in the catalogue or approved in writing for the application, the warranty claim is lost.

Grease lubrication

Depending on the product, size and temperature range of the application, the appropriate Harmonic Drive® Grease should be selected. The assigned standard lubricant is indicated in the respective product chapter.

Harmonic Drive® Grease SK-1A
This grease is characterised by high wear resistance and efficiency combined with excellent sealing performance and is a standard grease for many Harmonic Drive® Gear Series.

Harmonic Drive® Grease SK-2
This grease was developed as a standard grease especially for the smaller gear sizes.

Harmonic Drive® Grease Flexolub®-A1
This grease features excellent wear resistance and efficiency and is well suited for operation at lower operating temperatures. It is the standard lubricant for the CPU Series.

Harmonic Drive® Grease 4BNo.2
This grease features high load carrying capacity and good efficiency and can be used within a wide operating temperature range. It is a special lubricant used for high service life requirements in the CSG and SHG increased performance gears.

Attention!!
The Harmonic Drive® Greases Flexolub®-A1 and 4BNo.2 become relatively fluid during operation. When using these greases, the design must therefore be oil tight. Due to the special properties of these greases, a small amount of base oil leakage at the radial shaft seals cannot be completely excluded.

Table 3.29

Feature	SK-1A	SK-2	Flexolub®-A1	4BNo.2
Operating temperature range	0 °C ... +40 °C	0 °C ... +40 °C	-40 °C ... +70 °C	-10 °C ... +70 °C
Base oil	Mineral oil	Mineral oil	PAO/ Ester oil	Synthetic oil
Thickener	Lithium soap	Lithium soap	Lithium soap	Polyurea
Consistency class (NLGI)	2	2	1	1,5
Base oil viscosity (40 °C; 100 °C)	37 ; 5.9 mm²/s	37 ; 5.9 mm²/s	25 ; 5.2 mm²/s	50 ; 12 mm²/s
Drop point	197 °C	198 °C	180 °C	247 °C
Colour	yellow	green	beige	light yellow
Maximum storage time in airtight container	5 years			
Lifetime	o	o	●	●
Wear resistance	o	o	●	●
Low temperature performance	△	△	●	o
High temperature performance	△	△	o	●
Leakage safety	●	●	△	o

● excellent o good △ should be checked depending on the application

Safety data sheets and technical data sheets are available on our website in the downloads section.

Running in process when using Harmonic Drive® Greases

The Harmonic Drive® Greases are ideally suited for the lubrication of Harmonic Drive® Products.
The following measures can improve the life of the lubricant:

1. During lubrication
   The consistency of Harmonic Drive® Greases is firmer during storage than during operation. Note that the consistency may vary due to the storage time. Before lubricating, mix the grease to soften the consistency.

2. Running in process
   The running in process before the gear is fully loaded softens the grease and promotes an ideal distribution of the grease in the gear and the contact surfaces to be lubricated. Especially for Harmonic Drive® Grease 4B No.2 the running in process is important.

The following running in process is recommended:

- Operate the gear for a period of about 20 minutes or longer without load or with a very low load. Select the largest possible output rotation angle.
- For this purpose, select an input speed of ideally about 1000 rpm (but not higher than 3000 rpm at the maximum).
- Keep the internal operating temperature below 80 °C. Take care to avoid a steep rise in temperature during the running in process. Mounting the gear to the surrounding structure improves the dissipation of generated heat and avoids excessive heating of the lubricant.

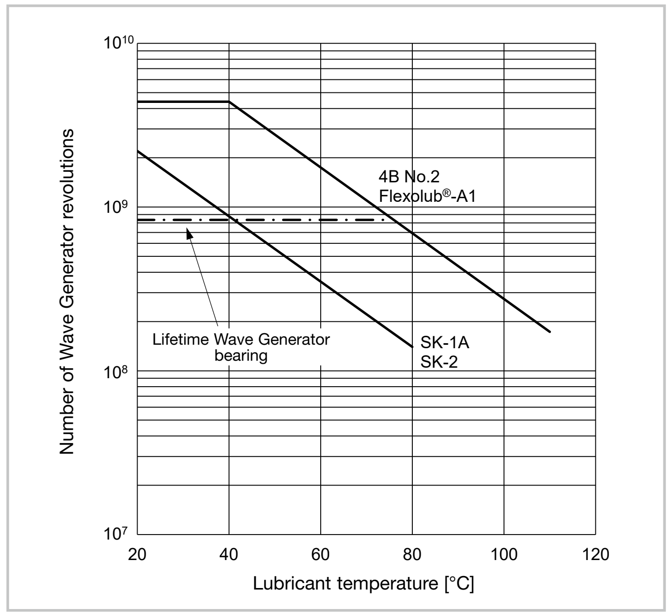
Please contact us if you have any questions regarding the handling of the Harmonic Drive® Greases.

Grease change

When operating the strain wave gears under regular operating conditions (average ambient temperatures ≤ 40 °C, average application loads ≤ rated torque or rated speed), the initial lubrication (applied at the factory or by the customer, depending on the product) is sufficient for lifetime lubrication of the gear. However, in case of long term high lubricant temperatures, a high load on the gearbox or a long operating time, a grease change may become necessary. The grease change intervals can be determined according to Illustration 3.28 and the following equations.

Usually, refilling the grease into the gear without cleaning the gear is sufficient. New grease should be filled into the Flexspline and the Wave Generator ball bearing. In the case of a complete grease change, the gear should be removed, cleaned and then relubricated.

Illustration 3.28



Lubricant service life in Wave Generator revolutions

Equation 3.35

$$L_{GT} = L_{GTn} \cdot \left(\frac{T_N}{T_{av}}\right)^3$$

Lubricant service life in hours

Equation 3.36

$$L_{GT,h}\,[h] = \frac{L_{GT}}{n_{av}\,[rpm]} \cdot \frac{1}{60}$$

Table 3.30

Symbol	[Unit]	Designation	Note
L_{GT}	[h]	Number of Wave Generator revolutions until grease change at application torque	-
L_{GTn}	-	Number of Wave Generator revolutions until grease change at rated torque	See diagram
$L_{GT,h}$ [h]	[h]	Operating time until grease change in hours	-
T_N	[Nm]	Rated torque of the gear	See product data
T_{av}	[Nm]	Average torque of the application	From application
n_{av}	[rpm]	Average input speed of the application	From application

Example

Table 3.31

Gear	[Unit]	CSG-17-80-2UH
Lubricant	[ ]	SK-2
Rated torque	[T_N]	29 [Nm]
Average torque of the application	[T_{av}]	35 [Nm]
Average input speed of the application	[n_{av}]	300 [rpm]
Lubricant temperature	[Θ]	40 [°C]

From diagram:
Number of Wave Generator revolutions until grease change at rated torque:

Equation 3.37

$$L_{GTn} = 8.5 \cdot 10^8$$

Number of Wave Generator revolutions until grease change at application torque:

Equation 3.38

$$L_{GT} = 8.5 \cdot 10^8 \cdot \left(\frac{29\ Nm}{35\ Nm}\right)^3 = 4.83 \cdot 10^8$$

Operating time until grease change in hours

Equation 3.39

$$L_{GH,h} = \frac{4.83 \cdot 10^8}{300} \cdot \frac{1}{1/\min 60/h} = 26862\ h$$

Lubricants for special operating conditions

Table 3.32 contains examples of lubricants for special operating conditions. In individual cases, depending on the application, other lubricants may be recommended. When using Harmonic Drive® Greases in the extended operating temperature range, the permissible performance data of the gears will be reduced.
When using non-standard lubricants, the performance data of the gears cannot be guaranteed. We recommend an application specific approval of non-standard lubricants on the basis of own tests.

