Screw connection/ bolt connections

Bolts
The high expectations on quality and service life of rothe erde® slewing bearings also requires efficient handling of bolted connections.

Boundary load curves
The boundary load curves shown in the static diagrams are in all cases related to bolts with strength class 10.9. A prestressing of 70% of the yield limit is a prerequisite.

In bearings without an entered bolt curve, the entire load capacity range below the boundary load curves is covered by bolts with the strength class 10.9.
The maximum load without factors is applied for testing against the bolt curve.

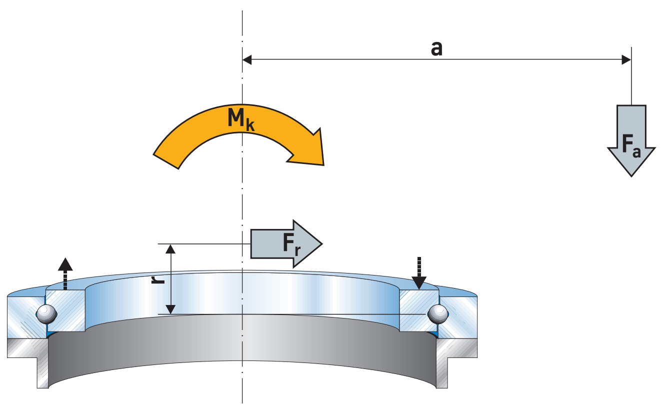


Figure 12: Axial load "application from above"

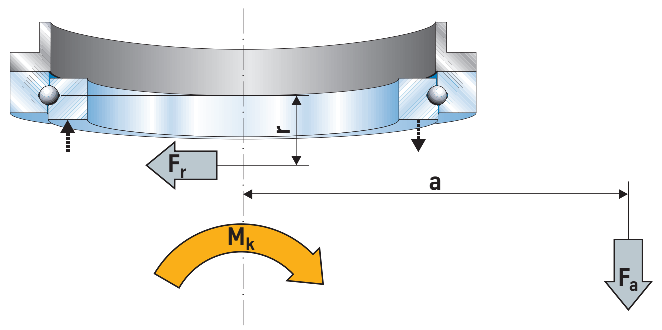


Figure 13: Axial load "suspended"

Preconditions
The following prerequisites apply to boundary load curves:

1. The axial load F_a acts with contact from the top, not "suspended", i.e. the axial operating force F_A from the axial load does not act on the bolts with tension, see Figures 12 and 13.
2. The bolts are evenly distributed around the bolt-hole circles.
3. The connection designs comply with our technical conditions, see page 220.
4. The slewing bearing and the connection structures are made from steel.
5. No cast resin lining is provided underneath.
6. The clamping length l_k is:
   - at least 5 · d in bearings with a full ring cross section
   - at least 3 · d in profiled rings such as the type series 25, 23, 28.

Table 2: Minimum screw-in depth with blind-hole thread for medium tolerance class (6 H)
Different tolerance classes require corresponding allocated screw-in depths

Bolt strength class	8.8/10.9	10.9/12.9	12.9
Thread fineness d/P	≥ 9/< 9	≥ 9/< 9	≥ 9
St 37	1,25 · d		
St 50, C 45 N,46 Cr 2 N, 46 Cr 4 N	1,0 · d	1,2 · d	1,4 · d
C 45 V, 46 Cr 4 V,42 CrMo 4 V	0,9 · d	1,0 · d	1,1 · d

d – Thread external Ø [mm]
Bolts with metric
ISO thread (standard thread)

P – Pitch of the thread [mm]
up to M 30 have a d/P < 9
> M 30 have a d/P ≥ 9

7. There are at least six free thread turns in the loaded part of the bolt.

Advantage The definition of standards creates planning certainty and reduces the coordination complexity.

Note Consultation is required in the event of different preconditions.

The boundary surface pressures listed in Table 3 in the contact surfaces of the bolt head and nut of the clamped parts are not allowed to be exceeded.

Advantage The loss of prestressing due to creep is avoided.

Note The selected product and strength class of the bolts and nuts must be guaranteed by the supplier. Pay attention to the identification according to DIN/ISO in this case.

Perpendicularity between the contact surface and axis of the thread of the bolt and nut must be guaranteed.

Pitch errors which result in falsification of the tightening torque especially with screw-in lengths > 1 · d reduce the bolt prestressing force and must be excluded.

For bolts larger than M30, it is preferable for a hydraulic bolt clamping cylinder to be used, see pages 214–215.
Based on our experience, the coefficients of friction are ex-cessively diverse, as a result of which Table 4, page 210 does not specify any tightening torques.

Note The design must take account of an increased space requirement for bolt head, nut, tightening tool and increased size of washer. The height of the washer must be adapted to the bolt diameter. Comply with plane-parallelism.

Rough procedure for determining the surface pressure under the head or nut contact surface
Condition:

$$p = \frac{F_M/0.9}{A_p} \leq p_G \qquad [kNm]$$

F_M – Mounting prestressing force of the selected bolt [N]
A_p – Contact surface or nut (bolt head) [mm²]
p_G – Boundary surface pressure for the compressed parts [N/mm²]

In this case, the reduction in the contact surface due to hole chamfering as well as washer face on the hexagonal profile must be taken into account.

$$A_p = \frac{\pi}{4}(d_w^2 - d_h^2) \text{ for } d_h > d_a$$

d_h – Hole diameter
d_a – Internal diameter of the head contact surface
d_w – External diameter of the head contact surface

Table 3: p_G - Boundary surface pressure [N/mm²] for the compressed parts

Material	p_G boundary surface pressure
S 235 JR + AR	260 N/mm²
E 295, C 45 N, 46 Cr 2 N, 46 Cr 4 N	420 N/mm²
C 45, profile rolled (Series 23, 25, 28)	700 N/mm²
C 45 V, 46 Cr 4 V, 42 CrMo 4 V	700 N/mm²
GG 25	800 N/mm²

If the boundary surface pressures are exceeded, washers of corresponding size and strength must be provided.

Screw connection/ bolt connections

Table 4: Clamping forces and tightening torques for bolts with metric standard thread DIN 13, für $\mu_G \approx \mu_K = 0{,}14$

Strength class according to DIN ISO 898 Yield strength $R_{p\,0,2}$ N/mm²			10.9 940			12.9 1100		
Metric ISO-Thread DIN 13	Clamping cross-section A_S mm²	Core cross-section A_3 mm²	Clamping force F_M N	for hydr. + electr. M_d driver M_A Nm	for M_d'-* key M_A' Nm	Clamping force F_M N	for hydr. + electr. M_d driver M_A Nm	for M_d'-* key M_A' Nm
M 12	84,3	76,2	61 500	137	123	72 000	160	144
M 14	115	105	84 400	218	196	98 800	255	230
M 16	157	144	115 700	338	304	135 000	395	356
M 18	193	175	141 000	469	422	165 000	549	495
M 20	245	225	181 000	661	595	212 000	773	696
M 22	303	282	225 000	904	814	264 000	1057	951
M 24	353	324	260 000	1136	1025	305 000	1329	1196
M 27	459	427	342 000	1674	1506	400 000	1959	1763
M 30	561	519	416 000	2274	2046	487 000	2662	2396
M 33	694	647	517 000			605 000		
M 36	817	759	608 000			711 000		
M 39	976	913	729 000			853 000		
M 42	1120	1045	830 000			971 000		
M 45	1300	1224	968 000	Find through elongation measurement of the bolt		1 134 000	Find through elongation measurement of the bolt	
M 48	1470	1377	1 090 000			1 276 000		
M 52	1760	1652	1 312 000			1 535 000		
M 56	2030	1905	1 511 000			1 769 000		
M 60	2360	2227	1 764 000			2 064 000		

* = M_A changes with different values for μ_G or μ_K

Prestressing of the fastening bolts with tightening torque (torsion)
The tightening torque is dependent on many factors, in particular however on the friction coefficient in the thread as well as on the head or nut contact surface.

For an average friction coefficient of $m_G \approx m_K = 0.14$ (thread and contact surfaces slightly oiled), the tightening torque M_A for prestressing F_M is specified for the hydraulic torque driver.

Taking account of a distribution of ±10 %, the assembly torque M_A' is defined for the torque wrench.

Tests and practical experience show time and time again that the tightening torques obtained by calculation for bolts larger than M 30 or 1¼" do not correlate to the actual conditions with sufficient accuracy.

Friction
The main reason influencing these differences is the friction in the thread and between the head or nut contact surface, for which only values based on experience or estimations are usually available. The friction coefficient determines the magnitude of the friction force.

