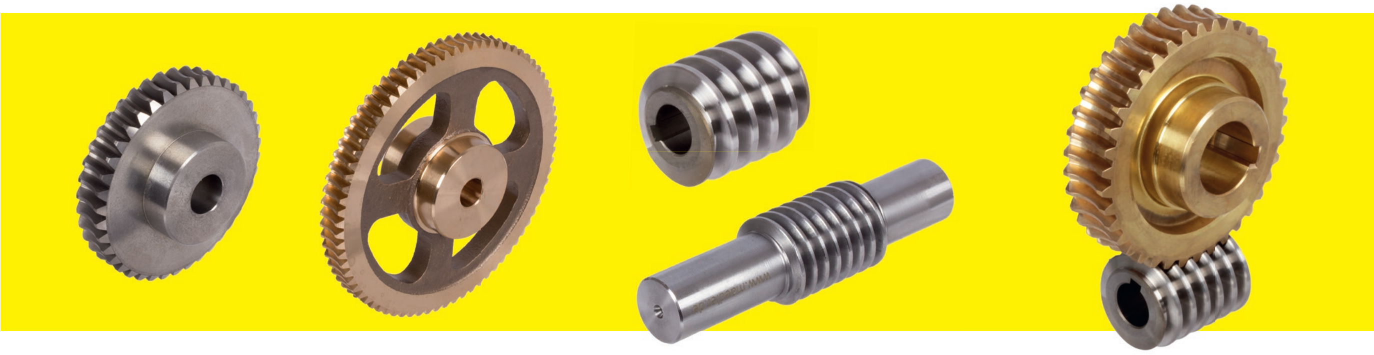
Worms and Worm Gears, General Basics and Overview



General descriptions:

- For right angled power transmission with simultaneous vertical offset (centre distance of the crossed axles).
- The movement usually takes places via the worm (the movement can be made via the gear wheel if necessary in the case of low transmissions up to 3:1).
- The selection/dimensioning is made as function of the torque (required torque on the worm gears).
- High transmissions up to approx. 100:1 are possible in just one stage.
- Several transmissions and centre distances on stock.
- Silent and low vibration.
- Power loss is greater than in spur and bevel gears, depending on the efficiency or transmission.
- Power loss is converted to frictional heat.
- Low transmission = higher efficiency and lower self-locking.
- High transmission = low efficiency and high self-locking.

Standard Worm Gears and Worm shafts page 290 - 297

For simple applications, e.g. manual operation or occasional motorised operation. Continuous operation is possible at medium torques. Reworking (custom bore, feather keyway, fixed thread) is an optional extra.
Single thread: For high to medium transmissions.
Double thread: For medium to low transmissions.

Sorted by number of threads and module. The gear wheels can be combined with worms having the same module and the same number of threads to make different transmissions. This results in the different centre distances.

Single thread, right hand		Page
Module 0.5 to 2.0	Worm Gears	290
	Worms	291
Module 3.0 to 5.0	Worm Gears	292
	Worms	293

Double thread, right hand		Page
Module 0.5 to 2.0	Worm Gears	294
	Worms	295
Module 3.0 to 4.0	Worm Gears	296
	Worms	297

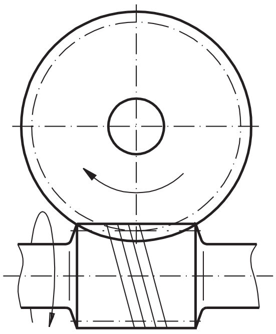
Precision worm gear sets page 299 - 308

Ideal for continuous operation at high speeds and torques. Mostly ready-to install without needing reworking. Hence they are also economical for simple applications.

Sorted by centre distance. The gear wheels can only be used with worms having the same centre distance and the same transmission. Several transmissions are available per centre distance.

Centre distance	Page	Centre distance	Page
17 mm	299	50 mm	304
22,62 mm	300	53 mm	304
25 mm	300	63 mm	305
31 mm	301	65 mm	305
33 mm	302	80 mm	306
35 mm	303	100 mm	307
40 mm	303	125 mm	308

Gear Set, Right Hand



The catalogue parts are right handed.

Left hand sets have to be custom made on request.