Table 3.32

Application	Type	Manufacturer, Designation	Extended operating temperature range [1]
Wide temperature range	Grease	Harmonic Drive SE, Flexolub®-A1	-40 °C … 120 °C [2), 3), 5)]
Low temperature	Grease	Harmonic Drive SE, Flexolub®-M0	-50 °C … 40 °C [2), 5)]
High temperature	Grease	Exxonmobil, Mobilgrease 28	-5 °C … 160 °C [2)]
	Oil	Exxonmobil, Mobil SHC 626	-5 °C … 140 °C [2)]
Food/pharmaceutical industry	Grease	Bechem, Berulub FG-H 2 SL	-40 °C … 120 °C [2), 4)]

1) Operating temperature = Lubricant temperature
2) Application tests recommended
3) Compatibility tested for Harmonic Drive® Gears with HFUC technology in Size 14 … 58
4) NSF-H1 certification. For food compatibility, output and support bearings must be lubricated with this lubricant in addition to the gear.
5) If the lubricant temperature exceeds 70 °C, the permissible performance data of the gears may be reduced, please consult Harmonic Drive SE.

Oil lubrication

For most applications with Harmonic Drive® Gears, grease lubrication is recommended. In certain applications, e.g. with high input speeds or predominant operation in only one direction of rotation, oil lubrication may be useful. For design information, please refer to the chapter “Design Integration” and to the respective product chapter regarding “lube holes” that may have to be considered in the Flexspline. Harmonic Drive® Gears with oil lubrication are customised special designs. For regular temperature conditions we generally recommend industrial gear oils (EP - Extreme Pressure) with class ISO VG 68. The following types are recommended as gear oil.

Table 3.33

Manufacturer	General	Klüber	Mobil	Castrol	Shell
Designation	Industrial gear oil (EP extreme pressure) ISO VG 68	Syntheso D 68 EP	Mobilgear 600 XP 68	Optigear BM 68	Omala S2 G 68

Oil change intervals

Table 3.34

First change	After 100 operating hours
Subsequent changes	Every 1000 operating hours

When using a magnetic oil drain plug, the first oil change can be omitted, please consult Harmonic Drive SE.

Assembly instructions

• Preparation for assembly

Gear assembly must be carried out with great care and in a clean environment. Make sure that no impurities get into the gear during assembly.

General notes
In order to establish a sufficient friction coefficient, the surfaces to be screwed must be cleaned, degreased and dried before assembly. If nothing else is defined (by means of screw calculation), the screws should be mounted without washers and comply with strength class 12.9.

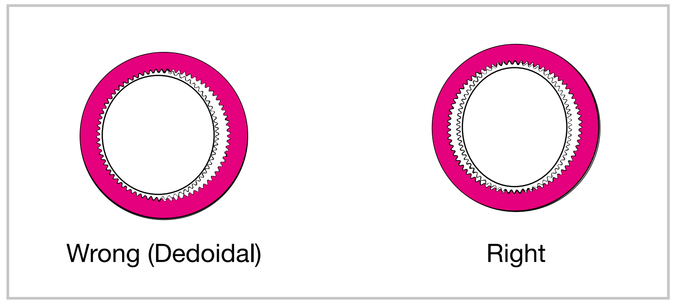
Assembly auxiliaries
We recommend the use of the following assembly aids or equivalent products. Please follow the manufacturer's instructions for use. Assembly aids must not get into the gear.

- Surface sealant: Loctite 518, Loxeal 28-10. Recommended for all flange surfaces if no O ring seal is applicable.
- Threadlocker: Loctite 243, Loxeal 55-03. Hard to loose and sealing.
- Assembly paste: Klüber Q NB 50. Recommended for O rings that may pop out of their groove during mounting. All other O rings should be lightly coated with the gearbox grease before assembly.
- Adhesive: Loctite 638. Can be used for glued, hard to loose shaft hub connections between motor shaft and Wave Generator (hub), if this is indicated on the confirmation drawing.

• Checking the correct assembly

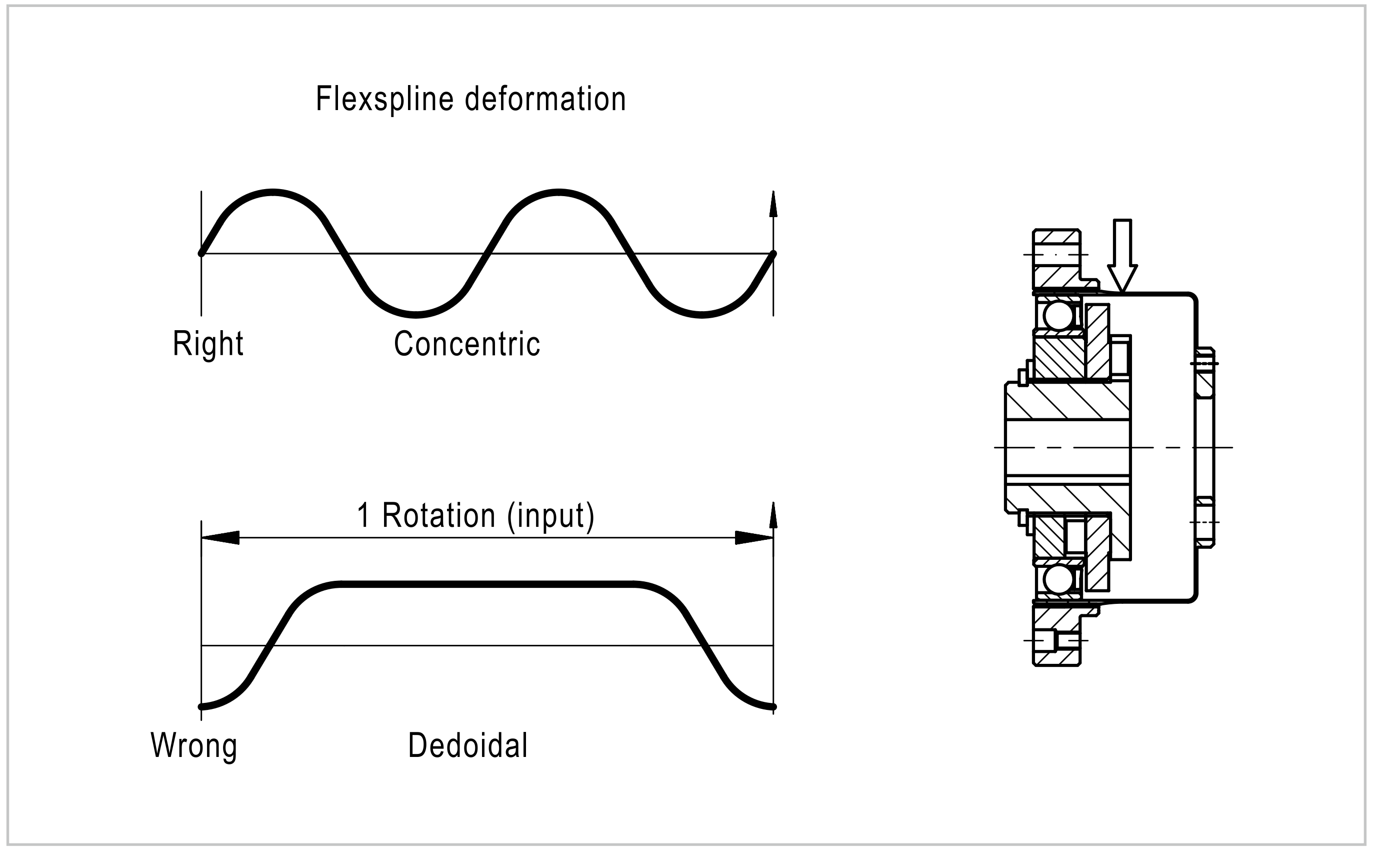
In rare cases, the gear may be assembled incorrectly with asymmetrical tooth engagement (Dedoidal), as shown in Illustration 3.29. Dedoidal can also occur when the gear teeth ratchet on one side due to overload.