In addition to these influencing factors, a bolted connection is additionally subject to settling factors that are predominantly determined by the smoothening of surface roughness.

Note These influencing parameters are significantly included in the calculation of the tightening torque, as a result of which there can be significant fluctuations in the bolt prestressing.

Distribution of friction coefficients
To illustrate this uncertainty, some factors are listed that influence the distribution of friction coefficients:

1. The thread friction depends on:
- The roughness of the thread surface, i.e. the type of thread manufacture (cut, rolled)
- The surface treatment (e.g. bare metal, phosphated or blackened)
- The type of lubrication (dry, lightly oiled, heavily oiled)
- Possible surface treatment of the nut thread
- The length of thread in contact
- Possible repeated tightening and loosening of the bolts

2. The distribution of friction between the head or nut contact surface depends on:
- The roughness of the contact surfaces
- The condition of the contact surfaces (dry, lubricated, painted)
- Hardness differences between the contact surfaces or the material pairing
- The dimension and angle deviations in between the contact surfaces

Determining the tightening torques of fastening bolts larger than M 30 or 1b"
Variations in the tightening torque can be significantly reduced if the tightening torque for bolts larger than M 30 or 1¼" is determined using the lengthways elongation of the bolt instead of being calculated.

This monitoring procedure can be carried out straightforwardly if both ends of the bolt are accessible in the bolted-on condition. If this is impossible, a model test must be carried out (Figure 14, page 212).

Calculation of the required lengthways elongation by means of the elastic resilience of the bolt
This produces

$$\delta = \frac{l}{E \cdot A}$$

$$\delta_S = \delta_K + \delta_1 + \delta_2 + \delta_{GM}$$

Head (δ_K), Shank (δ_1), Thread part not screwed in (δ_2), Thread part screwed in (δ_{GM})

where $l_G = 0.5$ d and $l_M = 0.4$ d

for nuts according to DIN EN ISO 4032

$$\delta_S = \frac{0.4\,d}{E_S \cdot A_N} + \frac{l_1}{E_S \cdot A_N} + \frac{l_2}{E_S \cdot A_3} + \frac{0.5 \cdot d}{E_S \cdot A_3} + \frac{0.4 \cdot d}{E_S \cdot A_N}$$

The force assigned to the length allocation in the elastic range is:

$$F_M = \frac{1}{\delta_S} \cdot \Delta \qquad [N]$$

Determining the prestressing force when using 70 % of the yield limit in relation to the clamping cross-section:

$F_M = 0.7 \cdot R_{p\,0.2} \cdot A_S$ [N]
$F_{0.2} = R_{p\,0.2} \cdot A_S$ [N]
$R_{p\,0.2}$ for strength class 8.8
= 640 N/mm² for d ≤ 16
= 660 N/mm² for d > 16
$R_{p\,0.2}$ for strength class 10.9
= 940 N/mm²
$R_{p\,0.2}$ for strength class 12.9
= 1100 N/mm²

In which case:
$\Delta l = F_M \cdot \delta_S$ [mm]

Screw connection/ bolt connections

Model test
The equivalent clamping length must be created using steel blocks of the same general size. Also, the surface composition of that surface on the model that is located under the part which turns during tightening (bolt head or nut) should correspond to the object. As a rule, hardened washers are used, meaning that this condition is easy to meet. The influence of a different number of separating gaps can hardly be measured and must therefore be disregarded.

The distribution normally to be expected is considered in the calculation in the tightening factor. The test ensures that the minimum clamping force of these larger bolts is also within the values assumed for the calculation.

For the bolt which is to be used, the elastic lengthways elongation under 70% prestressing in relation to the yield limit is calculated based on the elastic resilience of the bolt according to the clamping length.

The bolt is prestressed until the previously calculated bolt elongation Δl is displayed on the measuring gauge. The torque is then read off the clamping tool after the Δl dimension has been reached.

Note Several measurements should be performed and the average calculated because of possible spreads.

When a clamping tool with a socket is used for tightening the nut, this means the meas-uring bar must be removed and so the test bolts should be provided with a centering hole (Figure 14) at both ends, thereby largely excluding sources of errors due to incorrect application of the measuring bar.

Advantage Now, all fastening bolts on the slewing bearing can be prestressed with this uniform tightening torque.

Note In this case, the clamping tool used in the test must be used. Furthermore it is

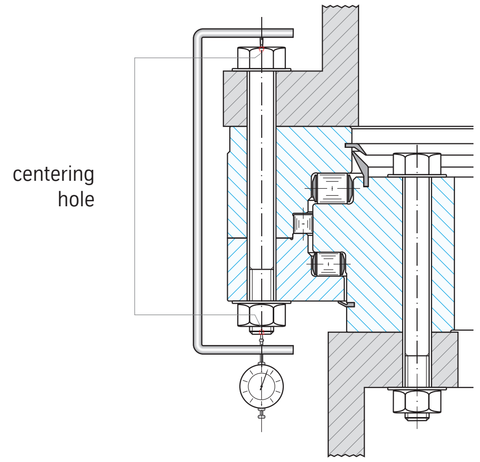


Figure 14

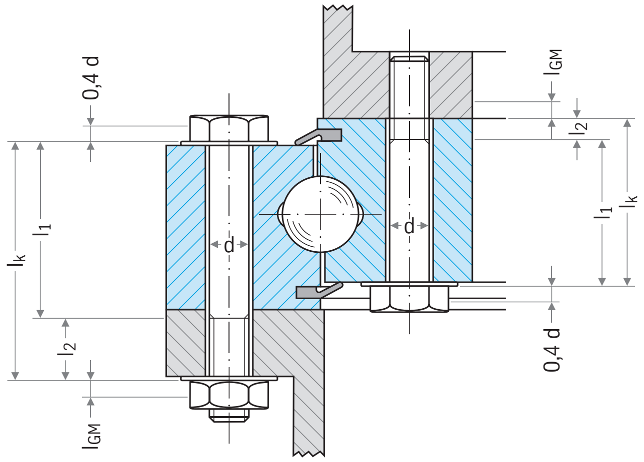


Figure 15

Expressions used in the formulas

A_N	= Nominal cross-section of the bolt	[mm²]
A_3	= Core cross-section of the thread	[mm²]
A_S	= Clamping cross-section of the bolt thread	[mm²]
E_S	= Modulus of elasticity of the bolt	205 000 [N/mm²]
F_M	= Assembly clamping force	[N]
$F_{0,2}$	= Bolt force on the minimum yield limit	[N]
l_1	= Elastic pin length	[mm]
l_2	= Elastic length of the thread	[mm]
Δl	= Change in length when tightening the bolt	[mm]
δ_S	= Elastic resilience of the bolt	[mm/N]
$R_{p\,0,2}$	= Tension on the yield limit of the bolt material	[N/mm²]
l_k	= Clamping length of the bolt	[mm]
l_{GM}	= Thread length l_G and nut dislocation l_M taken into account for the resilience of the screwed-in part of the thread; $l_{GM} = l_G + l_M$	[mm]

necessary to ensure that the bolts to be used and test bolts come from one production batch.

Prestressing of the fastening bolts with a hydraulic bolt clamping cylinder (torsion-free)
Negative influences on the bolt prestressing can be most effectively reduced by hydraulic clamping cylinders, in particular in bolts with relatively large diameter.

Advantage The additional loading on the bolt cross-section due to torsion and bending does not occur, in contrast to the con-ventional torque method. Thanks to the lack of friction, the remaining bolt prestressing force can be precisely defined – taking account of corresponding configuration parameters after previous investigations.

Note Prestressing diagonally across, with care, until reaching the prescribed values. In this case, depending on the tightening process, a tightening factor α_A of 1.2 up to 1.6 can be used in the calculation, and the yield strength of the bolt can be exploited up to 90% in the calculation.

The prestressing of the bolt that is tightened first is influenced by tightening of the other bolts. Therefore, it is necessary to provide at least two rotations.

Advantage This also compensates for the settling that occurs when prestressing nonloaded joining surfaces (thread and nut contact surface).

The theoretical clamping forces for a selected series of bolts can be seen in Table 7, page 215.

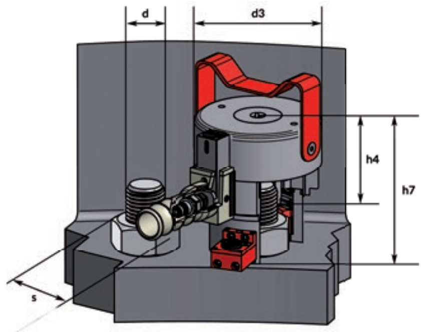
Note Insufficient parallelism between the nut and contact surface and the thread tolerance means that in this process as well, settling appearances after tightening of the nut cannot be excluded. (Perpendicularity tolerance is constrained at the bolt and nut manufacturer.)

