STÖBER

Please note!

This presentation template may be used for **presentation purposes** only it may **not** be passed on to third parties (e.g., customers etc.). For online events, it must be pointed out that recordings and screenshots are not permitted. Individual slides may be compiled into your **own presentations** and distributed. The prerequisite for this is to check and revise the content to ensure that they only contain **approved information** that can also be found in the catalog. **The author** is **responsible** for the content of the compiled presentation.

Precisely matched to each other:
Precision racks for STOBER Drive Systems

A wide range of systems for a wide range of applications

- ✓ Highest flexibility
- ✓ Highest speed
- ✓ Highest precision
- ✓ Highest feed forces

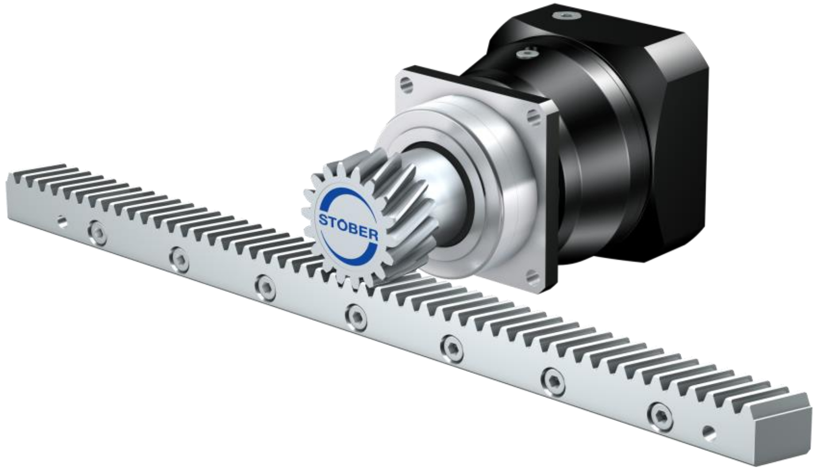
Agenda

- Rack and pinion - Overview
- Type designation and nameplate
- STOBER double bore design DBD:
  - Advantages
  - Transferable feed forces
  - Competition comparison
- Projecting
- Application examples
- Things to know:
  - Comparison of linear transfer elements
  - Axial dimension az and profile shift factor x
  - Total pitch error
  - Tooth thickness tolerance and roller dimension for racks
  - Surface layer hardening
  - Gear backlash – pinion rack adjustment
  - Feed Forces – Influence of quality, material and heat treatment
  - m=4; l_{ZS}=506,67mm
  - Helical angle ß=19°31´42´´
  - Feed constant u
- Assembly:
  - Possible shapes
  - Requirements for the connection design
  - Tools
  - Preparation
  - First Rack
  - Further Racks
  - Check the transition between the racks
  - Pin the rack
  - Gearbox with pinion to slide
  - Face pattern control
- Lubrication
- Causes of malfunctions

Rack and Pinion - Overview

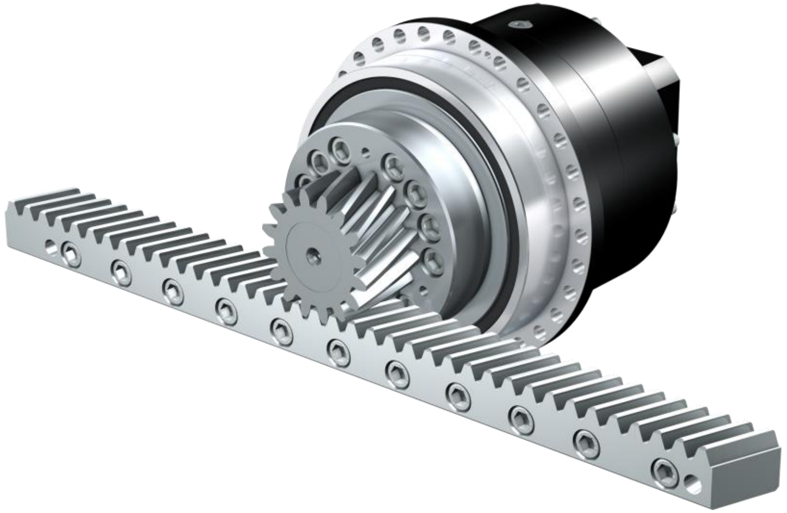
STÖBER

ZV Highest Flexibility

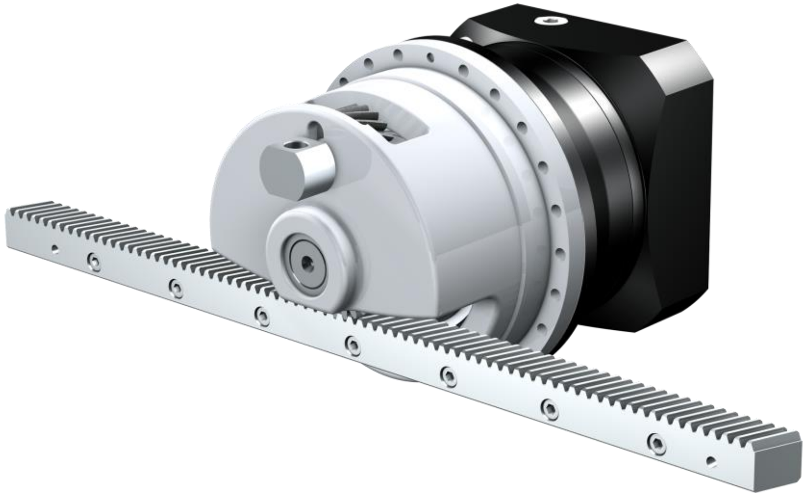


ZR Highest Speed

ZTR High Feed Forces



ZTRS Highest Feed Forces



Rack and Pinion - Overview

STÖBER

Typ	ZVP	ZVPE	ZVKS	ZVKL	ZVK	ZRPH	ZTRPH	ZTRPHV	ZTRSPH	ZTRSPHQ	ZTRSPHV	
BG	3 – 7	3 – 5	4 – 7	1 – 2	1 – 4	3 – 7	4 – 10	9 – 10	7 – 9	10	9	
m_n	2 – 4	2 – 3	2 – 4	2	2 – 4	2 – 4	2 – 8	5 – 8	3 – 8	8	5 – 8	[mm]
z	16 – 25	16 – 25	18 – 25	16 – 20	18 – 25	26 – 45	12 – 32	12 – 19	15 – 32	19	15 – 20	
F_{f2acc}	2 – 15	2 – 6,3	4,2 – 11	1,3 – 2,9	2,8 – 15	2,1 – 15	5,8 – 67	56 – 67	20 – 79	124	67 – 77	[kN]
$v_{f2maxZB}$	0,14 – 5,30	0,11 – 4,50	0,07 – 3,00	0,33 – 2,80	0,06 – 3,80	0,23 – 6,70	0,09 – 4,70	0,19 – 0,39	0,2 – 4,70	0,06 – 1,10	0,21 – 0,49	[m/s]
Δs	8 – 44	40 – 83	31 – 44	99 – 123	12 – 111	10 – 56	4 – 44	42 – 44	8 – 56	70	15 – 56	[µm]
Lineares Spiel	★★★★★	★★☆☆☆	★★★☆☆	★☆☆☆☆	★★★☆☆	★★★★★	★★★★★	★★★★☆	★★★★★	★★★★☆	★★★★☆	
Preisklasse	€€	€	€€€	€	€	€€€	€€€€	€€€€	€€€€€	€€€€€	€€€€€	

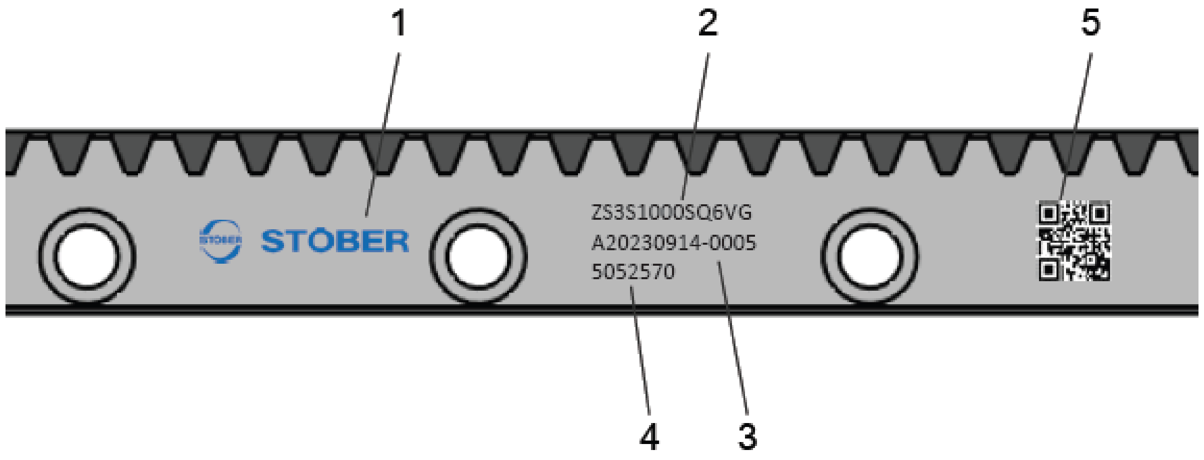
Rack and Pinion - Overview

STÖBER

Modul	Helical Angle	Material	Heat Treatment	Length	Bores for Screws DIN912	Bores for Pin DIN7979	Quality
m	ß			L	Quantity x Size	Quantity x Size	DIN3962-1
2	19°31´42´´	High Tensile Steel	Ind. Hardened Scanning	0,5m / 1m	7/15 x M6	2 x Ø5,7	6
3	19°31´42´´	High Tensile Steel	Ind. Hardened Scanning	0,5m / 1m	7/15 x M8	2 x Ø7,7	6
4	19°31´42´´	High Tensile Steel	Ind. Hardened Scanning	0,5m / 1m	7/15 x M10	2 x Ø9,7	6
5	19°31´42´´	High Tensile Steel	Ind. Hardened Single Tooth	0,5m / 1m	7/15 x M12	2 x Ø11,7	6
6	19°31´42´´	High Tensile Steel	Ind. Hardened Single Tooth	0,5m / 1m	7/15 x M16	2 x Ø15,7	6

Type Designation and Type Plate

An example gear rack nameplate is explained in the figure below.



Code	Designation
1	Name of manufacturer
2	Type designation
3	Production number of the gear rack
4	ID No.
5	QR code (link to product information)

Example code

ZS	4	S	1000	S	Q6	V	G

Explanation

Code	Designation	Design
ZS	Type	Gear rack
4	Normal module	m_n = 4 mm (example)
S	Toothing	Helical (right-hand 19° 31' 42")
0500 **1000**	Length	1000 mm (example)
S	Fastening bores	Standard
Q6	Gearing quality	Quality 6 in accordance with DIN 3962-1
V	Material	Heat-treatable steel in accordance with STOBER specification
G	Heat treatment	Hardened

STOBER double bore design DBD
Advantages

STÖBER

m_n [mm]	l_{ZS} [mm]	Typ	$F_{f,max}$ [kN]	F_{sv} LA125PIN [kN]	F_{sv} LA62,5 [kN]	F_{sv} LA62,5PIN [kN]	m [kg]
2	500,00	ZS2S0500SQ6VG	12,6	8,5	8,0	12,5	1,9
2	1000,00	ZS2S1000SQ6VG	12,6	13,5	18,0	22,0	3,9
3	500,00	ZS3S0500SQ6VG	22,5	16,0	15,5	23,0	2,7
3	1000,00	ZS3S1000SQ6VG	22,5	25,0	33,5	41,0	5,4
4	506,67	ZS4S0500SQ6VG	38,7	31,0	25,0	42,0	5,1
4	1000,00	ZS4S1000SQ6VG	38,7	45,5	55,0	71,5	10
5	500,00	ZS5S0500SQ6VG	60,0	38,5	38,5	55,0	5,8
5	1000,00	ZS5S1000SQ6VG	60,0	61,0	83,0	99,5	12
6	500,00	ZS6S0500SQ6VG	83,1	72,5	75,0	105,5	8,5
6	1000,00	ZS6S1000SQ6VG	83,1	116,0	163,0	192,5	17

- With the market standard (125mm + pins), the permissible toothing forces can only be transmitted for $l_{ZS} \geq 1m$.
- With the STOBER drill pattern (62.5mm without pins), the permissible feed forces of gear racks with $l_{ZS} \geq$ 1m can be transmitted without pins. **Saving on assembly work**. Racks with $l_{ZS} \leq$ 1m must be pinned.
- The STOBER drill pattern is compatible with the market standard. Every second screw hole remains unoccupied and these holes can be sealed with plugs if this is desired for visual reasons.
- The pin holes in the STOBER gear racks can be used to increase safety or realize multiple tooth engagement.