Illustration 3.29



The correct assembly can be checked as follows:

Illustration 3.30



- By visual inspection, checking in particular the symmetrical tooth engagement.
- If the gear engagement area is not visible during assembly, the gear can be turned by hand on the input shaft by hand. Uneven rotation indicates incorrect assembly ("Dedoidal").
- An unusually high motor current consumption indicates incorrect tooth engagement when the motor is coupled.
- A dial gauge can be placed on the surface of the Flexspline through a test hole in the housing.
- Nearly sinusoidal movements of the Flexspline surface, as shown in Illustration 3.30, are an indication of a correct assembly.

Glossary

Ambient operating temperature [°C]
Specifies the temperature range permitted for normal operation.

Average input speed $n_{av\ (max)}$ [rpm]
Maximum permissible average gear input speed.

Average torque T_A [Nm]
When a variable load is applied to the gear, the average torque should be calculated for the complete operating cycle. This value should not exceed the specified T_A limit.

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, eventually leading to a rupture at the bottom of the Flexspline. This is defined as buckling torque. When the Flexspline buckles, early failure of the Harmonic Drive® Gear will occur. The values for buckling torque can be provided on demand by Harmonic Drive SE.

Dynamic axial force $F_{A\ dyn\ (max)}$ [N]
With the bearing rotating, this is the maximum allowable axial load with no additional radial forces or tilting moments applied.

Dynamic load rating C [N]
Maximum dynamic load that can be supported by the output bearing before permanent damage may occur.

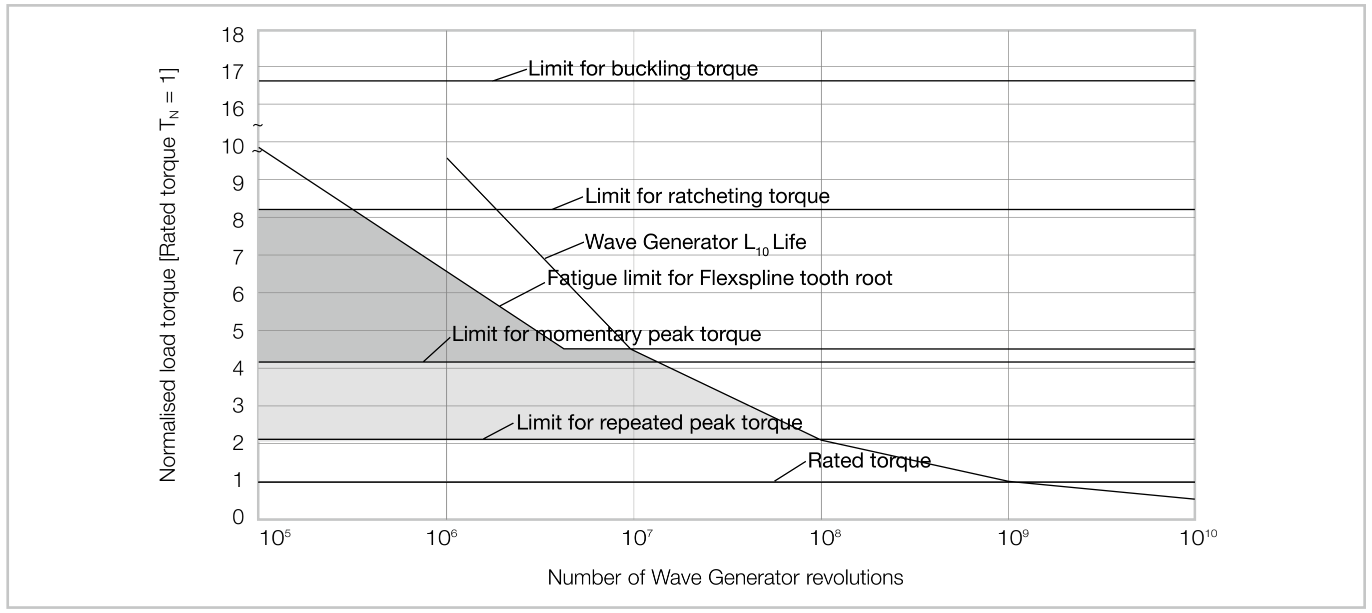
Dynamic radial force $F_{R\ dyn\ (max)}$ [N]
With the bearing rotating, this is the maximum allowable radial load with no additional axial forces or tilting moments applied.

Dynamic tilting moment $M_{dyn\ (max)}$ [Nm]
With the bearing rotating, this is the maximum allowable tilting moment with no additional axial forces or radial forces applied. This value is not based on the equation for lifetime calculation of the output bearing but on the maximum allowable deflection of the Harmonic Drive® Gear Component Set. This value must not be exceeded even if the lifetime calculation of the bearing permits higher values.

Efficiency
The efficiency of a gear results from the ratio of the output power to the input power. It is the sum of the individual efficiencies for bearing, seal and gearing. The efficiency of a Harmonic Drive® Gear depends on the lubricant type, the lubricant temperature, the input speed and the output torque.

Explanation of technical data

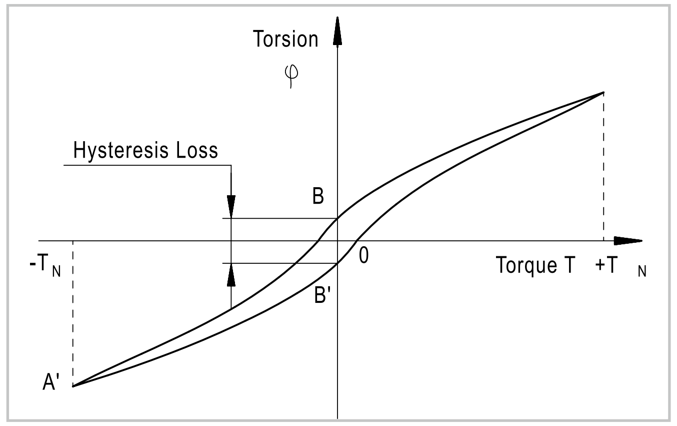
Illustration 3.31



Hollow shaft diameter d_H [mm]
Free inner diameter of the axial hollow shaft.

Hysteresis loss
When a torque is applied to the output of a Harmonic Drive® Gear with the input locked, the torque-torsion relationship measured at the output typically follows, starting from point 0, through the successive points, the hysteresis curve A-B-A'-B'-A (see figure). The value of the displacement B-B' is defined as the hysteresis loss.

Illustration 3.32

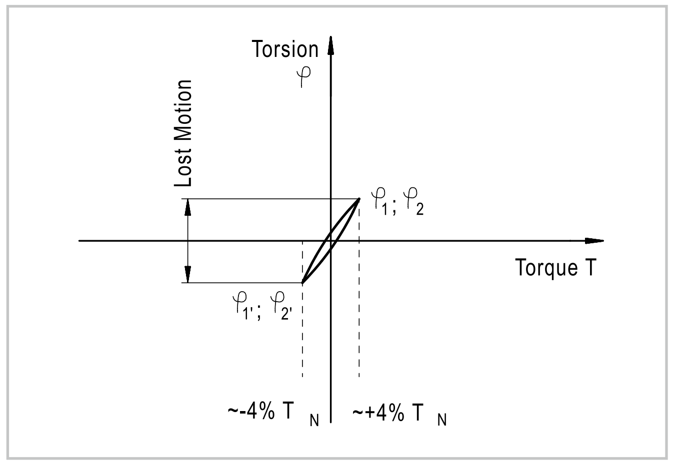


T_N = Rated output torque
φ = Output rotation angle

Lost Motion [arcmin]
Harmonic Drive® Gears exhibit zero backlash in the teeth. Lost motion is the term used to characterise the torsional stiffness in the low torque region.