In this process, not only the shank but also the thread is elastically stretched due to the applied clamping force, which means having the correct thread series or thread tolerances according to DIN 2510 is important. An inadequate thread play can result in nut seizing on a stretched bolt.

Note Taking account of the nut height used, it is essential to reach an agreement with the supplier of the clamping cylinders.

Screw connection/ bolt connections

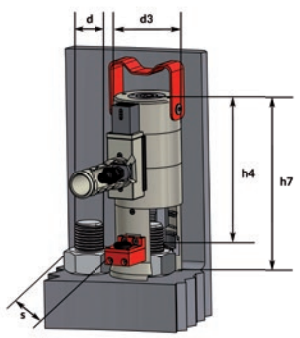
Table 5: ITH – One-stage bolt clamping cylinder type ES



Type	Order no.	Preload force		Nominal diameter bolt ø d		Width across flats s		External ø d3		Installation dimension h4		Overall height h7	
		[kN]	[lbs]	[mm]	["]*	[mm]	["]	[mm]	["]	[mm]	["]	[mm]	["]
ES 24 - 10.9	33.05441	306	68837	M 24x3	7/8	36	1 4/9	77,5	3,05	92,0	3,62	116,5	4,59
ES 27 - 10.9	33.05442	400	89834	M 27x3	1	41	1 5/8	87,5	3,44	90,5	3,56	116,5	4,59
ES 30 - 10.9	33.05443	486	109280	M 30x3,5	1 1/8	46	1 4/5	96,0	3,78	92,0	3,62	121,0	4,76
ES 33 - 10.9	33.05444	604	135875	M 33x3,5	1 1/4	50	2	105,0	4,13	105,2	4,14	137,3	5,41
ES 36 - 10.9	33.05445	712	160053	M 36x4	1 3/8	55	2 1/5	115,0	4,53	98,4	3,87	132,4	5,21
ES 39 - 10.9	33.05446	849	190787	M 39x4	1 1/2	60	2 3/8	124,5	4,90	102,8	4,05	139,2	5,48
ES 42 - 10.9	33.05447	981	220516	M 42x4,5	1 5/8	65	2 4/7	134,0	5,28	111,2	4,38	156,7	6,17
ES 45 - 10.9	33.05448	1146	257599	M 45x4,5	1 3/4	70	2 3/4	144,0	5,67	114,0	4,49	153,0	6,02
ES 48 - 10.9	33.05449	1290	290005	M 48x5	1 7/8	75	3	154,0	6,06	105,2	4,14	157,2	6,19
ES 52 - 10.9	33.05450	1540	346207	M 52x5	2	80	3 1/8	167,0	6,57	131,3	5,17	176,3	6,94
ES 56 - 10.9	33.05451	1775	399038	M56x5,5	2 1/4	85	3 1/2	177,7	7,00	131,0	5,16	179,0	7,05
ES 60 - 10.9	33.05452	2075	466618	M 60x5,5	2 3/8	90	3 3/4	193,0	7,60	138,5	5,45	190,5	7,50
ES 64 - 10.9	33.05453	2325	522728	M 64x6	2 1/2	95	3 7/8	204,0	8,03	191,4	7,54	239,4	9,43
ES 68 - 10.9	33.05454	2685	603700	M 68x6	2 3/4	100	4 1/4	219,5	8,64	135,3	5,33	193,3	7,61
ES 72 - 10.9	33.05455	3010	676694	M 72x6	3	105	4 5/8	231,5	9,11	160.4	6,31	221,4	8,72
ES 80 - 10.9	33.05456	3.691	829839	M 80x6	3 1/4	115	5	253,0	9,96	155,4	6,12	223,4	8,80
ES 90 - 10.9	33.05457	4.657	1046850	M 90x6	3 1/2	130	5 3/8	288,0	11,34	176,5	6,95	253,5	9,98
ES 100 - 10.9	33.05458	5.810	1306218	M 100x6	4	145	6 1/8	322,0	12,68	199,4	7,85	284,4	11,19

	Available bolt / nut configuration for thyssenkrupp rothe erde Germany GmbH	Order no. Key	Example type ES 36
Standard	Standard hexagon nut according to DIN ISO 4032	XX = 00	33.05445-10-50000-10-13
Optional	Nut (DIN 934) + washer (EN ISO 7090:2000, formerly DIN 125)	XX = 10	33.05445-10-50010-10-13
More	Other bolt / nut configurations possible on request		

Table 6: ITH – Multi-stage bolt clamping cylinder type MSK



Type	Order no.	Preload force		Nominal diameter bolt ø d		Width across flats s		External ø d3		Installation dimension h4		Overall height h7	
		[kN]	[lbs]	[mm]	["]*	[mm]	["]	[mm]	["]	[mm]	["]	[mm]	["]
MSK 24 - 10.9	33.50091	308,5	69354	M 24x3	7/8	36	1 4/9	57,0	2,24	164,0	6,46	188,7	7,50
MSK 27 - 10.9	33.50092	401,5	90261	M 27x3	1	41	1 5/8	63,5	2,50	170,6	6,72	197,4	7,86
MSK 30 - 10.9	33.50093	485,5	109152	M 30x3,5	1 1/8	46	1 4/5	70,0	2,76	170,7	6,72	199,2	7,98
MSK 33 - 10.9	33.50094	606,3	136302	M 33x3,5	1 1/4	50	2	78,3	3,08	190,0	7,48	222,6	8,84
MSK 36 - 10.9	33.50095	708,3	159233	M 36x4	1 3/8	55	2 1/5	82,6	3,25	201,0	7,91	235,0	9,33
MSK 39 - 10.9	33.50096	842,2	189335	M 39x4	1 1/2	60	2 3/8	90,8	3,57	219,4	8,64	255,8	10,21
MSK 42 - 10.9	33.50097	974,4	219044	M 42x4,5	1 5/8	65	2 4/7	98,0	3,86	220,0	8,66	257,0	10,35
MSK 45 - 10.9	33.50098	1140,5	256396	M 45x4,5	1 3/4	70	2 3/4	105,0	4,13	234,9	9,25	274,0	10,98
MSK 48 - 10.9	33.50099	1288,4	289645	M 48x5	1 7/8	75	3	111,5	4,39	245,8	9,68	287,0	11,57
MSK 52 - 10.9	33.50100	1529,7	343899	M 52x5	2	80	3 1/8	122,0	4,80	256,3	10,09	301,2	12,09
MSK 56 - 10.9	33.50101	1785,0	401286	M56x5,5	2 1/4	85	3 1/2	130,5	5,14	281,0	11,59	329,0	13,80
MSK 60 - 10.9	33.50102	2125,8	477892	M 60x5,5	2 3/8	90	3 3/4	140,8	5,54	284,5	11,42	336,0	13,46
MSK 64 - 10.9	33.50103	2336,8	525336	M 64x6	2 1/2	95	3 7/8	147,8	5,82	290,4	11,43	344,5	13,87
MSK 68 - 10.9	33.50104	2745,0	617103	M 68x6	2 3/4	100	4 1/4	159,8	6,29	318,4	12,54	375,8	14,86
MSK 72 - 10.9	33.50105	3041,2	683697	M 72x6	3	105	4 5/8	168,0	6,61	324,0	12,76	385,0	15,24
MSK 80 - 10.9	33.50106	3814,1	856746	M 80x6	3 1/4	115	5	182,0	7,16	370.0	14,60	439,0	17,28
MSK 90 - 10.9	33.50107	489,0	1045361	M 90x6	3 1/2	130	5 3/8	211,0	8,30	408,0	16,06	485,0	19,09
MSK100 - 10.9	33.50108	6134,1	13790000	M 100x6	4	145	6 1/8	230,0	9,05	425,4	16,75	510,4	20,08

	Available bolt / nut configuration for thyssenkrupp rothe erde Germany GmbH	Order no. Key	Example type ES 36
Standard	Standard hexagon nut according to DIN ISO 4032	XX = 00	33.50095-10-50000-10-13
Optional	Nut (DIN 934) + washer (EN ISO 7090:2000, formerly DIN 125)	XX = 10	33.50095-10-50010-10-13
More	Other bolt / nut configurations possible on request		

Table 7: Clamping force for bolts taking account of the thread tolerances for "Metric thread with large clearance" DIN 2510 – sheet 2 – when using hydraulic bolt clamping cylinders

Strength class according to DIN ISO 898 Yield strength $R_{p\,0,2}$ N/mm²				10.9 940	
Metric ISO thread DIN 13 Nominal Ø mm	Pitch mm	With tolerances according to DIN 2510: Clamping cross-section A_S mm²	Core cross-section A_3 mm²	Clamping force at the yield limit $F_{0,2}$ N	Theoretical clamping force utilization $F_M = 0.9 \cdot F_{0,2}$ N
16	2	148	133	139100	125200
20	2,5	232	211	218000	196000
24	3	335	305	315000	283000
27	3	440	404	413000	372000
30	3,5	537	492	504000	454000
33	3,5	668	617	627000	564000
36	4	786	723	738000	664000
39	4	943	873	886000	797000
42	4,5	1083	999	1018000	916000
45	4,5	1265	1174	1189000	1070000
48	5	1426	1320	1340000	1206000
52	5	1707	1590	1604000	1443000
56	5,5	1971	1833	1852000	1666000
64	6	2599	2426	2443000	2198000
72	6	3372	3174	3169000	2852000
80	6	4245	4023	3990000	3591000
90	6	5479	5226	5150000	4635000
100	6	6858	6575	6446000	5801000

Bolt length

The bolts shall be provided with sufficient length so that at least 1.0 · d is left clear above the nuts for positioning the hydraulic clamping cylinders.