STOBER double bore design DBD: Transferable feed forces

									acceleration feed force								e-stop feed force							
									0,5m length				1m length				0,5m length				1m length			
pinion type	m	z	string	STOBER-catalog F2_acc	STOBER-catalog F2_not	STOBER-rack F2_acc	STOBER-rack F2_not	reduction-factor	F2_acc 4 bores w/o pins	F2_acc 4 bores with pins	F2_acc 7 bores w/o pins	F2_acc 7 bores with pins	F2_acc 8 bores w/o pins	F2_acc 8 bores with pins	F2_acc 15 bores w/o pins	F2_acc 15 bores with pins	F2_not 4 bores w/o pins	F2_not 4 bores with pins	F2_not 7 bores w/o pins	F2_not 7 bores with pins	F2_not 8 bores w/o pins	F2_not 8 bores with pins	F2_not 15 bores w/o pins	F2_not 15 bores with pins
ZTR	2	12	ZTR2PH4	6700	11000	5752	11504	1,2	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
ZV	2	16	ZV2KL1	1500	3100	8629	17258	1,5	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ZV	2	16	ZV2P3	2000	4000	8629	17258	1,5	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ZV	2	16	ZV2PE3	1900	3800	8629	17258	1,8	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ZTR	2	16	ZTR2PH4	6700	9200	8629	17258	1,2	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
ZTR	2	19	ZTR2PH5	10000	14000	10354	20708	1,2	No	No	No	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	No	Yes	Yes	Yes
ZV	2	20	ZV2K1	4900	9900	11045	22090	1,2	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
ZV	2	20	ZV2KL2	2700	5400	11045	22090	1,5	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ZV	2	20	ZV2KS4	4200	6600	11045	22090	1,2	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ZV	2	20	ZV2P4	4800	9700	11045	22090	1,5	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
ZV	2	20	ZV2PE4	2700	5400	11045	22090	1,8	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ZTR	2	23	ZTR2PH5	11000	15000	12305	24610	1,2	No	No	No	Yes	No	Yes	Yes	Yes	No	No	No	Yes	No	Yes	Yes	Yes
ZTR	2	23	ZTR2PH7	15000	29000	12305	24610	1,2	No	No	No	Yes	No	Yes	Yes	Yes	No	No	No	No	No	No	Yes	Yes
ZV	2	25	ZV2K2	8300	15000	12287	24574	1,2	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	No	Yes	Yes	Yes
ZV	2	25	ZV2K3	10000	21000	12287	24574	1,2	No	No	No	Yes	No	Yes	Yes	Yes	No	No	No	No	No	No	Yes	Yes
ZV	2	25	ZV2KS5	7500	11000	12287	24574	1,2	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes
ZV	2	25	ZV2P5	9600	19000	12287	24574	1,5	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	Yes	Yes	Yes
ZV	2	25	ZV2PE5	6100	12000	12287	24574	1,8	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	No	Yes	Yes	Yes
ZR	2	33	ZR2PH4	4900	6400	12551	25102	1,2	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ZR	2	40	ZR2PH5	8100	10000	12598	25196	1,2	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes
ZTR	3	14	ZTR3PH5	9900	14000	12820	25640	1,2	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ZTR	3	16	ZTR3PH7	17000	30000	15532	31064	1,2	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	No	Yes	Yes	Yes
ZTRS	3	17	ZTRS3PH7	20000	41000	16513	33026	1,1	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	Yes	Yes	Yes
ZV	3	18	ZV3K2	7700	14000	17385	34770	1,2	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ZV	3	18	ZV3K3	11000	22000	17385	34770	1,2	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes
ZV	3	18	ZV3KS5	7000	10000	17385	34770	1,2	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ZV	3	18	ZV3P5	11000	21000	17385	34770	1,5	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes
ZV	3	18	ZV3PE5	5800	12000	17385	34770	1,8	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ZTR	3	19	ZTR3PH7	19000	26000	18408	36816	1,2	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	No	Yes	Yes	Yes
ZV	3	22	ZV3K4	15000	31000	21336	42672	1,2	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	Yes	Yes	Yes
ZV	3	22	ZV3KS7	11000	17000	21336	42672	1,2	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
ZV	3	22	ZV3P7	14000	28000	21336	42672	1,5	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	No	Yes	Yes	Yes
ZR	3	30	ZR3PH5	7700	9600	22089	44178	1,2	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ZTR	3	32	ZTR3PH8	25000	44000	22147	44294	1,2	No	No	No	Yes	No	Yes	Yes	Yes	No	No	No	No	No	No	Yes	Yes
ZTRS	3	32	ZTRS3PH8	28000	55000	22147	44294	1,1	No	No	No	Yes	No	Yes	Yes	Yes	No	No	No	No	No	No	Yes	Yes
ZR	3	35	ZR3PH7	16000	19000	22352	44704	1,2	No	No	No	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
ZR	3	40	ZR3PH7	14000	17000	22549	45098	1,2	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes

STOBER double bore design DBD: Transferable feed forces

STÖBER

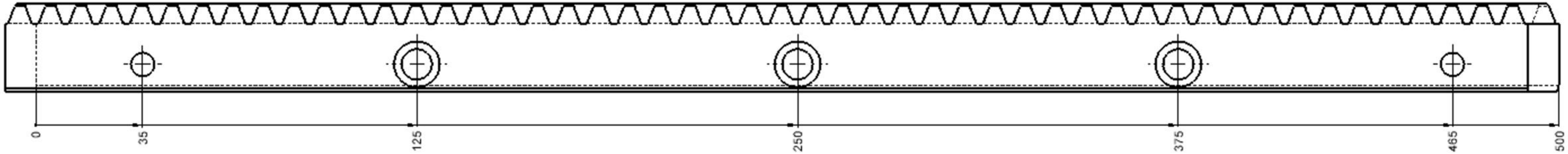
									acceleration feed force								e-stop feed force							
									0,5m length				1m length				0,5m length				1m length			
pinion type	m	z	string	STOBER-catalog F2_acc	STOBER-catalog F2_not	STOBER-rack F2_acc	STOBER-rack F2_not	reduction-factor	F2_acc 4 bores w/o pins	F2_acc 4 bores with pins	F2_acc 7 bores w/o pins	F2_acc 7 bores with pins	F2_acc 8 bores w/o pins	F2_acc 8 bores with pins	F2_acc 15 bores w/o pins	F2_acc 15 bores with pins	F2_not 4 bores w/o pins	F2_not 4 bores with pins	F2_not 7 bores w/o pins	F2_not 7 bores with pins	F2_not 8 bores w/o pins	F2_not 8 bores with pins	F2_not 15 bores w/o pins	F2_not 15 bores with pins
ZTR	4	12	ZTR4PH7	18000	28000	19271	38542	1,2	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ZTR	4	17	ZTR4PH8	35000	55000	30048	60096	1,2	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	No	Yes	Yes	Yes
ZV	4	18	ZV4K4	15000	29000	31447	62894	1,2	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ZV	4	18	ZV4KS7	10000	16000	31447	62894	1,2	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ZV	4	18	ZV4P7	15000	31000	31447	62894	1,5	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
ZTR	4	20	ZTR4PH8	36000	50000	35205	70410	1,2	No	Yes	No	Yes	No	Yes	Yes	Yes	No	No	No	Yes	No	Yes	Yes	Yes
ZTRS	4	20	ZTRS4PH8	45000	70000	35205	70410	1,1	No	No	No	Yes	No	Yes	Yes	Yes	No	No	No	No	No	No	Yes	Yes
ZR	4	30	ZR4PH7	14000	17000	38196	76392	1,2	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ZTRS	5	16	ZTRS5PH8	49000	70000	44179	88358	1,1	No	No	No	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	Yes	Yes	Yes
ZTR	5	18	ZTR5PH8	34000	44000	50314	100628	1,2	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
ZTR	5	19	ZTR5PH9	67000	133000	53479	106958	1,2	No	No	No	Yes	No	Yes	Yes	Yes	No	No	No	No	No	No	Yes	Yes
ZTR	5	19	ZTR5PHV9	67000	133000	53479	106958	1,2	No	No	No	Yes	No	Yes	Yes	Yes	No	No	No	No	No	No	Yes	Yes
ZTRS	5	20	ZTRS5PH9	77000	154000	55223	110446	1,1	No	No	No	Yes	No	Yes	Yes	Yes	No	No	No	No	No	No	Yes	Yes
ZTRS	5	20	ZTRS5PHV9	77000	154000	55223	110446	1,1	No	No	No	Yes	No	Yes	Yes	Yes	No	No	No	No	No	No	Yes	Yes
ZTR	6	15	ZTR6PH8	33000	44000	61359	122718	1,2	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ZTR	6	16	ZTR6PH9	56000	112000	64427	128854	1,2	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes
ZTR	6	16	ZTR6PHV9	56000	112000	64427	128854	1,2	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes
ZTRS	6	20	ZTRS6PH9	77000	150000	79153	158306	1,1	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	Yes	Yes	Yes
ZTRS	6	20	ZTRS6PHV9	67000	141000	79153	158306	1,1	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	Yes	Yes	Yes

STOBER double bore design DBD
Competitive Comparison

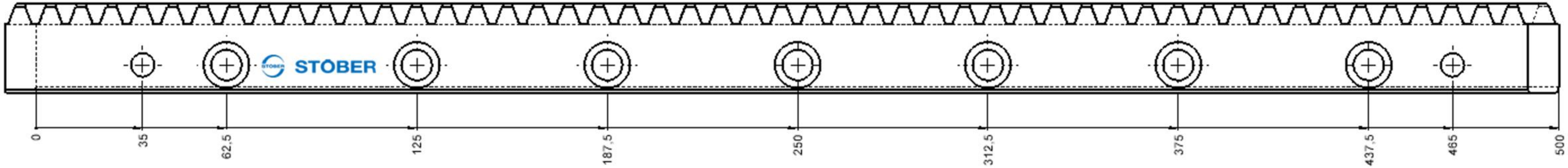
There are only 3 manufacturers who offer racks with a bore pitch of 62.5mm.