The illustration shows the angle of rotation φ measured against the applied output torque as a hysteresis curve with the Wave Generator locked. The lost motion measurement of the gear is taken with an output torque of about ±4 % of the rated torque.

Illustration 3.33



Maximum input speed $n_{in\ (max)}$ [rpm]
Maximum allowable input speed of the gear for short period. The maximum input speed can be applied as often as desired, as long as the application's average speed is lower than the permitted average input speed of the gear.

Momentary peak torque T_M [Nm]
In the event of an emergency stop or collision, the Harmonic Drive® Gear may be subjected to a brief momentary peak torque. The magnitude and frequency of this peak torque should be kept to a minimum and under no circumstances should the momentary peak torque occur during the normal operating cycle. The allowable number of momentary peak torque events can be calculated with the equations given in chapter "selection procedure".

Moment of inertia J [kgm^2]
Mass moment of inertia of the gear related to the input side.

No load backdriving torque
The no load backdriving torque is the torque required on the output side in order to backdrive the gear. The value represents the maximum value. Measuring condition: no load gear input side, ambient temperature 20 °C.

No load running torque
The no load running torque is the maximum input torque required to maintain a rotating Harmonic Drive® Gear in motion. Measuring condition: no load output, ambient temperature 20 °C

No load starting torque
The no load starting torque is the maximum input torque required to start a Harmonic Drive® Gear in no load condition. Measuring condition: no load output, ambient temperature 20 °C

Nominal service life L_{10h} [h]
Service life of the Wave Generator ball bearing at rated torque and rated speed for a failure probability of 10 %.

Offset R [m or mm]
Distance between output bearing centre and point of application of load.

Pitch circle diameter output bearing d_p [m] or [mm]
Pitch circle diameter of the output bearing rolling element raceway.

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 value at which this occurs is called ratcheting torque. Ratcheting may cause the Flexspline to become non concentric with the Circular Spline (Dedoidal, see also chapter Assembly Instructions). Operating in this condition may result in shortened life and a Flexspline fatigue failure. The values for ratcheting torque can be provided on demand by Harmonic Drive SE.

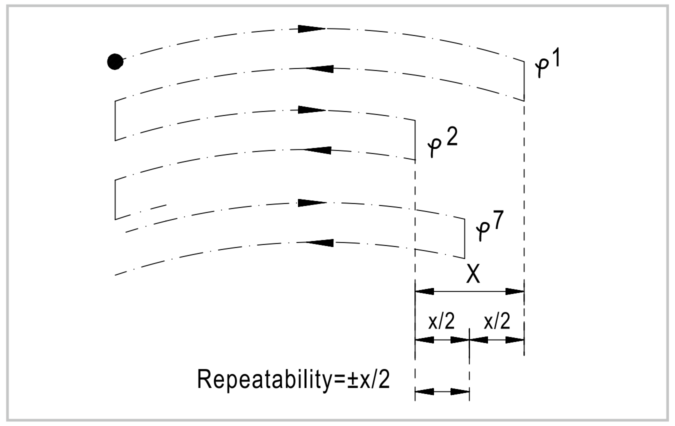
Rated speed n_N [rpm]
The rated speed is a reference speed for the calculation of the gear life. When loaded with rated torque and running at rated speed the Wave Generator Bearing will reach the nominal service life L_{10h} with 10 % probability of failure.

Rated torque T_N [Nm]
The rated torque is a reference torque for the calculation of the gear life. When loaded with rated torque and running at rated speed the Wave Generator Bearing will reach the nominal service life L_{10h} with 10 % probability of failure.

Ratio i [ ]
The gear ratio is the reduction of input speed to the output speed.
Note for Harmonic Drive® Gears: In the standard drive arrangement, the Wave Generator is the drive element while the Flexspline is the driven element and the Circular Spline is fixed to the housing. Since the direction of rotation of the input (Wave Generator) is opposite to the output (Flexspline), a negative ratio must be considered.

Repeatability [arcmin]
The repeatability of the gear describes the position difference measured during repeated movement to the same desired position from the same direction. The repeatability is defined as half the value of the maximum difference measured, preceded by a ± sign.

Illustration 3.34



Repeated peak torque T_R [Nm]
Specifies the maximum allowable acceleration and deceleration torque. During the normal operating cycle the repeatable peak torque T_R must not be exceeded. The repeated peak torque can be applied as often as desired, as long as the application's average torque is lower than the permitted average torque of the gear.

Size
The frame size is derived from the pitch circle diameter of the gear teeth in inches multiplied by 10.

Static load rating C_0 [N]
Maximum static load that can be supported by the output bearing before permanent damage may occur.

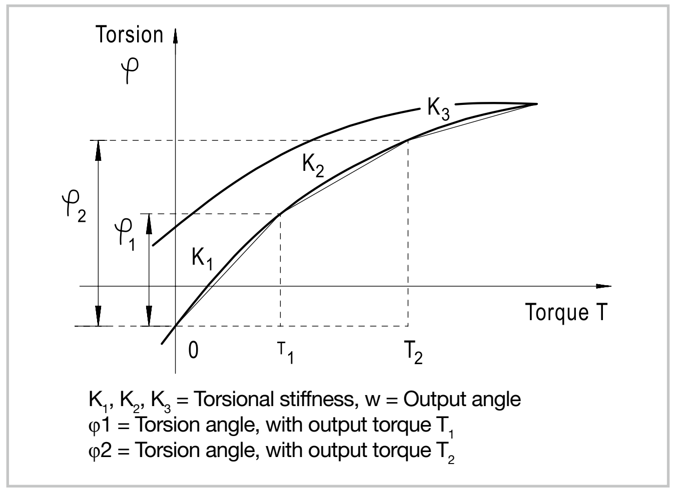
Tilting moment stiffness K_B [Nm/arcmin]
The ratio of the tilting angle of the output bearing and the applied moment load.

Torsional stiffness K_1, K_2, K_3 [Nm/rad]
The degree of elastic rotation at the output for a given torque with the Wave Generator blocked. The torsional stiffness may be evaluated by dividing the torque-torsion curve into three regions. The torsional stiffness values K1, K2 and K3 are determined by linearization of the curve.

K_1:	low torque region	$0 \sim T_1$
K_2:	middle torque region	$T_1 \sim T_2$
K_3:	high torque region	$> T_3$

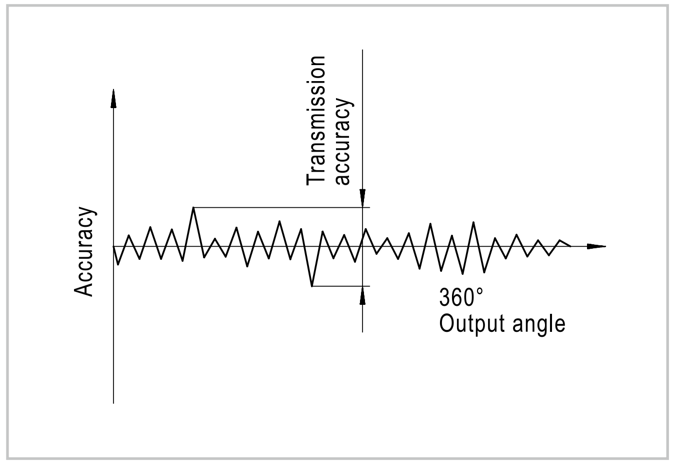
The values given for the torsional stiffness K_1, K_2 and K_3 are average values that have been determined during numerous tests. The limit torques T_1 and T_2 and an calculation example for the torsional angle can be found in chapter "torsional stiffness" and "calculation of the torsion angle" of this documentation.