The precise minimum length depends on the strength class of the bolts and the clamping tool used. Washers shall be of sufficient size so that when the bolts are tightened by the clamping cylinder, they are pressed against the contact surface.

Increased size washers are to be preferred over standardized washers. The height of the washer depends on the thread size. As a rule, as the thread diameter increases, it should also become larger. Coordination with the manufacturer of the clamping cylinder is essential.

The hydraulic clamping cylinders require more space above the bolt to be tightened than torque wrenches do, for example.

We recommend bolt clamping cylinders from the following company, for example **ITH GmbH & Co. KG**, Steinwiese 8, Postbox 1365, D-59872 Meschede. The quality management system of **ITH** is certified to DIN EN ISO 9001, EN 29001.

For bolts that are prestressed by torque there are also hydraulic **ITH**-torque drivers available.

Increase in friction coefficient between the bearing contact surfaces

Increase in friction coefficient zinc
Increase in friction coefficient between the contact surface can be achieved by zinc flame-spraying galvanization (in this case, the permitted levelness deviations in Table 8, page 225 must be complied with). Furthermore, Loctite can be used.

Increase in friction coefficient by flame spraying
- Preparation of the surfaces according to DIN EN 13507
- Zinc flame-spraying galvanization according to blasting Sa 3 ISO 8501-1, zinc flame-spraying according to DIN EN ISO 2063 (in which case the permitted levelness deviations in Table 8, page 225 must be complied with).

Figure 16: Application of Loctite

Increase in friction using Loctite-586

CAUTION

Risk of skin irritation caused by friction coefficient improver/ adhesive
- Safety gloves must be worn when handling friction coefficient improvers/ adhesives
- Pay attention to the producer's data

The surface roughness of the surfaces to be connected should not exceed a value of Rt 65, since larger surface roughness values reduce the shear strength.

Theoretically, the quantity required for a layer of 0.1 mm is 100 ml/m^2.

Note If the layer is to be applied by hand, it is advisable to use double or triple this quantity, since dosage by hand cannot always be absolutely accurate.

Assembly
Note the following points during assembly:

1. Cleaning of contact surfaces with a commercially available cleaning agent to remove any oil or grease.
2. Inactive surfaces (e.g. galvanized and coated surfaces, aluminum, non-metallic surfaces, etc.) must be pretreated with activator7471. Loctite 586 must only be applied to the non-activated surface. If both sides are active, or if Loctite is applied onto the activator, premature curing may result (drying within a few minutes).
3. Loctite must be applied with a brush onto one surface (Figure 16).
4. Spigot locations must not come into contact with Loctite. They must be coated with a separating agent, e.g. wax or grease.

5. Tightening the fastening bolts. Loctite will start curing from **about 30 min.** after positioning of the bearing. If it is not possible to fully tighten the bolts during this period, manual tightening will suffice as a preliminary solution. Ultimate strength after 12 – 24 hours.
6. Through holes and tapped holes have to be protected against Loctite (Figure 17).

Disassembly
The Loctite joint will resist compressive and shear forces, but not tension. Therefore, separating the bearing from its companion structure does not present any difficulties.

When using Loctite, the best solution is to incorporate tapped holes for jacking screws right at the design stage of the companion structure.

Note Use Loctite 620 at temperatures > 60 °C. The installation and removal instructions are the same as for Loctite 586.

Note For large and heavy bearings and/or a horizontal axis of rotation, the use of jacking screws is imperative, especially when the mounting space is restricted.

To lift the bearing off, the jacking screws are tightened consecutively until the bearing works itself free.

With smaller bearings and easily accessible mounting space, it may suffice to carefully lift the bearing at one side, e.g. by applying a pinch bar at several points around the circumference.

Under no circumstances should the bearing be suspended from eye bolts and lifted off before the joint has been released in the manner described above.

Before reassembly, the surfaces are best cleaned by means of a wire brush.

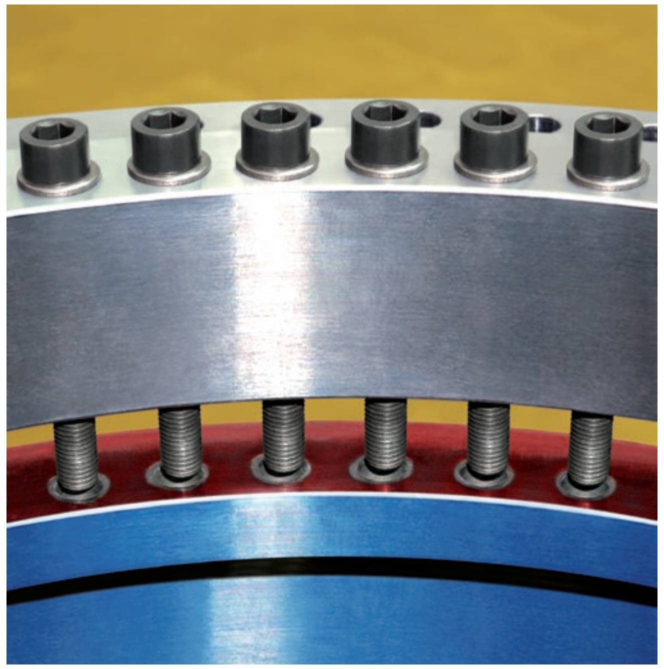


Figure 17: Through holes and tapped holes have to be protected against Loctite

Bearing installation, gearing, companion structures, application conditions

Gearing

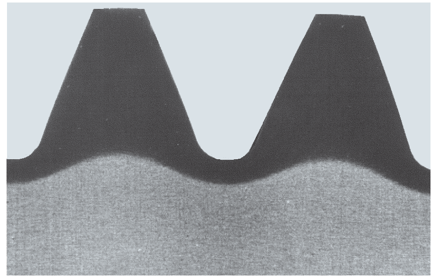


Figure 18: Circulation hardening

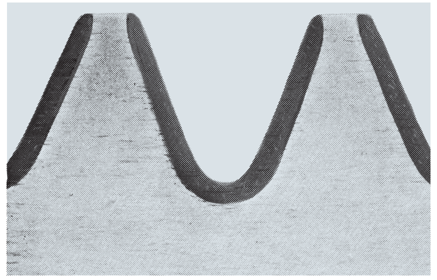


Figure 19: Tooth root hardening

Optimized design
Integrating the gearing into one of the bearing rings offers potential savings for the customer. In most cases, slewing bearings are configured with spur gearing. In this case, the gearing is cut into one of the bearing rings.

Advantage No additional driving gear wheel is required: this saves design work and costs.

Note Preferably, bearings with corrected gearing are used, addendum modification coefficient x = 0.5.

Long service life
For gears subjected to high tooth flank stress, hardened gears have proven very satisfactory for extending the service life. Depending on module and ring diameter, the gear rings are subjected to spin hardening or individual tooth induction-hardening, the latter predominantly in the form of tooth contour hardening.

Advantage Improved flank load carrying capacity at the same time as higher tooth root strength.

Note Hardened gearing requires individual calculation. We need to know the pinion data in order to be able to check the meshing geometry.

Reduced wear
Correct tooth backlash is a prerequisite for trouble-free operation. It significantly influences the wear. Therefore, during assembly of the drive pinion, adequate backlash must be assured.

Advantage Correct backlash ensures low-wear operation and also extends the service life.

Note The tooth backlash must be set on the three teeth marked in green with 0.03 – 0.04 x module. After final assembly and tightening of all the fastening bolts, the backlash must be checked.