- STÖBER
- GÜDEL – compatible with STÖBER
- Wittenstein – one screw hole more - F_{fSV} theoretically 6.7% higher

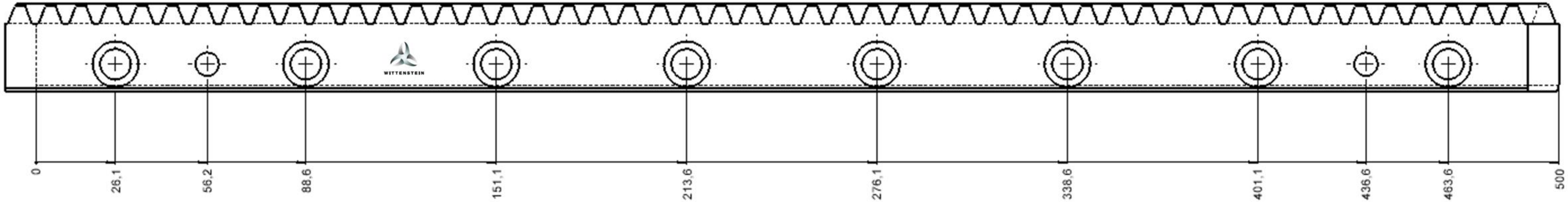
Standard



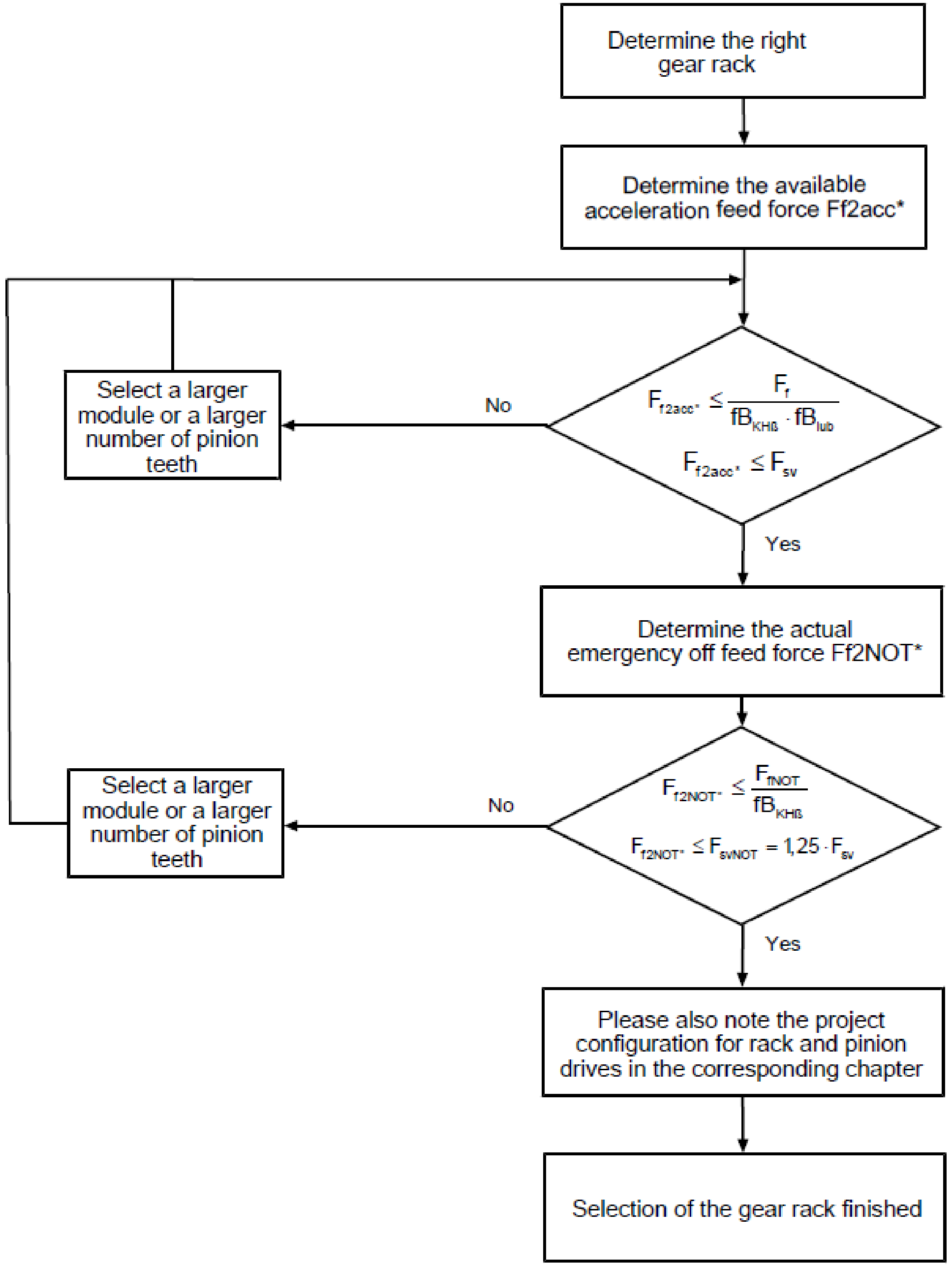
STÖBER



Wittenstein



Projecting



$$F_{f2acc^*} = m^* \cdot a^* + F_{L^*}$$

$$F_{f2NOT^*} = m^* \cdot a_{NOT^*} + F_{L^*}$$

Operating factors

Load distribution	Bearing design	$fB_{KH\beta}$
ZTRSPH	S	1.1
	V	1.1
ZTRSPHQ	S	1.1
ZTRSPHV	S	1.1
ZTRPH	S	1.2
	V	1.2
ZTRPHV	S	1.2
ZRPH	S	1.2
	V	1.2
ZVP	S	1.5
	D	1.3
ZVPE	S	1.8
ZVKS	-	1.2
ZVKL	-	1.5
ZVK	-	1.2

Lubrication	fB_{lub}		
	Permanent	Daily	Monthly
$v_{f2maxZB} \le 1$ m/s	1.0	1.1	5
$v_{f2maxZB} \le 2$ m/s	1.05	1.3	5
$v_{f2maxZB} \le 3$ m/s	1.1	1.5	5
$v_{f2maxZB} \le 5$ m/s	1.25	1.9	5

Projecting:
Permissible feed forces

STÖBER

Permissible forces of the bolt and pin connection

m_n [mm]	l_{ZS} [mm]	Typ	$F_{f,max}$ [kN]	F_{sv} LA125PIN [kN]	F_{sv} LA62,5 [kN]	F_{sv} LA62,5PIN [kN]	m [kg]
2	500,00	ZS2S0500SQ6VG	12,6	8,5	8,0	12,5	1,9
2	1000,00	ZS2S1000SQ6VG	12,6	13,5	18,0	22,0	3,9
3	500,00	ZS3S0500SQ6VG	22,5	16,0	15,5	23,0	2,7
3	1000,00	ZS3S1000SQ6VG	22,5	25,0	33,5	41,0	5,4
4	506,67	ZS4S0500SQ6VG	38,7	31,0	25,0	42,0	5,1
4	1000,00	ZS4S1000SQ6VG	38,7	45,5	55,0	71,5	10
5	500,00	ZS5S0500SQ6VG	60,0	38,5	38,5	55,0	5,8
5	1000,00	ZS5S1000SQ6VG	60,0	61,0	83,0	99,5	12
6	500,00	ZS6S0500SQ6VG	83,1	72,5	75,0	105,5	8,5
6	1000,00	ZS6S1000SQ6VG	83,1	116,0	163,0	192,5	17

Permissible acceleration feed force $F_{f,acc}$ in kN

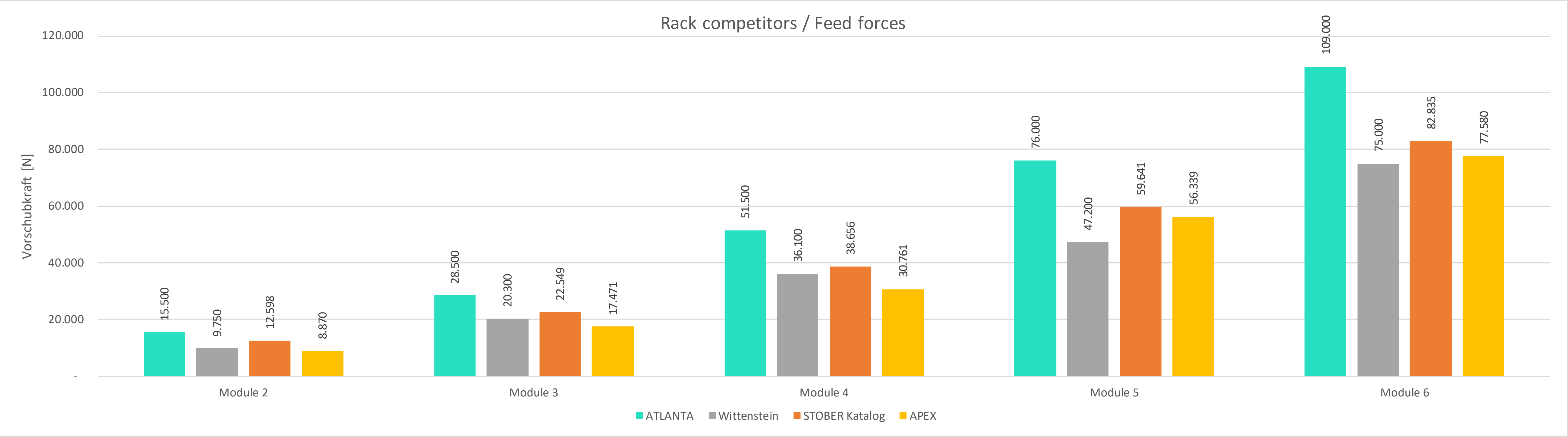
z_{pin}	$m_n = 2$	$m_n = 3$	$m_n = 4$	$m_n = 5$	$m_n = 6$
12	5,8	10,4	19,3	30,8	45,3
13	6,4	11,7	21,2	34,0	50,3
14	7,1	12,8	23,7	37,9	55,2
15	8,1	14,4	26,2	42,0	61,4
16	8,6	15,5	28,0	44,2	64,4
17	9,1	16,5	30,0	47,4	69,3
18	9,8	17,4	31,4	50,3	73,6
19	10,4	18,4	33,4	53,5	77,5
20	11,0	19,3	35,2	55,2	79,2
21	11,5	20,6	36,8	57,9	79,8
22	12,2	21,3	37,3	57,9	80,3
23	12,3	21,6	37,3	57,9	80,3
24	12,4	21,9	37,4	58,0	80,5
25	12,4	21,9	37,6	58,3	81,0

Permissible emergency stop feed force F_{fNOT} in kN

z_{pin}	$m_n = 2$	$m_n = 3$	$m_n = 4$	$m_n = 5$	$m_n = 6$
12	11,6	20,8	38,6	61,6	90,6
13	12,8	23,4	42,4	68,0	100,6
14	14,2	25,6	47,4	75,8	110,4
15	16,2	28,8	52,4	84,0	122,8
16	17,2	31,0	56,0	88,4	128,8
17	18,2	33,0	60,0	94,8	138,6
18	19,6	34,8	62,8	100,6	147,2
19	20,8	36,8	66,8	107,0	155,0
20	22,0	38,6	70,4	110,4	158,4
21	23,0	41,2	73,6	115,8	159,6
22	24,4	42,6	74,6	115,8	160,6
23	24,6	43,2	74,6	115,8	160,6
24	24,8	43,8	74,8	116,0	161,0
25	24,8	43,8	75,2	116,6	162,0