Illustration 3.35

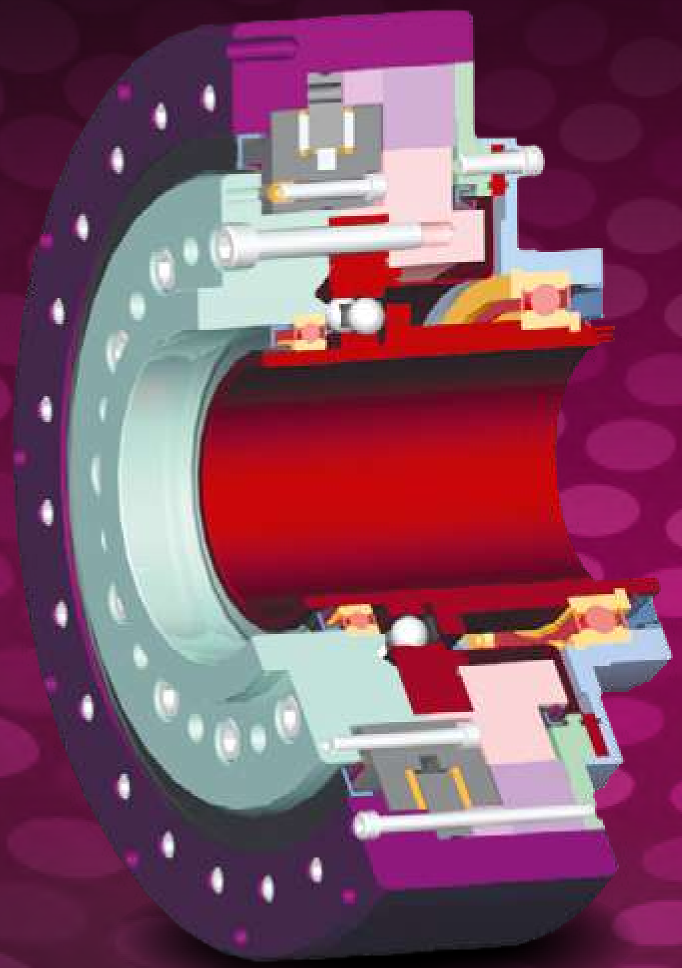


Transmission accuracy [arcmin]
The transmission accuracy of the gear represents the linearity error between input and output angle. The transmission accuracy is measured for one complete output revolution using a high resolution measurement system. The measurements are carried out without direction reversal. The transmission accuracy is defined as the sum of the maximum positive and negative differences between the theoretical and actual output rotation angles.

Illustration 3.36



Weight m [kg]
The weight specified in the catalogue is the net weight without packing and only applies to standard versions.



Individual solutions

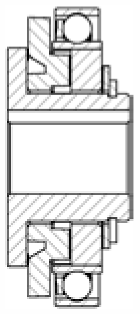
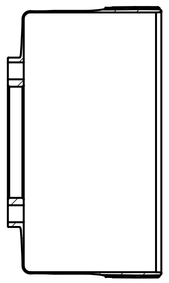
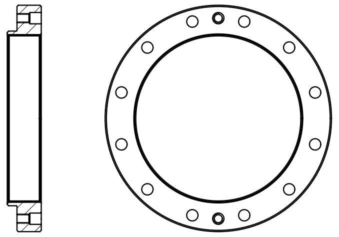
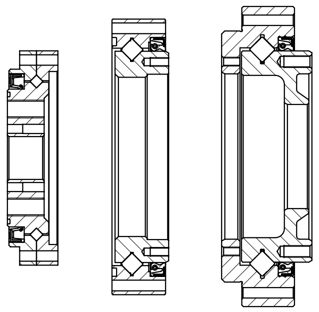
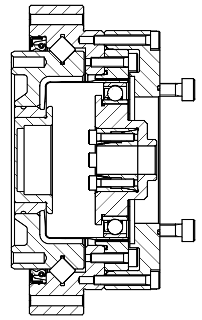
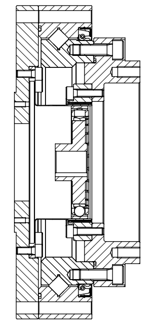
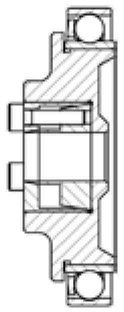
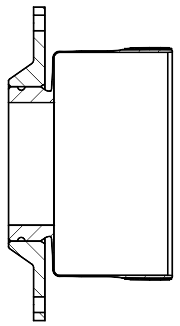
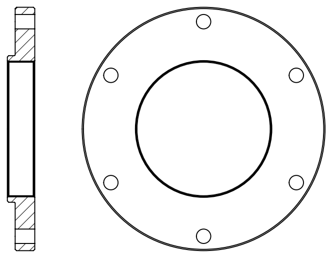
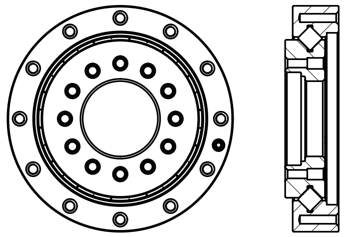
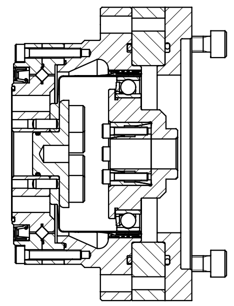
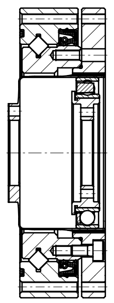
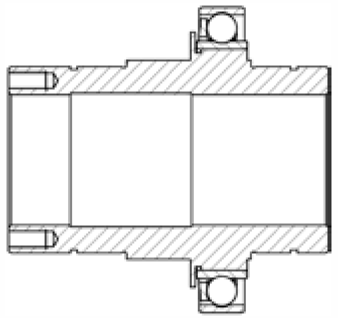
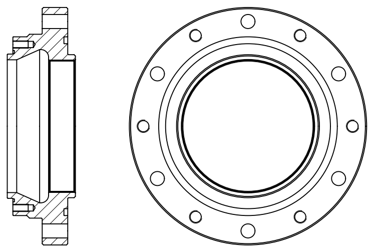
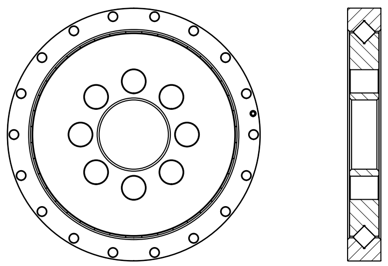
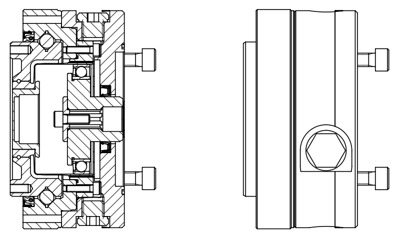
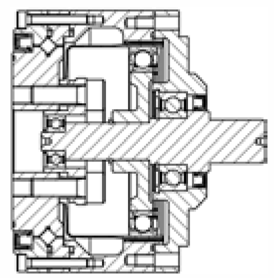
Does your application place requirements on the drive system that is not yet ideally solved by our standard products? In close partnership with the customer we develop individual solutions according to your requirements.