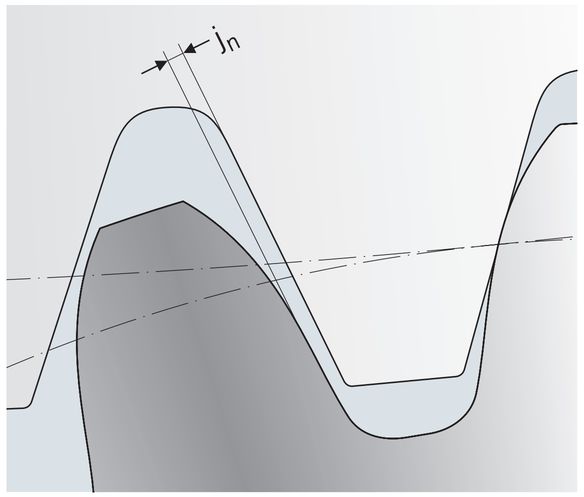


Figure 20: Backlash

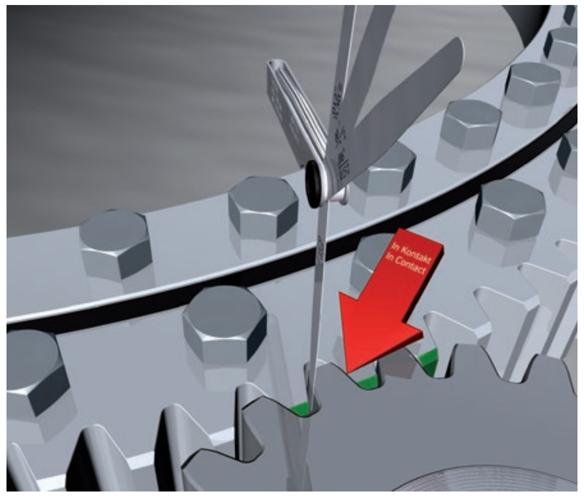


Figure 21: Measuring the flank backlash

Maintaining functional safety
Highly-loaded gearing (force-carrying gearing) requires special measures to be taken to ensure its function. This is because in spite of a correct geometrical profile and theoretically perfect gear pairing, there can still be meshing problems. These occur primarily in gears with an inadequate tooth tip edge relief combined with hardened pinions, in which case the tip edge of the pinion generates abrasive wear on the flanks of the gear.
The causes of such meshing problems such as “scuffing” or “chipping” at the dedendum flank of the gear are various.

C_a = 0.01 · m
h = 0.4 to 0.6 · m
C_a : h = 1 : 40 to 1 : 60
(In relation to the full tooth width
R approx. 0.1 to 0.15 · m

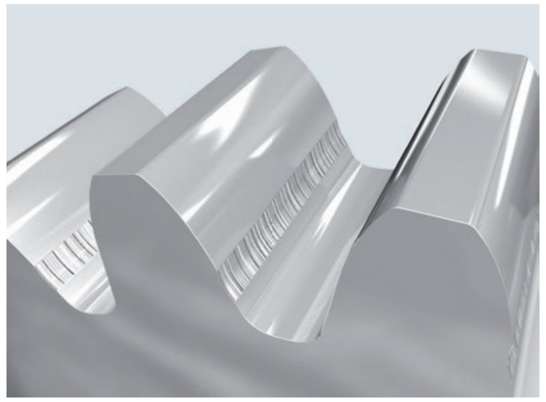


Figure 22: Scuffing

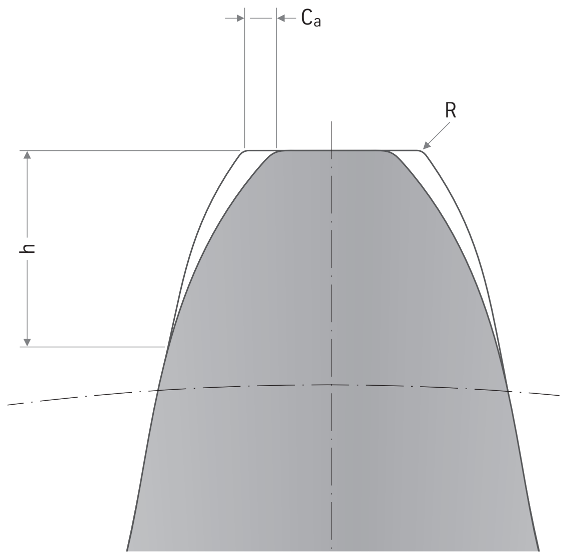


Figure 23: Tip flank profile

Bending
Elastic deformation due to load peaks – caused by acceleration, vibration or the effects of force – changes the contact behavior of the meshing teeth.

Slewing drive
Elastic deformation in the area of the drive bearings changes the tooth meshing.

Lubrication
Selecting an unsuitable lubricant (not on our recommended list, see table 10, page 229) can result in the lubricant film becoming compromised, leading to increased wear on the head edge.

As a result of these risks we require the use of pinions with a tip flank relief and tip edge rounding of 0.1 - 0.15 x m rounding radius (R) for such applications.

In this case, the radius R must blend into the addendum flank without forming an edge. This change towards an involute-like shape ensures a smooth transition from the modified tip flank profile to the normal flank profile.

Advantage Reduced tendency to meshing problems with highly stressed gearing (forcetransmission gearing).

Companion structure

Perfect connections
For reasons of better economy, the bearing cross-sections of slewing bearings are kept relatively small in comparison to their dia-meter. However, even with small diameters, rothe erde® slewing bearings can transmit very high loads because of their specific load carrying capacity. They therefore depend on a rigid and distortion-resistant companion structure. Those of us correspondingly designed bolts ensure the connection of the companion structures to the bearing and thus for an optimal load transfer.

Advantage Deformations under the operating loads that occur are largely prevented in connection with suitable companion structures.

Figure 25 shows: The vertical supports of the companion structure must be located in the vicinity of the raceway diameter in order to limit bowing of the contact surfaces under extreme operating loads.

Rings
thyssenkrupp rothe erde Germany GmbH is one of the world's leading manufacturers of seamlessly rolled rings. These are produced with a large number of cross-sections and, on request, machined according to your specifications. Ring carriers (rolled connection flanges with rotation system as shown in Figure 24) offer decisive advantages for the companion structure.

Advantage Torsionally rigid attachment of the slewing bearings. Optimum load transfer between the anti-friction bearing and companion structure.

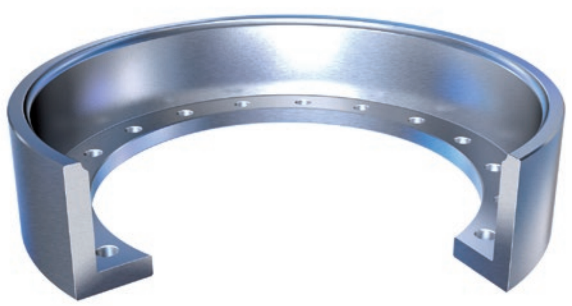


Figure 24: Connection pot

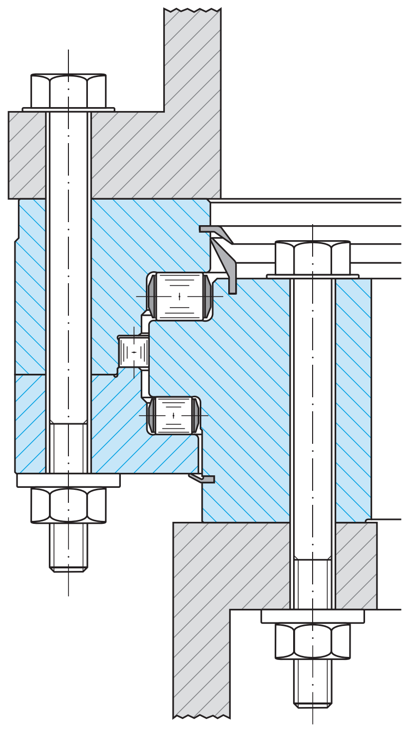


Figure 25: Companion structure

Measuring and machining of the contact surfaces, permitted levelness deviations of the companion structures
Before the slewing bearing is installed, we recommend measuring the contact surfaces using a laser measuring instrument.

If the measured values are outside our tolerances, we advise reworking by machining. If the machining of large-volume companion structures presents difficulties, use of transportable machine tools can provide a solution, even for superstructures and overhead machining. Service providers carry out this work on site.

Note The levelness of the companion structure must be complied with; to avoid local overloads due to narrow points in the raceway, it is necessary to prevent peaks being formed in small sectors. In the area from 0° - 180°, the curve profile of the levelness deviation is only allowed to rise evenly and then fall again.