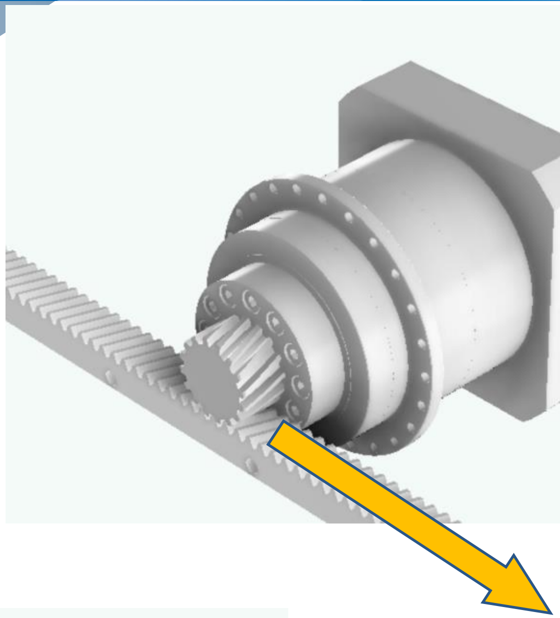
Projecting:
Competition comparison

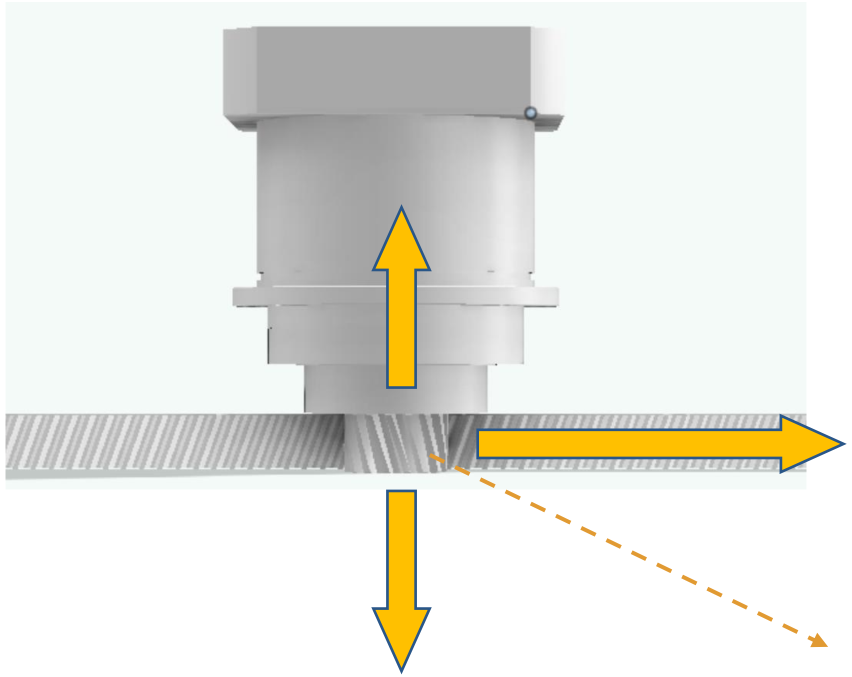
		Racks		Material		Heat Treatment				Quality						
Manucacturer	Productportfolio	Helical	Straight	C45k	16MnCr5	Soft	Quenched and Tempered	Inductive Hardened	Case Hardened	3/4	5	6	7	8	9	9/10
STÖBER	Gearoxes / Motors / Drives / Racks / Pinions	X		X				X				X				
Atlanta	Gearboxes / Racks / Pinions	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Wittenstein	Gearboxes / Racks / Pinions	X		X	X			X	X		X	X				
Apex	Gearboxes / Racks / Pinions	X	X	X			X	X		X	X	X		X		X
Güdel	Gearboxes / Racks / Pinions / Portals	X	X	X		X	X	X			X	X	X	X	X	
Schneeberger	Guides / Racks - no feed forces in catalogue	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Gambini	Racks / Pinions	X	X	X	X		X	X	X			X	X	X	X	X
YYC	Racks / Pinions	X	X	X			X	X			X	X		X		X
K.H.	Racks / Pinions	X	X	X		X	X	X			X	X	X	X	X	X



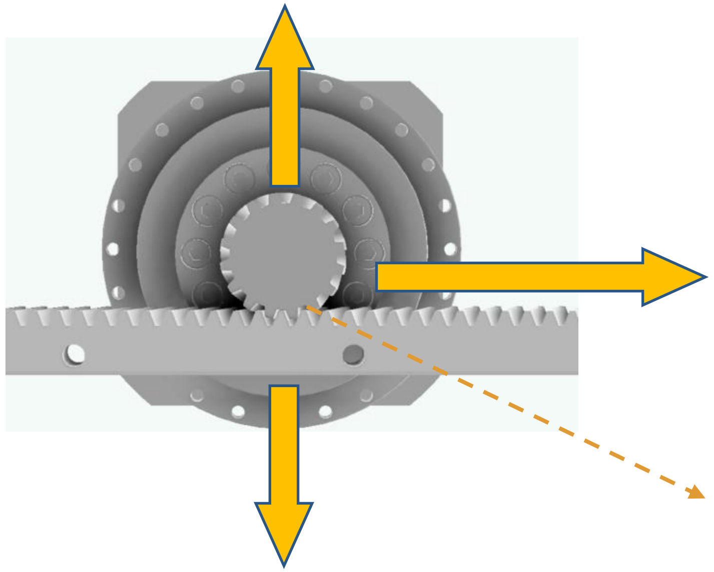
Projecting:
Feed force, axial force and tooth push apart force

Pressure angle: $\alpha = 20°$
Heical angle: $\beta = 19° \, 31' \, 42''$





$F_y = F_{f2,acc} \times \tan\beta$



$F_z = F_{f2,acc} \times \tan\alpha$

SERVOsoft® – Complete design of drive systems. Electrical and Mechanical

- Easy product selection via product database
- Import/Export Function
- Easy exchange of project files with STOBER
- 5 sample projects that you can use directly for your application
- 12 templates for typical drive mechanisms, such as pinion/rack, belt or spindle drive

Projecting: Configuration

Online Configurator

- Find it quickly and configure it with just a few clicks
- Filter, compare, save, and share
- Download: 3D models, dimensional drawings and technical data sheets
- Request a quote directly!

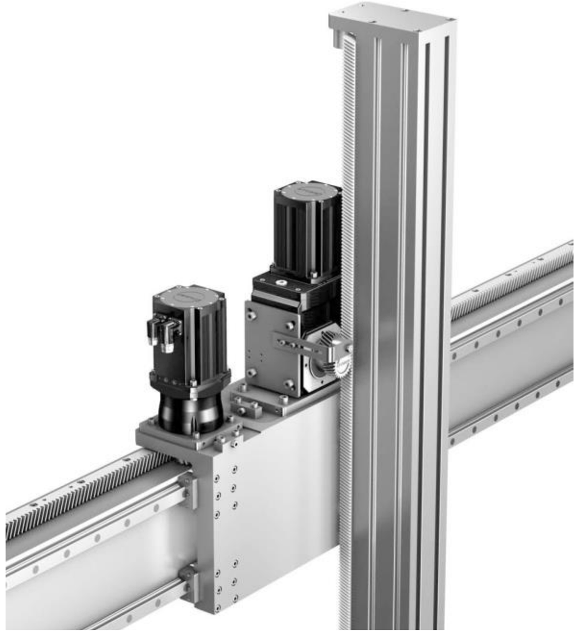
configurator.stober.com

Make it yours!

Application Examples

STÖBER

- Cartesian robots for loading and unloading machine tools, injection molding machines, etc.
- Axis 7 for an articulated robot.
- Large machine tools
- Laser Cutting Machines

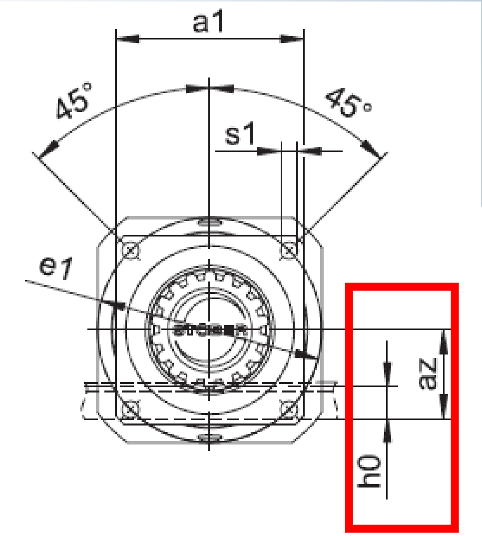


Things to know:
Comparison linear transmission elements

STÖBER

	Stiffness	Running Noise	Lubrication	Speed	Axis Length	Logistics	Position of Drive	Bearing Load
Rack and Pinion	+++ Independent of Position	+++	- Necessary	+++	+++ Unlimited	+++ Out of 1m Pieces	- On carriage. Drag chain required	++ Depending on Feedforce
Ballscrew	+ Depending on Position	+++	- Necessary	+ Limited by natural frequency	-	--- Usually ordered from supplier application specific	+ Stationary. Coupling between Drive Shaft and Ballscrew	- High Axial Forces need expensive helical contact Ballbearings.
Pulley and Belt	-- Plastic Pulley with Steel Wires	---	+++ Not Necessary	+	-	- Endless Belt Only for certain center distances	+ Stationary. Coupling between Drive Shaft and Pulley	-- High preload forces load bearings regardless of torque.

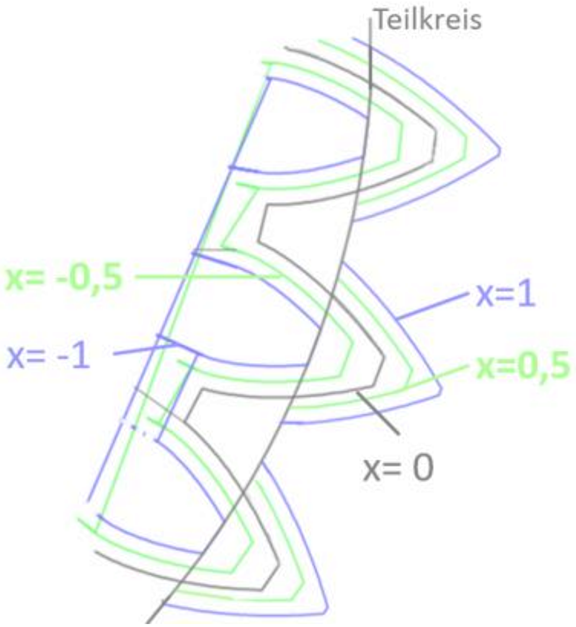
Things to know:
Center distance az and profile shift factor x



Maße Abtrieb

Typ	mn	□a1	ap	az	Øb1	Ød0	Ødk	Ødsi	Øe1	f1	h0	i3	lz	lz4	lsi	r	Øs1	x
ZV216SEP331_	2	72	72	39,98	60_{h6}	33,95	39,81	25	75	7,5	22	19	26	49,5	4	0,025	5,5	0,5
ZV216SEP332_	2	72	75	39,98	60_{h6}	33,95	39,81	25	75	7,5	22	19	26	49,5	4	0,025	5,5	0,5
ZV220SEP431_	2	76	98	44,02	70_{h6}	42,44	47,90	30	85	7,5	22	19	26	57,5	6	0,025	6,6	0,4
ZV220SEP432_	2	76	100	44,02	70_{h6}	42,44	47,90	30	85	7,5	22	19	26	57,5	6	0,025	6,6	0,4

- The center distance az is the nominal dimension of h0 + rolling radius of the pinion
- The profile shift factor x is already taken into account in the rolling radius of the pinion and thus the center distance is
  - ➢ az = ½ d0 + h0 + x*mn
- The center distance az is therefore an important nominal dimension for the design of a rack and pinion drive.
- The profile shift allows gears to be designed larger or smaller with a constant number of teeth.
  Design requirements for center distances can be met with standardized modules. With a positive profile shift, the gear becomes larger and the teeth stronger.
  The tooth root and flank load capacity increases.