Individual combinations
Our individual solutions enable the recombination of proven and reliable components. This means that customised solutions can be realised quickly and flexibly.

Adaptations of the interfaces
In order to adapt our products to the design particulars of your application, the mechanical interfaces often have to be changed. In this way, components such as the housing, motor adaptation, etc. can be customised. The interfaces of the core components such as Circular Spline, Flexspline and Wave Generator can be adapted as long as their function is not affected.

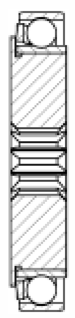
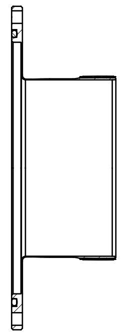
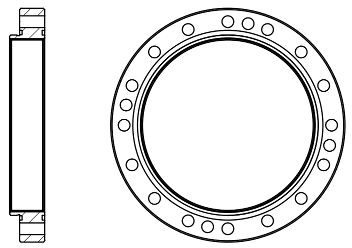
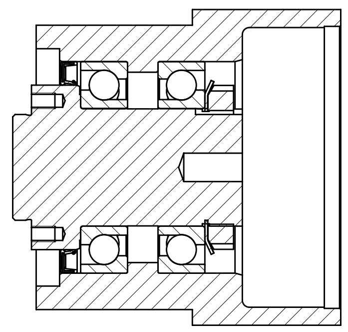
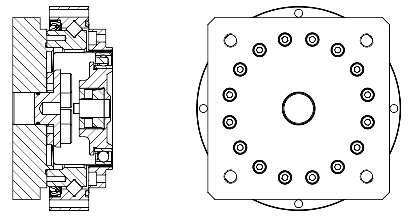
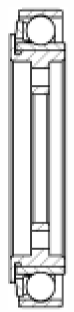
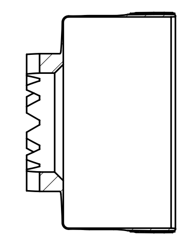
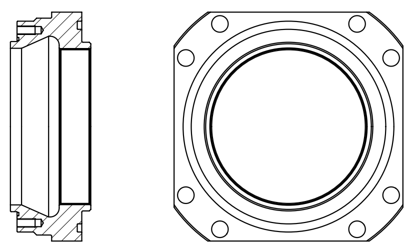
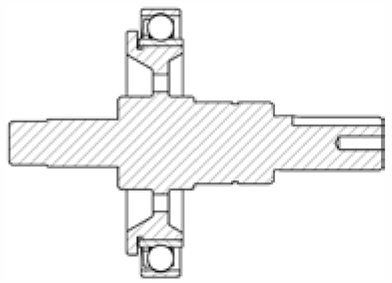
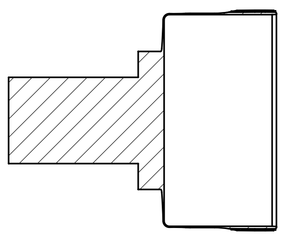
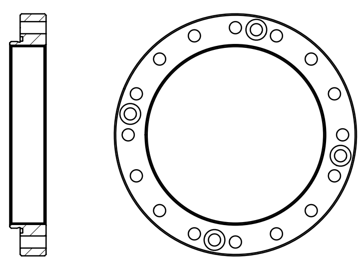
Short development times
Since the core components remain unchanged in their function, the basic qualification of the components can remain. This enables a high degree of individualisation with a short development time.

Individual solutions for Harmonic Drive® Gear Component Sets and Gears with output bearing

Wave Generator	Flexspline	Circular Spline	Output bearing	Motor adaptation	Design combinations
Oldham coupling with feather key	**Flexspline with enlarged central bore hole**	**Circular Spline with modified bore hole pattern**	**Selection of different output bearing types**	**Gear with adapter flange**	**Combination of gear component set and output bearing of different sizes**
					
The Oldham coupling is used to compensate concentricity and coaxiality errors of the motor shaft. Different bore diameters are possible.	The large Flexspline bore offers maximum space for the feed through of supply lines and drive shafts.	Customised design of bores and threads.	Different output bearing types allow a flexible adjustment to the load situation of the application.	Simplified motor assembly by using a gear including adapter flange suitable for the selected motor.	For high demands on the load capacity of the output bearing and lower torque requirements on the gear.
Solid Wave Generator with clamping set	**Flexspline with welded output flange**	**Circular Spline with modified outer diameter**	**Special output bearing in intermediate sizes**	**Motor connection with two piece adapter flange**	**Combination of gear component set and output bearing of different product series**
					
The Solid Wave Generator with clamping set enables a backlash free connection of the Wave Generator to the motor shaft.	The welded Flexspline connection enables the safe transmission of overloads as well as the individual adaptation to the design environment.	Customised design of the Circular Spline.	Special output bearing in intermediate size, e. g. to reduce the outside diameter.	The two piece adapter flange is required in some motor adaptations when the bore pitch circles of the gearbox and motor are similar.	Combination of a CSG-2A Gear Component Set and the HFUS output bearing in order to achieve a short overall length.
Wave Generator with hollow shaft	**Flexspline with Friction Shim**	**Design of the Circular Spline as gear housing**	**Special output bearing with customised interface**	**Gear with oil lubrication**	**Gear with reduced outer diameter**
					
The Wave Generator with hollow shaft enables the central feed through of supply lines and drive shafts. The hollow shaft can be individually adapted to the application.	The Friction Shim increases the transmittable torque of the Flexspline bolted joint and therefore ensures a higher overload capacity.	Integration of the gear housing into the design of the Circular Spline.	Adaptation to the design environment by a bearing with customised interface.	Oil inlet and outlet screw for the lubrication with oil, integrated into the adapter flange (optional use of oil inspection glass)	A reduced outer diameter is achieved by modified housing geometry.

4. Individual solutions

Individual solutions for Harmonic Drive® Gear Component Sets and Gears with output bearing

Wave Generator	Flexspline	Circular Spline	Output bearing	Motor adaptation	Design combinations
Solid Wave Generator with internal spline	**Flexspline with O ring groove**	**Circular Spline with additional O ring groove**	**Double row bearings**		**Gear with customised output flange**
					
The internal spline enables an interlocking connection between the Wave Generator and the input shaft.	Space saving integration of a seal.	Space saving integration of a seal.	By selecting two preloaded roller bearings, a design with a small outer diameter can be achieved.		By an individual design of the gear output flange an additional customer flange can be omitted.
Ring shaped Wave Generator	**Flexspline with axial spline**	**Square design Circular Spline**	**Output bearing with corrosion protection**		
					
The ring shaped Wave Generator allows a low mass as well as a reduced inertia of the drive shaft, as well as a large central bore.	The axial spline in combination with a central nut enables an interlocking connection of the Flexspline to the output flange.	To avoid overlapping with interfering components.	The output bearing can be coated in order to increase the corrosion protection.		
Wave Generator with input shaft design	**Flexspline with integrated output shaft**	**Circular Spline with counter sunk bores**			
					
The Wave Generator with input shaft enables the direct connection of a pre-stage, such as a belt stage. The shaft can be adapted individually.	High overload capacity, compactness and weight reduction due to Flexspline with integrated output shaft. The output shaft can be customised.	To avoid overlapping by sunk screw heads.			