Permitted levelness deviations of the machined contact surface for rothe erde® slewing bearings
The maximal permitted levelness deviations according to DIN EN ISO 1101 can be found in Table 8, page 225. See also Figure 26 in this regard.

Advantage Compliance with levelness deviations ensures the service life of the slewing bearing is achieved.

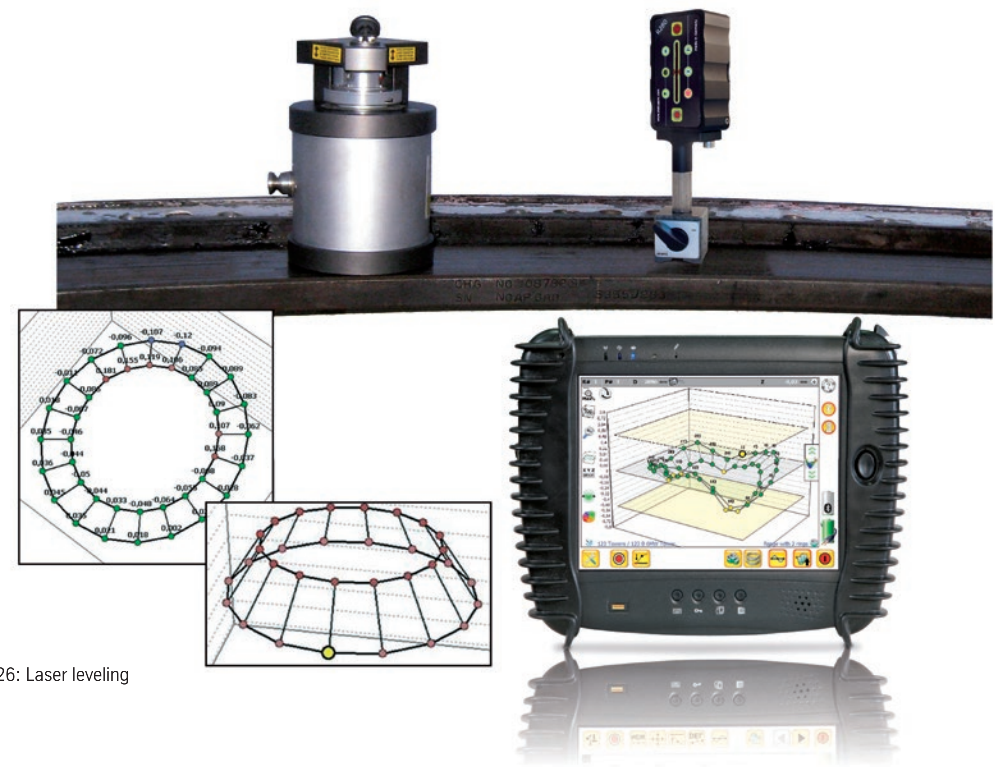


Figure 26: Laser leveling

Application conditions

Standard and special solutions
In most cases, slewing bearings are operated in pivot-ing operation or with slow rotational movements. The following information is also based on this.

Sudden shock loads that require a high toughness of the material shall be listed separately.

It goes without saying, however, that rothe erde® slewing bearing are also configured for speeds with a higher circumferential velocity. In this case, however, the raceway and gearing must be tested and adapted specially, so you are requested to provide you application conditions and requirements in this case.

Advantage You receive the optimum design solution for your individual requirement profile, irrespective of the rotation movement and speed.

Note Operation with a horizontal axis of rotation requires our examination in all cases.

Operating temperature
thyssenkrupp rothe erde Germany GmbH, by selecting and processing corresponding materials, is capable of offering slewing bearings for a wide range of temperatures. In the normal
version, the products are designed for operating tem-peratures from -20° to +60°C. A suitable lubricant must be used in each case (see the information on page 229).

For more extreme operating temperatures and/or temperature differences between the outer and inner rings we must be advised beforehand so that checks can be carried out. Requirements regarding the mechanical properties of the ring material are of particular importance.

Classification/special conditions
For application areas with particular requirements such as offshore systems or deck cranes, there is generally speaking a classification in place according to the application conditions. In this case, acceptance of the bearing according to the catalog of requirements of the particular classification society is a requirement.

Please provide us with the detailed regulations so that we can suggest the ideal bearing for, taking account of such specifications.

Seals
Seals protect the race system against external environmental influences such as dust and water, and keep the lubricant in the bearing race system.

An evenly distributed collar of grease supports the seal function (dust seals).

For applications in general engineering, open-cast mining, offshore or wind energy, we offer a wide variety of special seal solutions to protect the race system against other environmental conditions such as dirt buildup, water or aggressive media. (see Figs. 27 and 28)

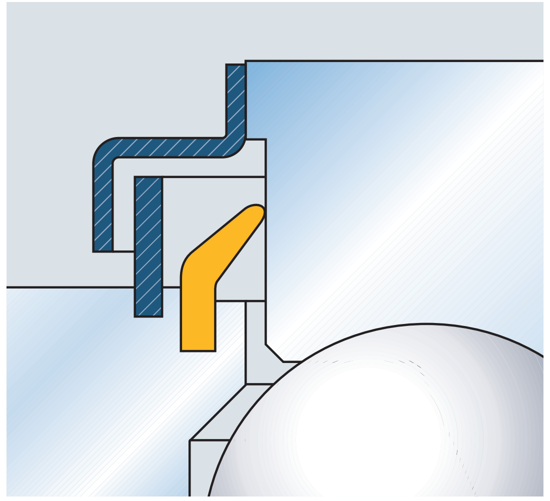


Figure 27

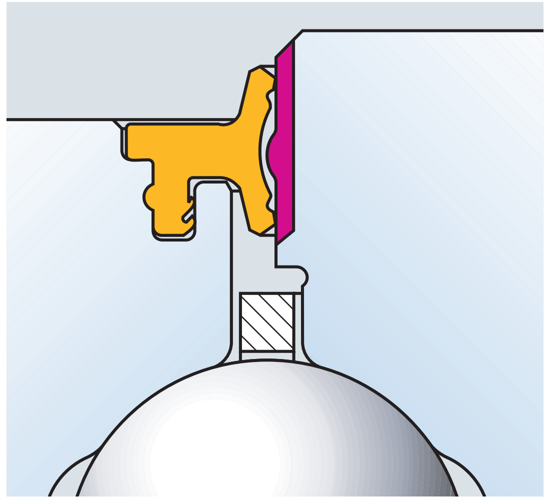


Figure 28

Installation · Lubrication · Maintenance (ILM)

Does not apply to bearings with specific ILM instructions – for replacement deliveries it is essential to get into contact with the machine manufacturer regarding installation, lubrication and maintenance.

thyssenkrupp rothe erde Germany GmbH offers an extensive slewing bearing service (see chapter Service or www.thyssen-krupp-rotheerde.com -> Products and Service).

Transport and handling

DANGER	
	Danger of life by overhead load • Do NOT step underneath the load • Use suitable slings • Use suitable lifting devices • Suitable transport tap hole are stated in the bearing drawing

Slewing bearings, like any other part of a machine, require careful handling. They should always be transported and stored in horizontal position. For safe handling of bearings which include transport holes, high tensile lifting eye bolts must be used. In special cases an internal cross bracing (transporting cross) is required. The bearing weight must be indicated on the crate or pallet. Impact loads, particularly in a radial direction, must be avoided.

Delivery condition

- Raceway system
  The slewing bearings are delivered filled with one of the greases (see table 10 on page 229) unless no special lubricant and special grease quantities are required.

- External contours
  The external contours of the bearings (except for holes) have Cortec VCI corrosion protection applied.

- Gearing
  The gearing is not greased. The corrosion protection is applied as for the external contours.

Storage

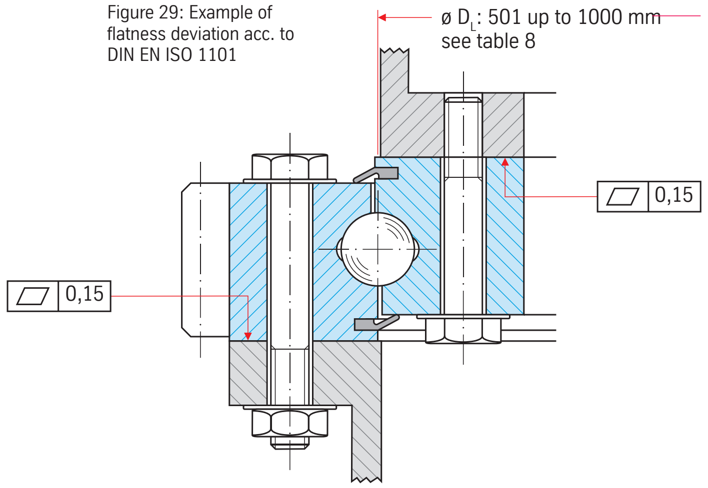
ATTENTION	
	Sensitive surface • Do not open the packing with a sharp blade • Surface may be damaged

Approx. 6 months in roofed storage areas. Approx. 12 months in enclosed, temperature-controlled areas (temperature > 12 °C). Outside storage is not allowed.