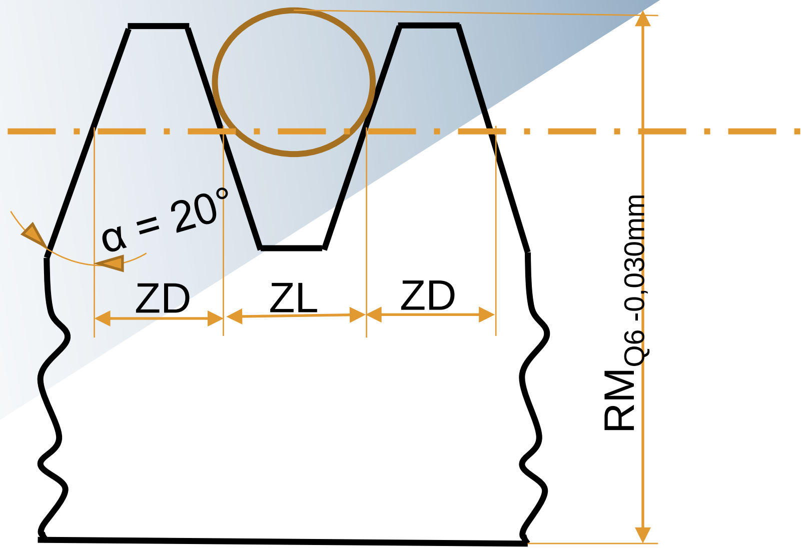
Things to know
Total pitch error F_p of a rack

- The total pitch error F_p of a rack in quality 6:
  - L=500mm Fp≤ ±0,032mm
  - L=1000mm Fp≤ ±0,036mm
  - L=1500mm Fp≤ ±0,036mm
  - L=2000mm Fp≤ ±0,047mm
- The total pitch error is independent of the modul
- The total pitch error is the max. allowed deviation of the theoretical lenght L=(m / cos ß) • π • Z at 20°C
- The total pitch error is a ± value.
- The rack is mentally bent into a gear wheel, the pitch circle diameter is calculated by dividing the length by π (3.1416), and the total pitch error F_p is taken from DIN3962-1 using this th. pitch circle diameter.

Things to know: Total pitch error of a axis consisting out of multiple racks

- The total pitch error of an axis is composed as follows
- $Fp_{Achse} = n \cdot Fp + (n-1) \cdot Q_{Stoß} + Q_T$
- Definitions:
  - n … nomber of racks
  - Fp … total pitch error of the rack
  - $Q_{Stoß}$ … error in the joint between two racks
    - Assembly with assembly rack $Q_{Stoß} \approx 0{,}025mm$
    - Assembly with measuring bridge, pin and adjustment device $Q_{Stoß} \approx 0{,}005mm$
  - Q_T … Longitudinal expansion based on temperature change
  - Q_T is calculated as follows:
    Steel has a length expansion factor coefficient of about 0,000012 m/(m·K)
    An axis with a length of 10m and a warming of 10K will expand 1,2mm.

Things to know:
Tooth thickness tolerance and measurement over pin at Racks



The partial line of a rack lies in such a way that
Tooth thickness ZD = tooth gap ZL
The face pitch pt = ZD + ZL = (m.π)/cosß
The tooth thickness tolerance T_{SN} = 0 / -0.020mm at Q6.
Only depending on the quality, not on the module.

Since tooth thickness is difficult to measure, this measurement is made using a measuring roller against the back of the rack. This is known as the measurement over pin RM.

Module	Pin Diameter	Measurement over pin RM
2	4	25,532
3	6	31,298
4	8	42,064
5	10	42,830
6	12	53,596

The tooth thickness tolerance must be converted depending on the pressure angle α = 20°.
RM-Tolerance = $T_{SN} \cdot 1.5 = -0.020\text{mm} \cdot 1.5 = -0.030\text{mm}$

The measuring roller must protrude beyond the teeth of the rack and should touch the flanks near the partial line.
The measuring roller must have a tolerance of ±0.001mm.
Test pins 426 according to DIN 2269 have this tolerance.

Things to know:
Surface layer hardening

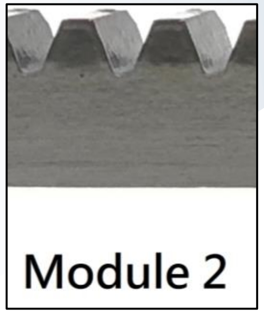
STÖBER

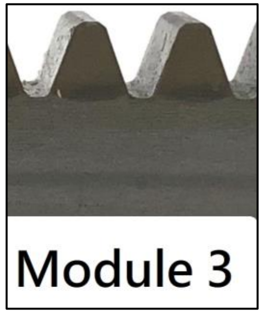
The STOBER racks are made of high tensile steel with a carbon content of approx. 0.45%. This allows the racks to be hardened using the surface layer process. In this process, the tooth is heated and quenched immediately afterwards. Up to module m=4 is hardened in a scanning process, from m=5 each tooth is hardened individually. The single-tooth method is used to create sufficient hardness even into the tooth base at the high tooth height.

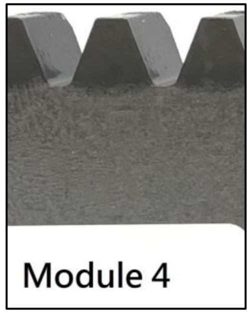
- For cost reasons, module 5 is still hardened by many competitors in a scanning process.
- The hardening of the tooth base area no longer works with the large modules in the scanning process.
- The permissible feed forces must be significantly reduced.

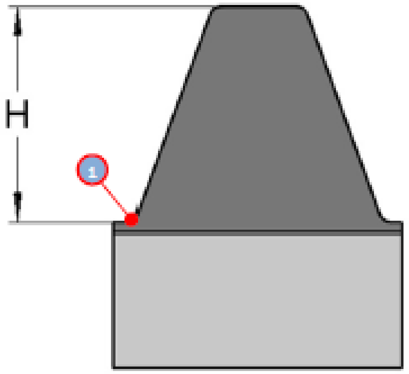
Things to know:
Surface layer hardening

Scanning process



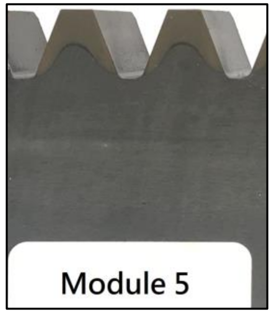


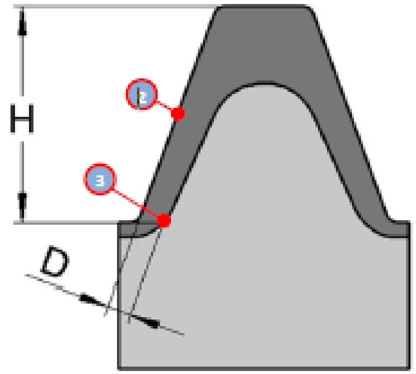




Module	Surface Hardness Measuring Point (1)	H [mm]
2	550 + 80 HV	4,5
3		6,75
4		9

Tooth by tooth process

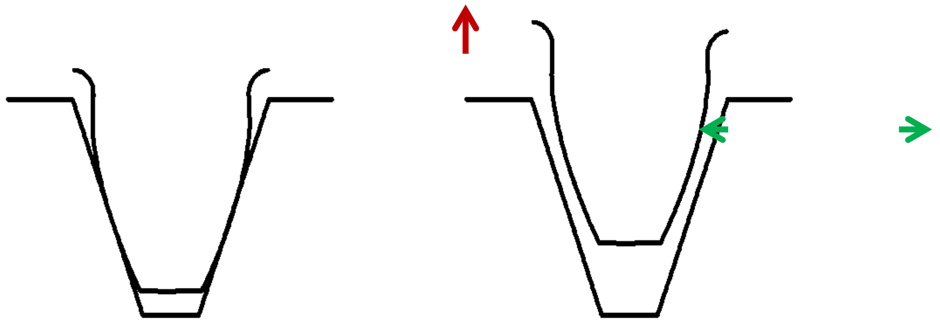




Module	Surface Hardness Measuring Point (2)	Hardness at Measuring Point (3)	H [mm]	D [mm]
5	550 + 80 HV	550 + 80 HV	11,5	0,3
6			13,5	0,3

Things to know:
Gear backlash – pinion rack adjustment

For ground racks, we recommend a gear backlash of approx. 0.020mm as a guideline.



↑radial distance ← + → Gear backlash

↑Radial distance	← + → Gear backlash
0,015	0,01
0,029	0,02
0,044	0,03
0,058	0,04
0,073	0,05
0,146	0,1

Gear backlash = Radial distance/ 1,5

Things to know:
Feed Forces – Influence of quality, material and heat treatment

STÖBER

Example: m=4 / helical gearing

Pinion: 16MnCr5 case-hardened / Z=20 / Q5

Rack: C45E

Induktiv Gehärtet			Ind. Gehärtet	Vergütet	Weich
Q6	Q7	Q8	Q10	Q8	Q9
35,2kN	35,2kN	31,5kN	23,5kN	10,5kN	4,5kN

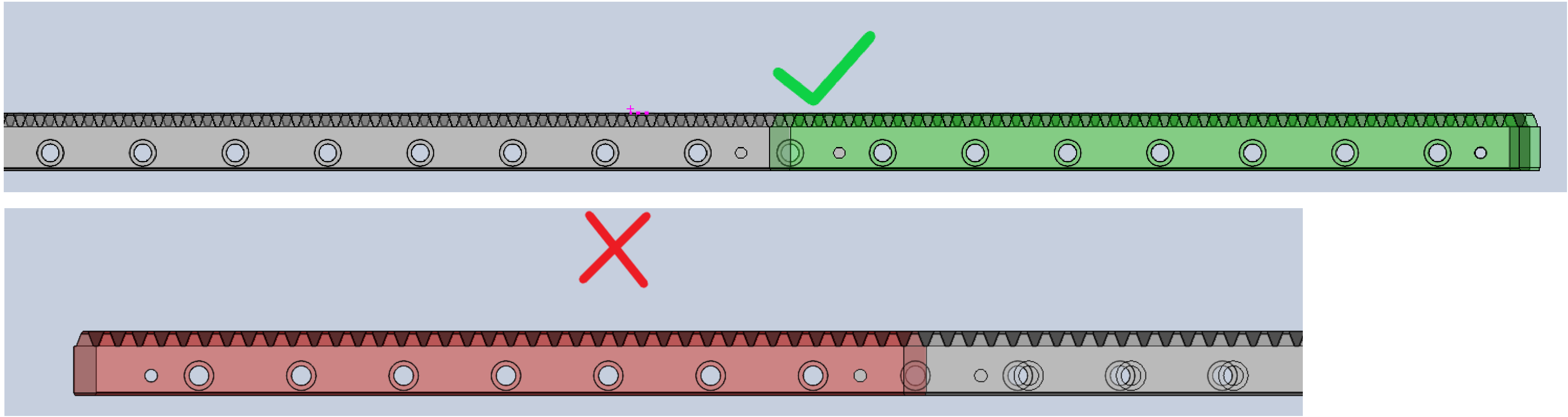
Same as above, but now different materials

16MnCr5	C45E
Q6 / Eingesetzt u. Ind. Geh.	Q6 / Ind. Geh.
50kN	35,2kN

With high-quality, hardened racks, modern Machines can be built much more compactly!

Things to know:
Why does the rack m=4 have an odd length L=506.67mm?

- Z=38 → L=506,6667
- Z=37 → L=493,3336
- → Exactly L=500mm is not possible, because you always have to stop in the middle of a tooth gap.
- Due to this effect, the short rack with L=506.67 must always be the last rack on the right.
  This is the only way for the customer to drill the threaded holes in the machine bed at the same consecutive distance.