Selected examples of customised gears

Illustration 4.1

Lightweight gear based on CPL-2A Gear Component Set

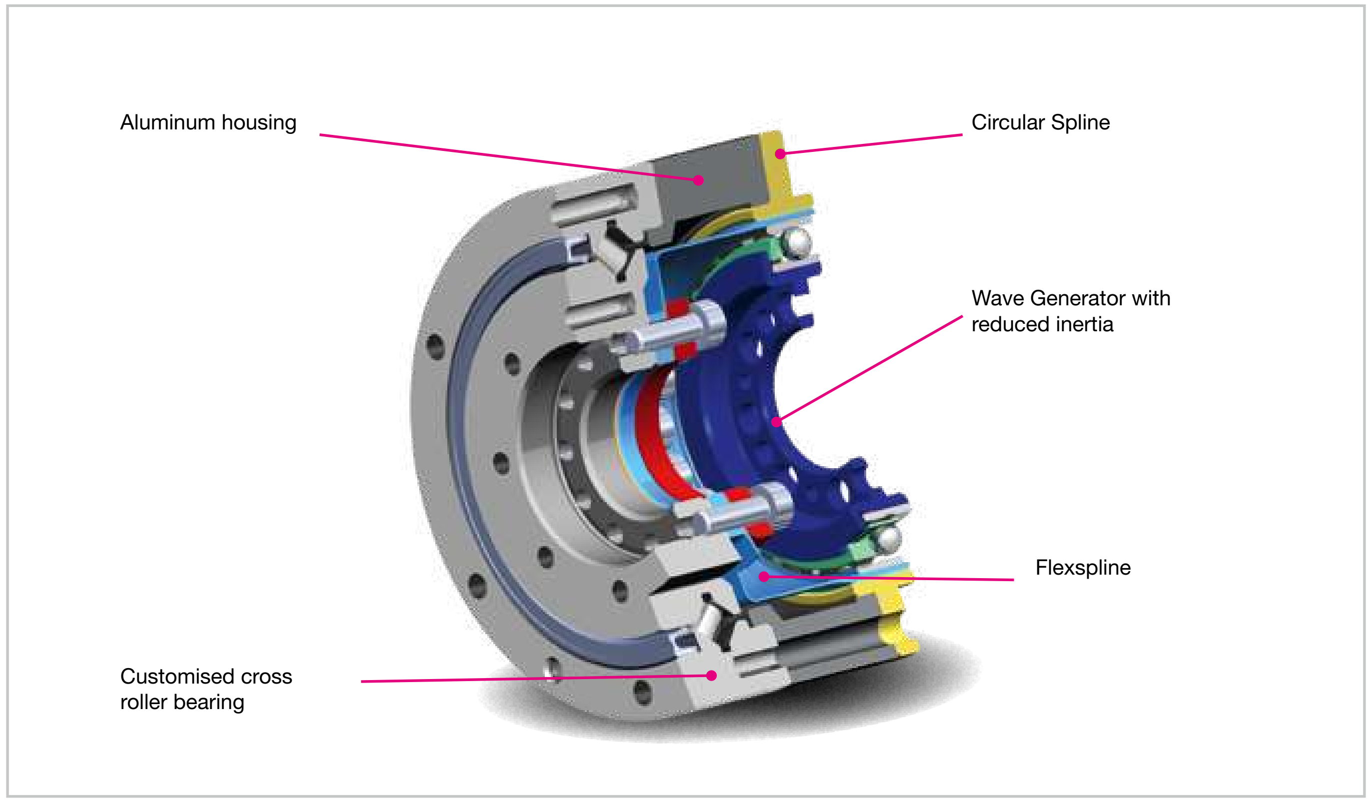


Illustration 4.2

Gear for robotic axis with customised hollow shaft for adaptation of rotor magnets, encoder and brake

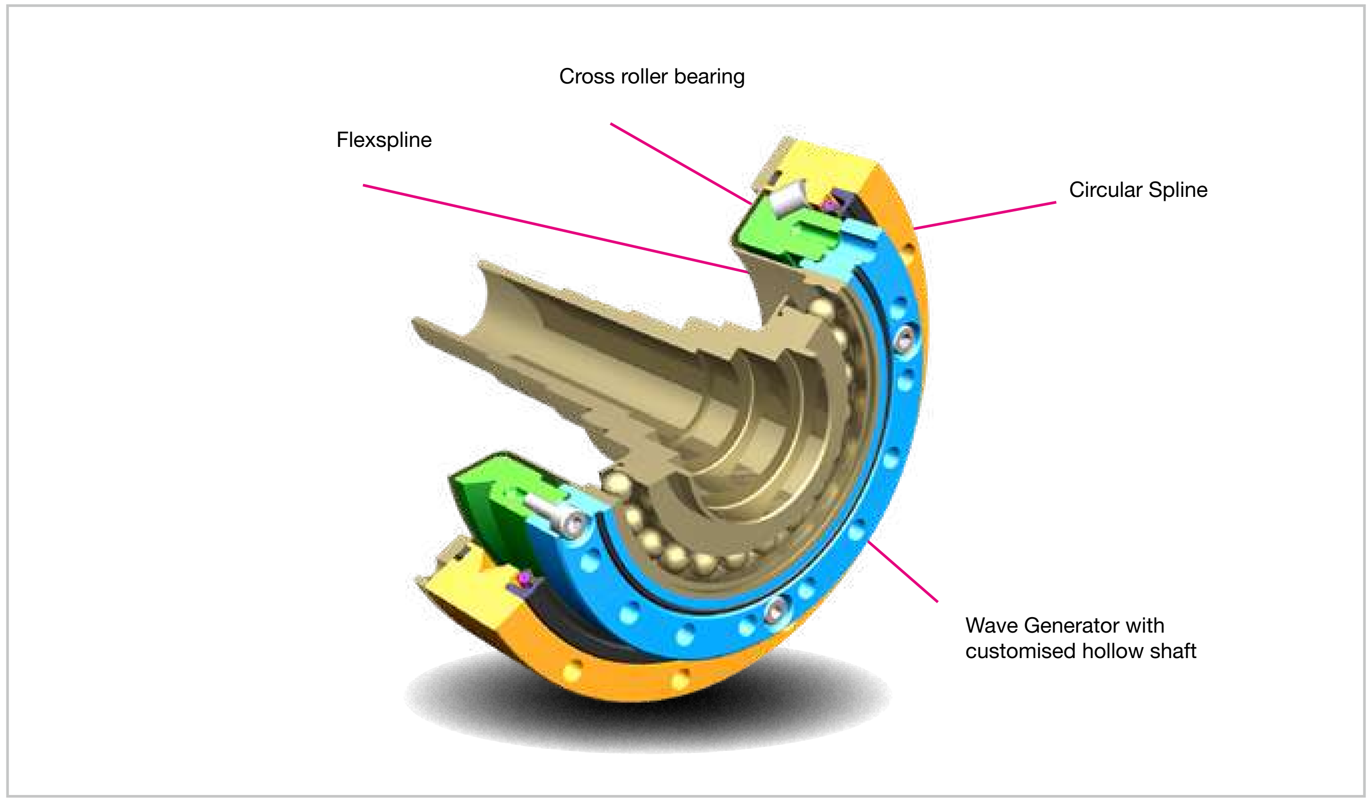


Illustration 4.3

Swivel joint for X-ray system based on the SHG-2UH Hollow Shaft Gear, bevel gear pre-stage and a toothed belt pre-stage