If required, other corrosion protection agents and types of packaging can be used, e.g. long-term packaging for up to 5 years.

Longer storage periods will necessitate special preservation. After the slewing bearing has been stored for a relatively long time, an increased frictional torque may be observed caused by the suction adhesion of the sealing lip. Careful lifting of the sealing lip with a blunt object around the entire circumference and several clockwise and counterclockwise rotations of the slewing bearing through 360 degrees will reduce the frictional torque to normal.

Figure 29: Example of flatness deviation acc. to DIN EN ISO 1101



Installation

CAUTION	
	Risk of skin irritation caused by preservative • Safety gloves must be worn for removal • Pay attention to the producer's data

DANGER	
	Entrapment hazard when putting the load down • Location control before putting the load down • Mind the staff

A flat mounting surface free of grease and oil is essential for the upper and lower ring to seat firmly. Welding beads, burrs, excessive paint and other irregularities must be removed prior to installation. The bearing rings must be completely supported by the connecting structure.

thyssenkrupp rothe erde Germany GmbH recommends conducting a check on the mounting surfaces with a leveling instrument or laser equipment (this service can be provided by thyssenkrupp rothe erde Germany GmbH). The flatness values should not exceed the values shown in table 8. To avoid larger deviations and the occurrence of peaks in smaller sectors, any deviation in the range of 0°–180° may only rise evenly once and fall again.

Table 8: Permitted evenness deviation acc. to DIN EN ISO 1101 on the support surfaces

Track Ø in mm D_L	Flatness acc. to DIN EN ISO 1101 per support surface in mm for		
	BF 01 Double-row ball bearing slewing rings BF 08 Axial ball bearings	BF 06 Single-row ball bearing slewing rings 4-point contact bearings BF 09 – Double 4-point contact bearings BF 25, 23, 28 profile bearings*	BF 19 BF 13 Roller slewing bearings BF 12 Combination bearings
up to 500	0,15	0,10	0,07
up to 1000	0,20	0,15	0,10
up to 1500	0,25	0,19	0,12
up to 2000	0,30	0,22	0,15
up to 2500	0,35	0,25	0,17
up to 4000	0,40	0,30	0,20
up to 6000	0,50	0,40	0,30
up to 8000	0,60	0,50	0,40

The serial number relates to the first two places in the drawing number.
The permitted values in table 1 are not allowed to be used for special configurations as high-precision bearings with high running accuracy and low bearing play, please contact thyssenkrupp rothe erde Germany GmbH: www.thyssenkrupp-rotheerde.com
*) Double these values are permitted for normal bearings BF 25, BF 23.

Installation · Lubrication · Maintenance (ILM)

Does not apply to bearings with specific ILM instructions – for replacement deliveries it is essential to get into contact with the machine manufacturer regarding installation, lubrication and maintenance.

Mechanical machining of the bearing connection surfaces on the connecting structure is required if the values are exceeded. The mounting position of slewing bearings must correspond to that shown in the drawing. If a transporting cross was delivered, it has to be removed before installation.

The corrosion protection can be removed with an alkaline cleaner. Cleaner must be prevented from coming into contact with the seals or the raceway. Remove the protective coating from the upper and the lower mounting surfaces of the slewing bearing as well as from the gear.

Note The corrosion protection can easily be removed, for example, using a biodegradable alkaline cleaner.

Advantage Rapid removal of the corrosion protection and low environmental impact.

Hardness gap
The unhardened zone between the beginning and the end of the hardened region of the raceway is marked with an “S” on the inner or outer diameter of each bearing ring. On the gear ring, the hardness gap is marked on the axial surface. Wherever possible, the hardness gap “S” must be positioned outside the main load-carrying areas. If the main working area for the application is known, then the hardness gap of the ring loaded on the circum-ference must also be positioned outside the main load-carrying area.

Commissionings
The bearing must be completely screwed on for commissionings and test runs. Sufficient load / moment load must be applied to avoid a slip-stick effect on the anti-friction bearing bodies.

Gearing

DANGER

Entanglement hazard due to exposed gear
• Keep hands away from moving parts

The backlash is adjusted relative to the three gear teeth marked in green and should be 0.03–0.04 x module.
After the final tightening of the bearing, the backlash should be rechecked over the entire circumference. A tip edge radius and a tip relief must be provided on the pinion (see the “Gearing” chapter in the catalog rothe erde® Slewing Bearings or www.thyssenkrupp-rotheerde.com).

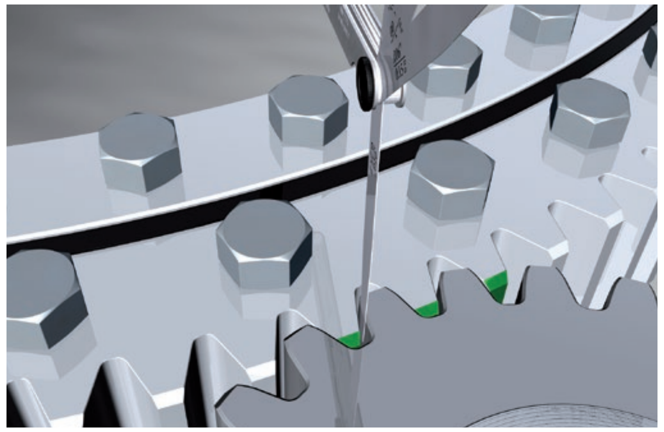


Figure 30: Backlash measurement

Table 9

Thread/ bolt diameters	Hole diameters mm	Tightening torques Nm for bolts in strength class $\mu_G \approx \mu_K = 0{,}14$	
	DIN EN 20273	for hydr. + electr. M_d-torque wrench 10.9	for M_d-key 10.9
M 12	14	137	123
M 14	16	218	196
M 16	17,5	338	304
M 18	20	469	422
M 20	22	661	594
M 24	26	1136	1022
M 27	30	1674	1506
M 30	33	2274	2046
		Grade 8	**Grade 8**
UNC t" – 11	18	286	260
UNC c" – 10	21	506	460
UNC u" – 9	25	803	730
UNC 1" – 8	27,5	1210	1100
UNC 1r" – 7	32	1716	1560
UNC 1b" – 7	35	2410	2190
		Grade 8	**Grade 8**
UNF t" – 18	18	320	290
UNF c" – 16	21	560	510
UNF u" – 14	25	902	820
UNF 1" – 12	27,5	1330	1210
UNF 1r" – 12	32	1936	1760
UNF 1b" – 12	35	2685	2440

Bolting/bolting assembly
Bolt holes on the bearing and connecting structure must match up, otherwise impermissible levels of stress will be established. Through-holes shall be configured acc. to DIN EN 20273, medium series, – see table 9.

Installation, lubrication, maintenance, bearing inspection

Installation · Lubrication · Maintenance (ILM)

Does not apply to bearings with specific ILM instructions – for replacement deliveries it is essential to get into contact with the machine manufacturer regarding installation, lubrication and maintenance.

Fastening bolts
Normal fastening bolts, nuts and washers (without surface treatment) in strength class 10.9 acc. to DIN ISO 267. It is essential to comply with the specified number and diameter. The bolts must be carefully preloaded crosswise to the specified values (table 9 on page 227 gives several recommended values). The surface pressure underneath the bolt head or nut must not exceed the permitted limit values (see the “Fastening bolts” chapter in the catalog rothe erde® Slewing Bearings or www.thyssenkrupp-rotheerde. com, also with regard to the minimum grip of the bolt). If the limiting surface pressure is exceeded, washers of the appropriate size and strength must be provided. The minimum length of engagement must be guaranteed in the case of blind hole threads.
If a hydraulic tensioning device is used, it is essential to adhere to the required projections for the screw threads or stud bolt threads and to use the appropriate washers (see the “Bolts” chapter in the catalog rothe erde® Slewing Bearings or www.thyssenkrupp-rotheerde.com).

The determination of the tightening torque depends not only on the strength class of the bolt and the tightening process but also on the friction in the thread and the contact surface of the bolt head and nut. The tightening torques given in table 9 on page 227 are recommended values based on lightly oiled threads and contact surfaces.