STÖBER

Why exactly helical angle ß=19°31´42´´?

- Pitch p = (m · π)/cosß
- ß = 19°31´42´´ = 19,528333°
- m=2: p=6,66666 → 3 teeth → 20,000mm
- m=3: p=10,000mm
- m=4: p=13,3333 → 3 teeth → 40,000mm
- m=5: p=16,6666 → 3 teeth → 50,000mm
- m=6: p=20,000mm

→ 3 divisible numbers of teeth in the pinion always result in an integer feed constant. At m=3 and m=6 even any number of teeth.

Things to know:
Feed constant u

Feed constant u: $u = (Z \cdot p)/i$

Example: ZV318S_P531_0070ME

Only the pinion has $u = Z \cdot p = 18 \cdot 10 = 180$ mm/rev

Due to the gearbox, this value is reduced by the ratio i.

$u = (18 \cdot 10mm)/7 = 180/7 = 25.714285$ mm/U

At a motor speed of 3000rpm, the linear axis travels with

$v = n \cdot u = 3000$ rpm $\cdot$ 25.714285 mm/rev = 77142.855 mm/min = 1.2857m/s

Or as a cropped size equation:

$$v = (n \cdot u)/60000$$

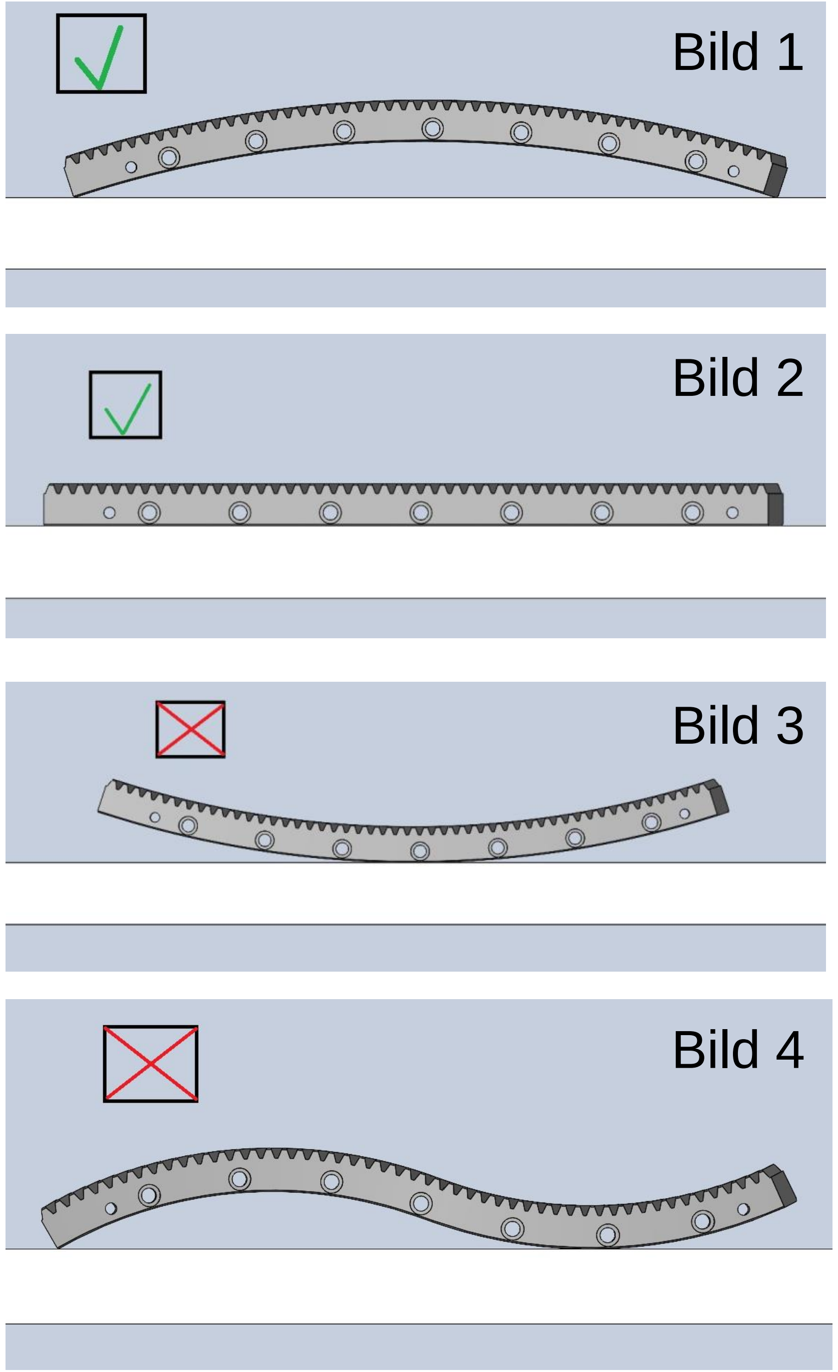
If the required motor speed is searched for at a given speed, the formula is changed to n:

$$n = (v \cdot 60000)/u$$

Assembly:
Possible shapes

A rack is a long, slender rod that has been machined and hardened. When untensioned, the back of the rack must be concav (Fig. 1) so that it rests on a flat surface with the ends. This is created by "straightening" after hardening. This design makes it possible to clamp the rack against the machine bed with appropriate tools and to screw it in this state and, if necessary, pin it (Fig. 2).

Pictures 3 and 4 show undesirable shapes. These make it difficult to mount at the machine bed as desired (Fig. 2).



Assembly:
Requirements for the connection design

To ensure that the gear rack is installed correctly and the machine operates flawlessly, the connecting structure and installation location must correspond to the following requirements.

- The installation location of the gear rack must be clean and dry, as dust and fluids can impair the function of the rack and pinion drive.
- The gear rack has a chamfer between the contact side and screw mounting side to allow for easy installation onto the connecting structure. The dimensions of the chamfer can be found in the dimensional drawings in the product catalog.
- STOBER recommends the following shape and position tolerances for the connecting structure, which apply to gear racks with a length of 1 m.
- The recommended parallelism tolerance of the connecting structure for the drive depends on the required smooth operation and positioning accuracy as well as on the size of the mounting surface (dimension a1) as follows.

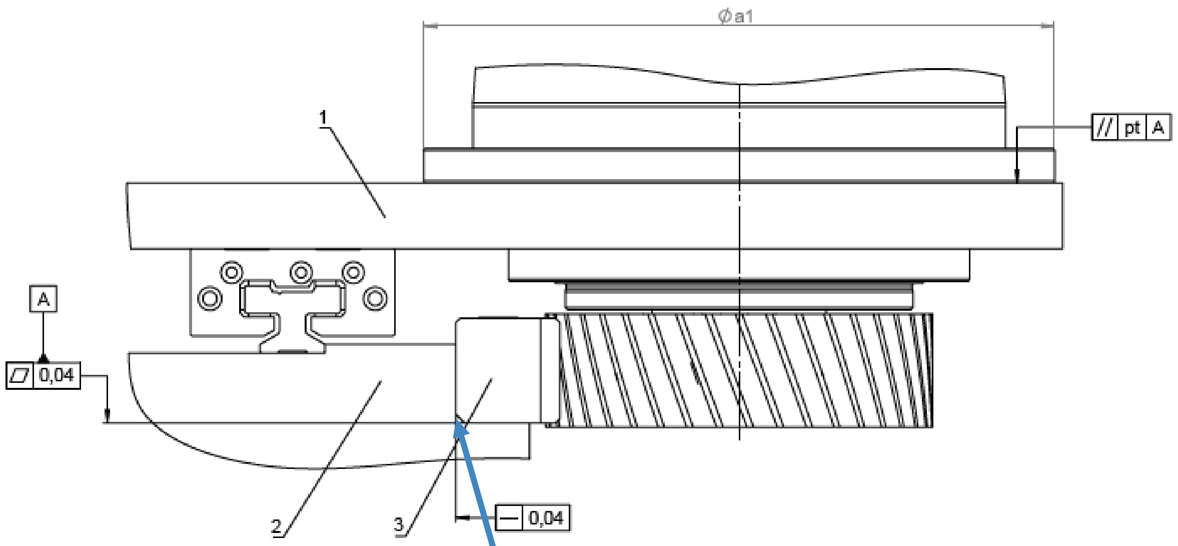


Fig. 1: Shape and position tolerances for the connecting structure

1 Connecting structure for drive
2 Gear rack
3 Connecting structure for gear rack

Modul	Fase	max. Eckenradius
2-4	2x45°	$R_{max.}$ 1,7mm
5-6	3x45°	$R_{max.}$ 2,7mm

Requirements for smooth operation and positioning accuracy	Parallelism tolerance pt [µm], based on a1 = 100 mm
High	10
Normal	15
Low	30

Assembly:
Tools

- If necessary due to the weight, lifting gear with appropriate fastening elements and sufficient lifting capacity
- Cleaning agent
- Sharpening stone
- Clamps with protective caps or intermediate layers made of plastic
- Torque wrench with hexagon sockets
- Drill (diameters are specified in the chapter Securing a gear rack with pins [} 17])
- Reamer

If you want to mount multiple gear racks next to each other, you need the following tools:

- Mounting gear rack with the same module as the gear racks. Mounting gear racks can be obtained as accessories from STOBER.
- Dial gauge with measurement bridge
- 3 needle rollers (diameters are specified in the chapter Checking the transition between the gear racks [} 16])
- Magnet for magnetizing the needle rollers
- Dead blow hammer
- Copper punch

Assembly: Preparation

- Upon delivery, the gear rack is protected by a corrosion protection agent. The corrosion protection agent must be removed from all contact surfaces of the gear rack with the connecting structure before assembly. STOBER recommends removing the corrosion protection with a suitable cold cleaner (e.g. Carlofon Autocleaner) which, in contrast to volatile solvents, is almost odorless. Otherwise, you can use commercially available solvents.
- Unpack the gear racks.
- Leave the unpacked gear racks in the installation space until they reach the room temperature.
- Clean the contact surfaces of the gear racks and grind them down with a sharpening stone if necessary.
- Clean the contact surfaces of the connecting structure and grind them down with a sharpening stone if necessary.

Assembly:
First rack

If you want to install three or more gear racks next to each other, start in the center of the connecting structure.

The connecting structure must have a suitable mating surface counterface for applying the clamps that are used during installation.

- Position the gear rack (6) on the screw mounting surface (1) so that the through-holes of the gear rack are aligned centrally with the threaded holes in the screw mounting surface.
- Clamp the gear rack to the mounting surface (7) using clamps (4) near every second through-hole (starting from the outside). Use intermediate layers, e.g. made of plastic(2), so that the toothing is not damaged.
- Screw cylinder screws (3) into the through-holes.
- Tighten the cylinder screws with the tightening torque specified below, starting from the center outward.
- Remove the clamps.