Recommendation regarding the Lubrication

Peripheral Speed	Lubrication	Lubricant
up to 1 m/s (gear submerged)	Dip-Feed Lubrication	Grease
up to 4 m/s (gear submerged)	Dip-Feed Lubrication	Oil
over 4 m/s (gear submerged)	Spray lubrication	Oil
up to 4 m/s (worm submerged)	Dip-Feed Lubrication	Grease
up to 10 m/s (worm submerged)	Dip-Feed Lubrication	Oil
over 10 m/s (worm submerged)	Spray lubrication	Oil

Efficiency and self-locking

The calculated efficiency depends on the friction conditions in the contact zone and where the bearings and seal are mounted. These conditions may vary depending on the environmental conditions or lubrication. This leads to a large array, where no exact statement regarding the self-locking capacity can be made. This array is marked with "limited".

A calculated self-locking capacity can be negatively influenced by various factors. For this reason we cannot grant any guarantee regarding the self-locking capacity.

Maximum Torque

The torque values are to be taken as Maximum Values that should under no circumstances be exceeded!
Depending on the power of the gear unit , the prevailing temperature and lubrication conditions in the worm gear unit (depending on the cooling , lubricant, mounting etc.) operating set ups with increasing wear may occur - having a negative influence on the wear lifespan of the unit - although the permissible torques were not exceeded. In order to go to the upper limit of the maximum torques, the whole construction must have a rigid design (housing, bearing, bearing distance), to avoid negative influences due to deformation.

The stated torques were calculated presuming an alternating load. They are output torques (of the worm gear, not the worm shaft).

Torque Conversion

Output torque = Input Torque x Efficiency x Transmission

$$\text{Input torque} = \frac{\text{Output torque}}{\text{Efficiency x Ratio}}$$

Worm dimensions

to be calculated	given unit	formula
Reference Circle Pitch = t_s	Lead and Number of Gears	$\frac{H}{z}$
Standard pitch = t_{no}	Pitch and Lead Angle	$t_s \cdot \cos. \Upsilon_m$
Real module = m_s	Reference Circle Pitch	$\frac{t_s}{\pi}$
Standard module = m_n	Standard pitch	$\frac{t_n}{\pi}$
med. lead angle = $°_m$	Lead and Pitch Ø	$\tan \Upsilon_m = \frac{H}{d \cdot \pi}$
Pitch Ø = d	Lead and Lead Angle	$\frac{H}{\pi \cdot \tan \Upsilon_m}$
Tip Ø = d_a	Pitch Ø and Standard Module	$d + 2m_n$
Lead = H	Number of Gears and Real Module	$z \cdot m_s \cdot \pi$

Worm Gear - Dimensions and Torque

to be calculated	given unit	formula
Pitch Ø = d		$z \cdot m_s$
Tip Ø = d_a in Median Plane of Gear		$\approx d + 2\ m_s$
Output torque = Md in Nm		$9550 \cdot \frac{P_2}{n_2}$

Material quality:
Information about the material quality can be found at each worm and worm gear.

Note Regarding the Torque-Values Stated in the Catalogue page 290 bis 297

The worm gear sets are calculated in accordance with DIN 3976 or Niemann/Winter (Niemann/Winter "Maschinenelemente Band III, 2. Auflage, Nachdruck 1986", Machine Components Volume III, 2nd Edition, Reprint 1986 , Publisher: Springer-Verlag).
The decisive strength criterion for small modules is the pitting resistance of the worm gear flanks and for larger modules usually the tooth-root strength of the worm gear.

Calcul. Factor/Determining Factor	Value	Note
Tooth root safety S_F	min. 2.0	–
Flank safety S_H	min. 1.3	Endurance strength 10,000 h
Application factor K_A	1.25	Industrial gear mechanisms, uniform, light shocks

The following permissible Hertzian stress was assumed for the materials used:

Material	permissible flank pressure s_{Hlim} in N/mm²	Maximum Limit Stress before Tooth Fracture U_{lim} in N/mm²
G-CuSn12	265	115
GG25	350	150

The load bearing capacity of a worm gear depends on various different factors. The stated torques are only reference values, serving to facilitate the selection process. If necessary a specific calculation of strength and load bearing capacity must be carried out for each application.