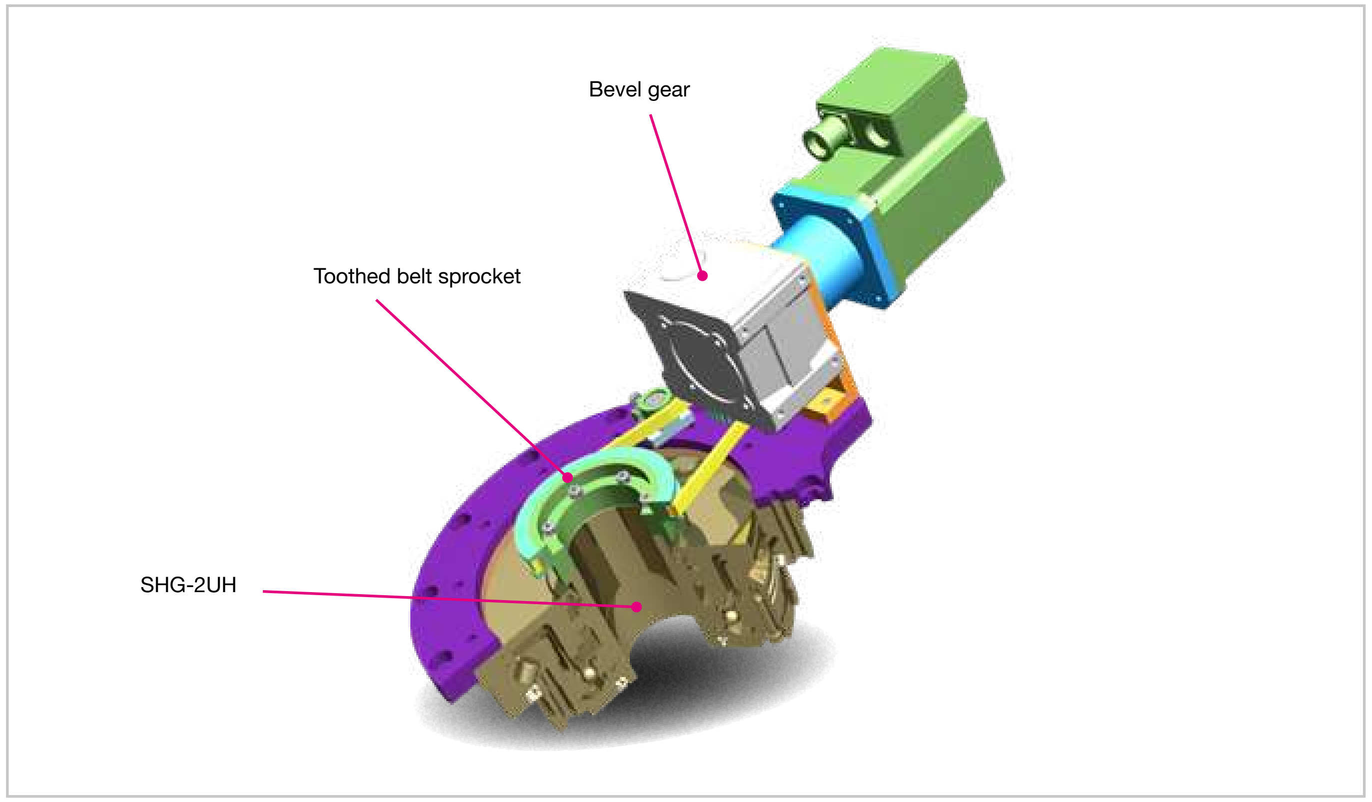
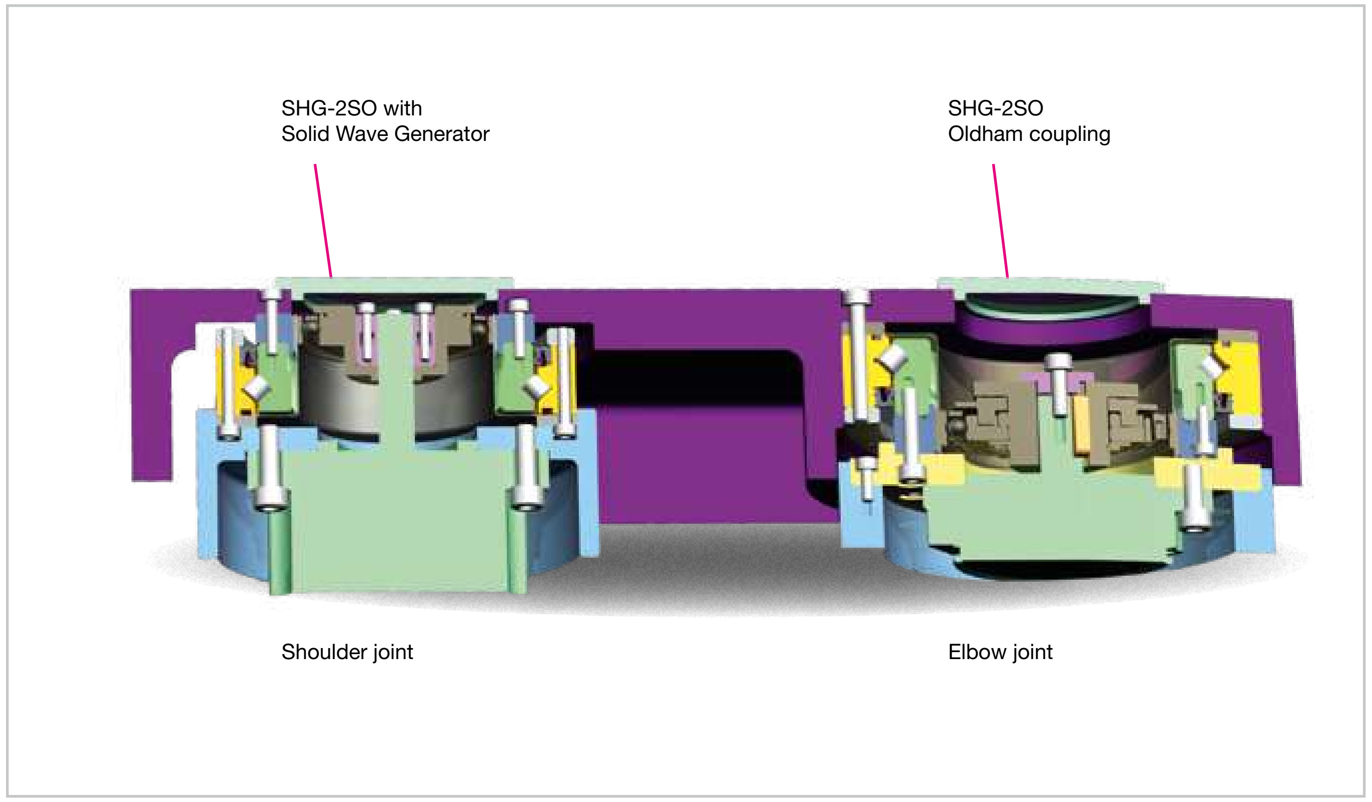


Illustration 4.4

Two SCARA robot axes based on SHG-2SO with motor adaptation



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The values reproduced in this catalogue are based on measurements performed in numerous tests during the development of our products. Further tests are performed on an ongoing basis in order to assure the quality of our products. Please note that these values, as with all measurements, can vary from product to product. If these values are used for a specific application, the measurement accuracy of these results should also be taken into account. Unless otherwise indicated, all tests, as described in this catalogue, are performed with new components at normal air pressure and temperature using standard lubrication. The results can vary considerably under different conditions. Please contact us for further details.

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Harmonic Drive SE
Hoenbergstraße 14
65555 Limburg/Lahn
Germany

T +49 6431 5008-0
info@harmonicdrive.co.uk
www.harmonicdrive.co.uk

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