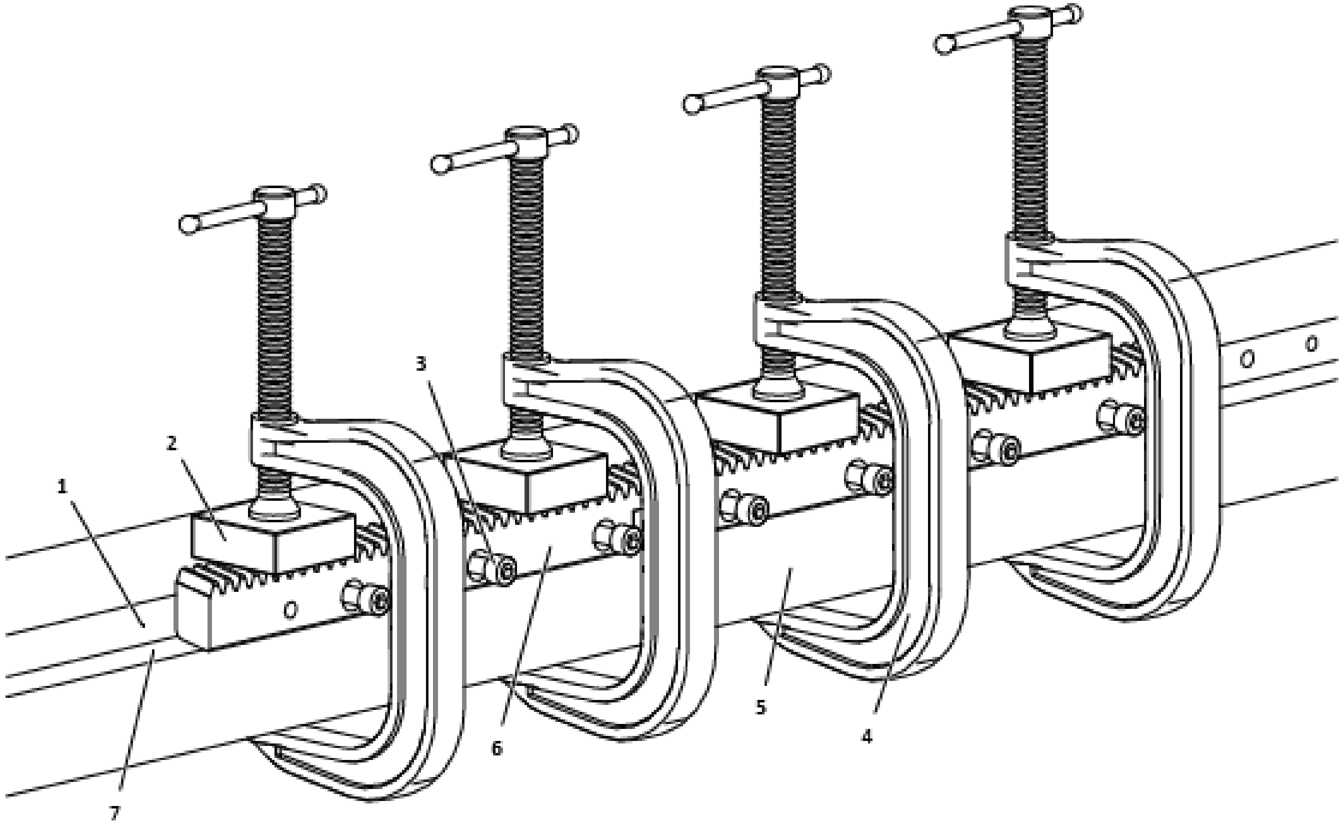


Fig. 2: Installation of a gear rack on the connecting structure (example)

1	Screw mounting surface	2	Intermediate layer
3	Cylinder screw	4	Clamp
5	Connecting structure	6	Gear rack
7	Contact surface		

Assembly:
Further racks

The end of a gear rack and the start of another gear rack each form a half tooth gap. A narrow gap remains between the correctly installed gear racks that allows the gear racks to be adjusted.

- Position another gear rack (5) at the end of the preceding gear rack (7). Note that a gear rack with a length of 500 mm and module 4 can be installed only to the right of a gear rack with a length of 1000 mm due to the design.
- Position the mounting gear rack (1) in a center position above the joint between the gear racks and use a clamp (2) to clamp it onto the connecting structure (4).
- Using a clamp (2) with intermediate layer (3), clamp the gear rack (5) onto the connecting structure near the first through-hole.
- Screw a cylinder screw (6) into the first through-hole.
- Tighten the cylinder screw with half of the specified tightening torque.
- Repeat steps 3 through 5 for all other cylinder screws.
- Remove the mounting gear rack.
- Remove the mounting gear rack. – see next page.
- Tighten all cylinder screws with the tightening torque specified below.
- Remove the clamps.

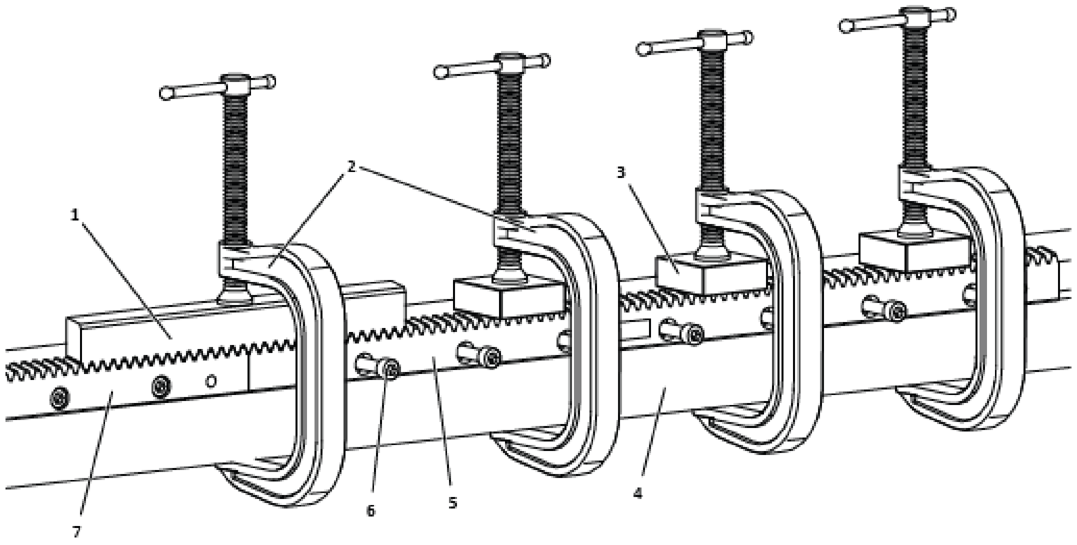


Fig. 3: Assembly of another gear rack (example)

1	Mounting gear rack	2	Clamp
3	Intermediate layer	4	Connecting structure
5	(Another) gear rack	6	Cylinder screw
7	(Preceding) gear rack		

Assembly:
Cylinder head bolts

Type	Number of screws [1]	Screw size	Strength class	Tightening torque [Nm]
ZS2S500S	4/7	M6	12.9	18
ZS2S1000S	8/15	M6	12.9	18
ZS3S500S	4/7	M8	12.9	43
ZS3S1000S	8/15	M8	12.9	43
ZS4S500S	4/7	M10	12.9	84
ZS4S1000S	8/15	M10	12.9	84
ZS5S500S	4/7	M12	12.9	145
ZS5S1000S	8/15	M12	12.9	145
ZS6S500S	4/7	M16	12.9	365
ZS6S1000S	8/15	M16	12.9	365

Assembly:
Check the transition between the racks

ATTENTION! Particles of iron are stuck to a magnetized gear rack and can damage the toothing. Do not place magnets near the gear rack.

- Magnetize the 3 needle rollers with the magnet so they remain in their positions.
- Position the measurement bridge (2) with dial gauge (1) on a surface-ground surface and set the dial gauge to zero.
- Place a needle roller (5) in the tooth gap at the joint between the gear racks.
- Place one needle roller each in the tooth gap to the right (4) and left (6) of the joint.
- Position the measurement bridge with dial gauge on the needle rollers so that the dial gauge button can sample the center needle roller.
- Move the measurement bridge slightly to the right and left and read off the maximum deviation on the dial gauge.
- If the deviation is outside the tolerance range (in the following table), lightly tap the downstream gear rack with a dead blow hammer to correct its position. If necessary, use a copper punch that you attach to a mounting hole in the gear rack.
- If the deviation is within the tolerance range, continue the installation (see previous chapter).

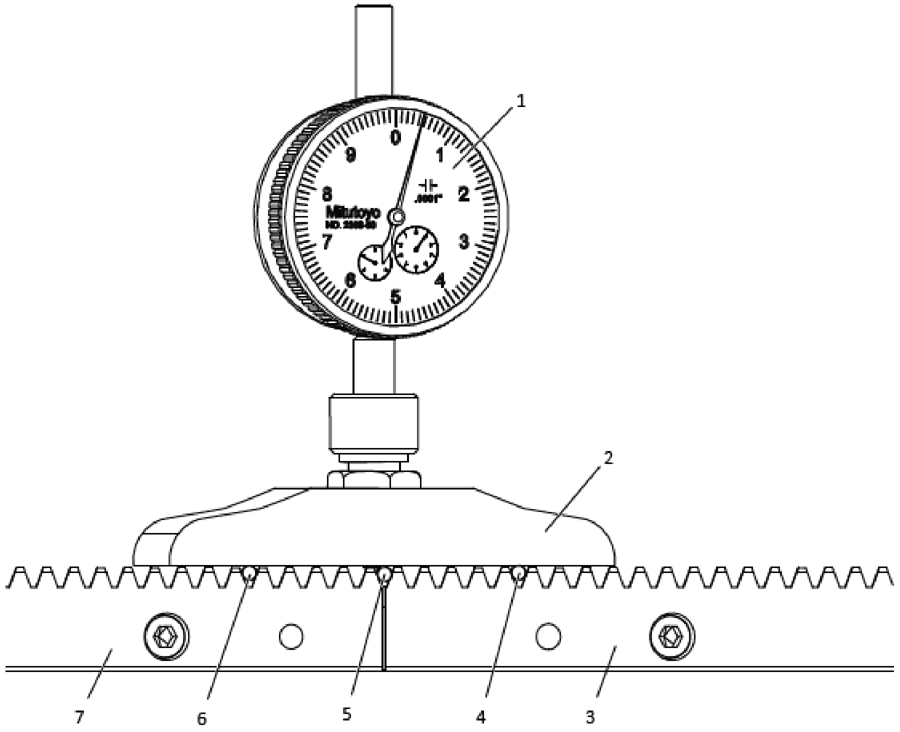


Fig. 4: Checking the transition between two gear racks (example)

1	Dial gauge	2	Measurement bridge
3	(Next) gear rack	4	Needle roller (right)
5	Needle roller (at the transition)	6	Needle roller (left)
7	(Preceding) gear rack		

Module [mm]	∅ of needle roller [mm]	Tolerance range² [mm]
2	4.0	± 0.01
3	6.0	± 0.011
4	8.0	± 0.011
5	10.0	± 0.016
6	12.0	± 0.016

Tab. 2: Needle rollers and tolerance ranges

Assembly: Pin the rack

If required by the design of your rack and pinion drive, secure the position of the gear rack with cylindrical pins.

STOBER recommends using hardened cylindrical pins with internal thread in accordance with EN ISO 8735. The internal thread allows the cylindrical pins to be easily removed again if needed.

For drilling the pin bores, STOBER recommends a magnetic drill, for which suitable surfaces have been provided in the connecting structure.

Specifications for required drills and cylindrical pins can be found in the following table.

- Drill the pin bores in the connecting structure. Guide the drill through the respective bore (4) in the gear rack to do so.
- Ream the bores in the gear rack together with those in the connecting structure to fit size H7 for the cylindrical pins.
- Remove chips with a vacuum.
- Hammer the cylindrical pins (3) into the bores.