Depending on the operating conditions, the wear lifespan may be influenced by grease/oil lubrication. Please also note that insufficient lubrication may lead to scuffing of the gear flanks.

IMPORTANT: The torque values stated refer to the permissible output torques (of the worm gear).

Note regarding the Precision Worm-Gear Sets page 299 to 306

Worm gears up to a centre distance of 65 mm are made from special brass CuZn40Al2/So, above made from bronze G-CuSn12 Ni.

Worms made from 11SMnPb30, inspected for fissures, case hardened or C45 induction hardened, hardness HV620-700, shafts (if used), bore and flanks ground.

Pressure angle 15° (to reduce the radial force at the worm shaft). Especially designed for use with high torques, ready bored and some with keyway.

IMPORTANT:
Some of the keyways are not in accordance with the DIN. Please take good note of the keywidth stated.

The stated torques are permissible driving torques for the worm gear, permissible at a speed of 2800 min^{-1} at the worm shaft. The calculations are based on an expected service life of 3,000 h. With lower torques, or a shorter expected service life, the driving torque can be increased. The factor of security against rapture is 3.

The given torques are valid for shock-free drive, 10 starts per hour, operating time up to 40% and sufficient lubrication with mineral low-viscosity grease. Viscous synthetic oil should, however be preferred. The figures for efficiency stated in the table are theoretical values that can be negatively influenced by various factors.

For that reason we do not offer any guarantee regarding the efficiency and the self-locking capacity.

Precision Worm Gear Sets, Flank Clearance at Centre Distance a = 17 - 100 mm

Flank-clearance tolerances for worm gears are only valid for gears with a pressure angle of 15°.

Reference Diameter of the Worm Gear d_{m2}	Module m_n	Clearance at Centre Distance S_{a2}		Tolerance	Engagement Backlash S_{e2}		Circumferential Backlash at Pitch Ø with γ_o up to 24°		Circumferential Backlash at Pitch Ø with γ_o above 25°	
		min.	max.		min.	max.	min.	max.	min.	max.
mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
over 12 up to 25	0,4 - 0,6	0,13	0,172	0,042	0,067	0,089	0,07	0,092	0,077	0,102
	>0,6 - 1,3	0,14	0,185	0,045	0,072	0,096	0,075	0,099	0,083	0,109
	>1,3 - 2,0	0,15	0,198	0,048	0,078	0,102	0,08	0,106	0,089	0,117
over 25 up to 50	0,4 - 0,6	0,14	0,185	0,045			0,075	0,099	0,083	0,108
	>0,6 - 1,3	0,15	0,198	0,048			0,08	0,106	0,089	0,117
	>1,3 - 2,0	0,16	0,212	0,052	0,083	0,11	0,086	0,114	0,095	0,125
	>2,0 - 4,0	0,17	0,231	0,056	0,091	0,12	0,094	0,124	0,103	0,137
over 50 up to 100	0,4 - 0,6	0,15	0,198	0,048			0,08	0,106	0,089	0,117
	>0,6 - 1,3	0,16	0,212	0,052			0,086	0,114	0,095	0,125
	>1,3 - 2,0	0,175	0,231	0,056			0,094	0,124	0,103	0,137
	>2,0 - 4,0	0,19	0,25	0,06	0,098	0,129	0,102	0,134	0,112	0,148

γ_o is the lead angle of the worm.

Self-locking capacity

The self-locking capacity is influenced by the lead angle, the surface structure of the flanks, the sliding speed, the lubricant and the heating. Dynamic and static self-locking capacity must be distinguished.

Dynamic self-locking capacity: up to 3° lead angle lubricated with grease; up to 2.5° lead angle lubricated with synthetic oils.
Static self-locking capacity: from 3° up to 5° lead angle lubricated with grease; from 2.5° up to 4.5° lead angle lubricated with synthetic oils.
With lead angles of 4.5° or 5° there is no self-locking capacity.

Shocks or vibration can override the self-locking capacity. Apart from that, various factors in connection with lubrication, gliding speed and load can create such favourable operating conditions that the self-locking capacity is negatively influenced.

For this reason we cannot grant any guarantee regarding the self-locking capacity.