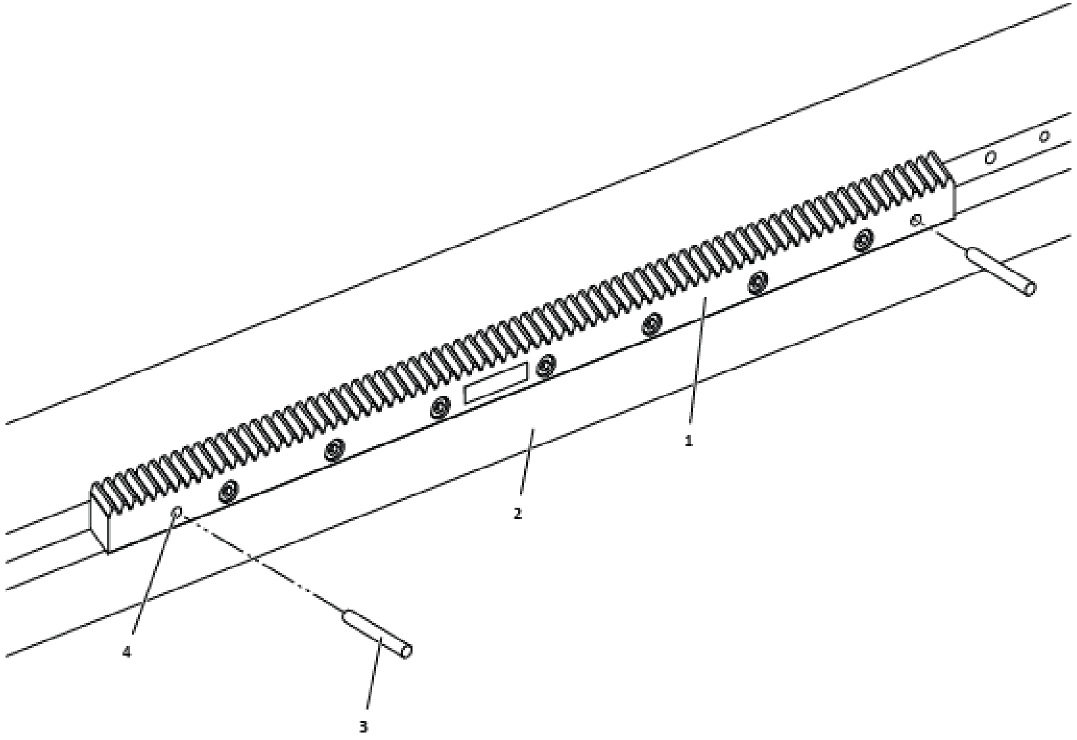


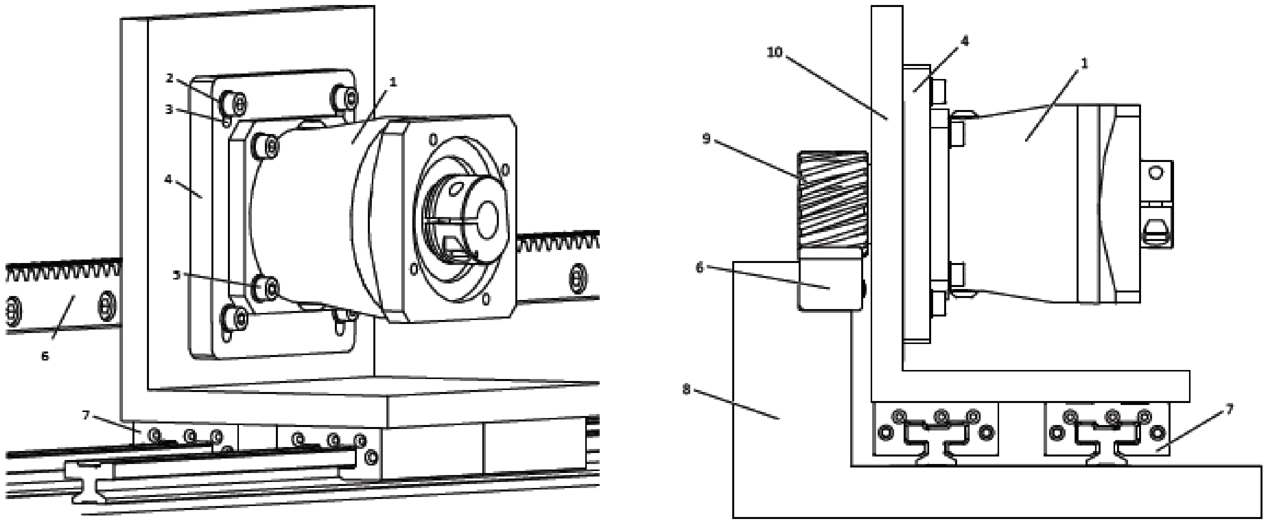
Fig. 5: Securing a gear rack with pins (example)

1	Gear rack	2	Connecting structure
3	Cylindrical pin	4	Bore (for cylindrical pin)

Module [mm]	Bore Ø [mm]	Cylindrical pin size [mm]	Number per gear rack
2	5.7	6 m6	2
3	7.7	8 m6	2
4	11.7	12 m6	2
5	11.7	12 m6	2
6	15.7	16 m6	2

Assembly:
Gearbox with pinion to slide

- Install the gear unit (1) with the adjustment plate (4). In the process, initially position the adjustment plate with thegear unit so that the distance between the pinion (9) and gear rack (6) is as large as possible.
- Loosen the cylinder screws (5) in the adjustment plate.
- Push the gear unit to the gear rack radially by hand until the pinion is seated in the toothing of the gear rack with low backlash.
  On ZR pinions from STOBER, the tooth with the highest radial runout deviation is marked with a dot.
- Tighten the cylinder screws in the adjustment plate.
- Move the gear unit in the guide along the entire travel path to check if this is possible at all positions when an equal level of force is applied. The running noise should also remain consistent. There must be no knocks at the transitions between the gear racks.
- **ATTENTION! If the pinion is mounted on the gear rack under pretension, this can result in premature wear, toothing damage or rolling bearing damage in the drive!** The tooth flanks of the pinion and gear rack should be in contact attheir highest positions without backlash and pretension. Flank play is possible in some parts of the travel path.
- If necessary, correct the distance between the pinion shaft and gear rack using the adjustment plate. STOBER recommends gearing play of 0.02 mm, which corresponds to a radial distance of 0.03 mm between the pinion gearing and gear rack.entspricht.

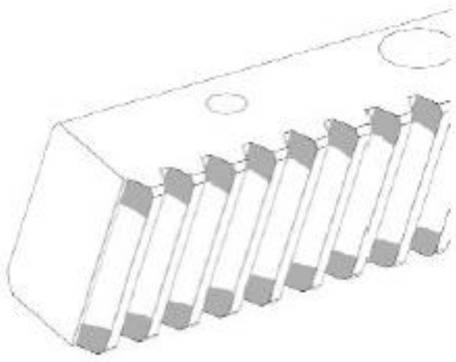


Tab. 4: Mounting a gear unit with pinion and adjustment plate (example)

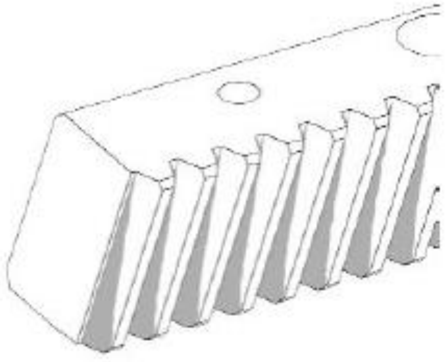
1	Gear unit	2	Washer
3	Slot (in adjustment plate)	4	Adjustment plate
5	Cylinder screw	6	Gear rack
7	Linear guide	8	Connecting structure for the gear rack
9	Pinion	10	Connecting structure for the gear unit

Assembly:
Face pattern control

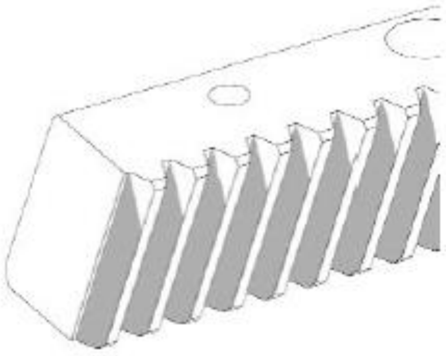
- Degrease the tooth flanks of the gear rack.
- Coat the tooth flanks with spotting paste.
- Move the drive back and forth along the gear rack several times.
- Check the areas of the tooth flanks in which the spotting paste has been removed.
- Using the following example contact patterns, assess whether the gear unit is correctly aligned with the gear rack.
- If required, correct the position of the gear unit and repeat the previous steps.



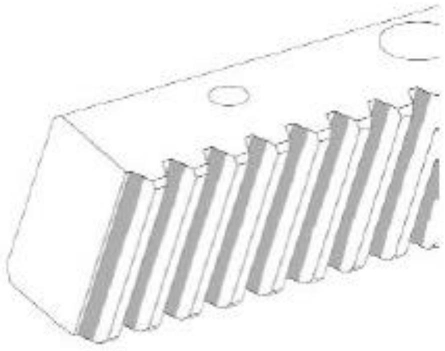
Correct



Not parallel



Not a right angle



Incorrect center distance

Lubrication

ATTENTION! A lack of or no lubrication of the gear rack and pinion results in toothing damage during operation.

- Install a lubrication system that ensures lubrication of the rack and pinion drive during operation.
- Before commissioning the gear rack, clean and lubricate the gear rack and pinion manually.

Schmierstoffe

STOBER recommends the following lubricants for the rack and pinion drive:

- Klüber Microlube GB 0
- Klüber Structovis AHD
- Oest Langzeitfett LT 200
- BP Energrease LS EP 00
- DEA Glissando 6833 EP 00
- Fuchs Lubritech Gearmaster ZSA
- Molykote G-Rapid plus 3694

Metering quantities

In the following table, you will find metering quantities for lubrication gears made of felt or PU foam, which can be engaged in the pinion or gear rack depending on the design conditions.

Vorschubgeschwindigkeit (v) [m/s]	$v \leq 1$	$1 < v \leq 2$	$2 < v \leq 3$	$3 < v \leq 4$	$v > 4$
Modul [mm]	Tägliche[3] Dosiermenge [cm³]				
2	0,25	0,5	0,75	1	1,25
3	0,25	0,65	1	1,25	1,5
4	0,25	0,75	1,25	1,5	2
5	0,25	1	1,5	2	2,5
6	0,25	1,25	1,75	2,5	3

STOBER recommends a metering quantity that is 1.5 to 2 times higher for lubrication with a lubricant brush and for drip lubrication or injection lubrication.

[3] in relation to single-shift operation

Lubrication

Continuous lubrication is the state of the art. Automatic lubricators or centralized lubrication systems are used for this purpose. The latter is also suitable for lubricating all other lubrication points on a machine, such as bearings, guides and screw drives.

You can purchase lubrication systems and lubricants from the following providers:

perma-tec GmbH & Co. KG
https://www.perma-tec.com/

Gruetzner GmbH
https://g-lube.com/de/

STW - Kim Friedrich GmbH
https://schmiertechnikwerk.com/

DLS Schmiersysteme GmbH
https://www.dls-schmiersysteme.de/

Causes of malfunctions

Faults	Possible causes	Actions
Unusual operating noises	A lack of or no lubrication	Check lubrication system according to documentation
	Toothing damage	Check the design and installation of the rack and pinion drive; replace defective components
	Pinion braced against gear rack	Check the installation according to chapter Installing the gear unit with pinion [▶ 18]
	Gear rack incorrectly mounted	Check the installation according to chapter Final inspection [▶ 19]
Toothing damage such as wear, pitting or broken toothing	A lack of or no lubrication	Check lubrication system according to documentation
	Gear rack incorrectly mounted	Check the installation according to chapter Final inspection [▶ 19]
	Overload of the drive	Check the design of the rack and pinion drive
Position deviation within the travel path or increased flank play	Center distance incorrectly set	Set the center distance according to chapter Installing the gear unit with pinion [▶ 18]