Dry threads will require higher torques whilst heavily oiled threads will require lower tightening torques. The values may, therefore, vary considerably. This applies in particular to threads larger than M 30 or 1b”. For bolts of this size the use of bolt tensioning is recommended.

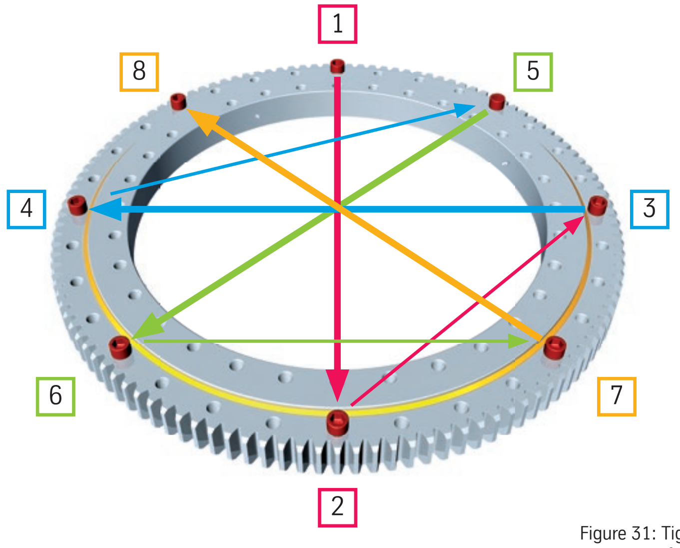


Figure 31: Tightening sequence of the fastening bolts

If the frictional bond is not adequate, it is advisable to use a suitable compound to increase the frictional bond, or else make a form-locking connection. Welding of slewing bearings is not permitted.

Note After prestressing the 8th bolt diagonally across, make one complete circuit. The prestressing of the bolt tightened first is influenced by tightening the other bolts. Therefore, it is necessary to provide at least two rotations.

Lubrication and Maintenance
All the grease nipples must be easily accessible, lubrica-tion lines must be provided if necessary. thyssenkrupp rothe erde Germany GmbH recommends the installation of an automatic central lubricating system. The bearing system and the gearing must be greased immediately after installation. The lubricants specified in table 10 on page 229 are to be used for this and each subsequent lubrication. The only lubrication to be used on the raceway is KP 2 K grease, i.e. lithium saponified mineral oils of NLGI Grade 2 with EP additives. The raceway lubricants listed in table 10 on page 229 can be mixed together. The lubricants are listed in alphabetical order. The grease fill prevents friction, provides protection against corrosion and is a component of the seal.

Therefore the bearing must always be greased liberally so that a collar of fresh grease forms around the whole circumference of the bearing gap and lip seals. This collar of grease must be removed regularly in order to prevent water building up. The bearing should be rotated during relubrication.

Table 10: Lubricants

ARAL	●	Aralub HLP 2	243 K bis 393 K (–30°C bis +120°C)
	▲	Castrol Molub-Alloy OG 936 SF Heavy	243 K bis 373 K (–30°C bis +100°C)
Castrol	●	Spheerol EPL 2	253 K bis 413 K (–20°C bis +140°C)
	▲	Castrol Molub-Alloy OG 9790/2500-0	253 K bis 363 K (–20°C bis +90°C)
Klüber Lubrication	●	Centoplex EP 2	253 K bis 403 K (–20°C bis +130°C)
	▲	Grafloscon C-SG 0 ultra	243 K bis 473 K (–30°C bis +200°C)
Fuchs Lubritech	●	Lagermeister EP 2	253 K bis 403 K (–20°C bis +130°C)
	▲	Ceplattyn KG 10 HMF	263 K bis 413 K (–10°C bis +140°C)
Mobil	●	Mobilux EP 2	253 K bis 393 K (–20°C bis +120°C)
	▲	Mobilgear OGL 461	253 K bis 393 K (–20°C bis +120°C)
Shell	●	Gadus S2 V220 2	248 K bis 403 K (–25°C bis +130°C)
	▲	Gadus S2 OGH NLGI 0/00	263 K bis 473 K (–10°C bis +200°C)
Total	●	Multis EP 2	248 K bis 393 K (–25°C bis +120°C)
	▲	Copal OGL 0	248 K bis 423 K (–25°C bis +150°C)

● Raceway grease
▲ Gear grease

(Symbols see Figure 32, page 230)

Lubricants

⚠ CAUTION

Risk of skin irritation caused by lubricants
- Safety gloves must be worn when handling lubricants
- Pay attention to the producer’s data

Queries about lubricants should be directed to the respective manufacturer.

The greases listed in table 10 are approved for our slewing bearings and tested for compatibility with the materials which we use for our spacers and seals. The list of greases is not exhaustive.

Obtain confirmation of suitability from the lubricant manufacturer before using other lubricants. The properties must at least correspond to those of the greases listed in table 10, and compatibility with the materials we use must be assured. When automatic lubricating devices are used, the lubricant manufacturer must confirm that the lubricant selected is suitable for a “pumped” system. Special lubricants are necessary if the bearings are used in extreme temperatures.

Lubricants are contaminants. They must not be allowed to get into the ground, the groundwater, or into the water and sewage system.

Installation · Lubrication · Maintenance (ILM)

Does not apply to bearings with specific ILM instructions – for replacement deliveries it is essential to get into contact with the machine manufacturer regarding installation, lubrication and maintenance.

Relubrication of the raceway system
The bearing should be rotated during relubrication until a fresh collar of grease is seen to form around the whole circumference of the bearing gaps and lip seals. It is the responsibility of the maintenance personnel to ensure that the correct amounts of grease at individual regular intervals are administered to the bearing, determined by regular monitoring of the lubricated condition of both the bearing raceway and gear. The amount of lubrication will need to be increased and the lubrication intervals shortened in extreme conditions, e.g. in the tropics, where humidity levels (moisture) are raised, exposure to dust and dirt is high, and extreme temperature fluctuations prevail.

Bogie bearings for railway and tram vehicles as well as bearings for wind energy turbines are subject to special requirements, and thyssenkrupp rothe erde Germany GmbH should be contacted in such cases.

In the case of partially assembled bearings, or if there is a long period between bearing installation and equipment commissioning, then appropriate maintenance procedures will be required, e.g. relubrication under rotation or adequate slewing after no more than three months and thereafter every three months. Relubrication is absolutely essential before and after prolonged shutdown of the equipment. The bare metal bearing contours and holes must have corrosion protection applied, and must be checked regularly.

Cleaning the equipment
When cleaning the equipment, care must be taken to prevent cleaning agents or water from damaging the seals or penetrating into the raceways.

Lubrication intervals for the gear
We recommend automatic gear lubrication. This is because the tooth flanks should always have sufficient grease applied

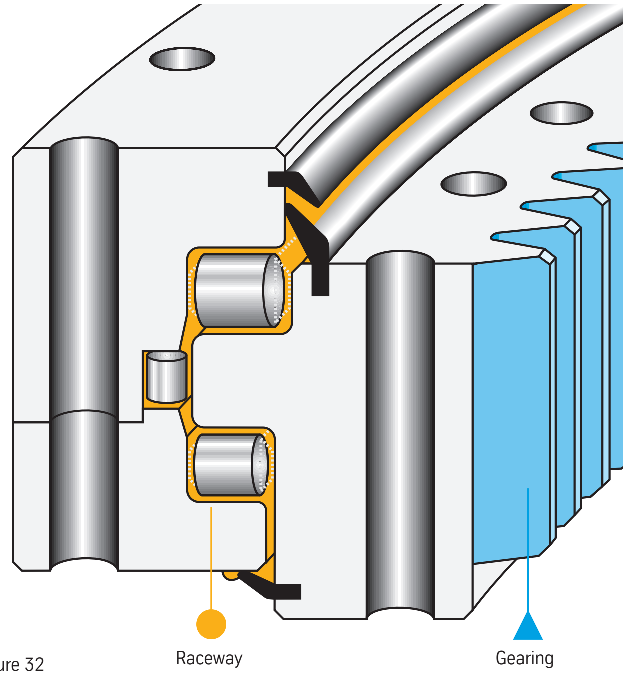


Figure 32

relative to both the application and the duty. It is the responsibility of the maintenance personnel to ensure that the correct amounts of grease at individual regular intervals are administered to the gearing, determined by regular monitoring of the lubricated condition.

Note Effective lubrication is essential for the raceway system and the gearing. This is the only way to achieve a satisfactory service life.

Advantage Optimum use of lubricant and intervals increase the availability of the system.

Examination of bolts
The bolted connection must be capable of maintaining a pre-designated preload during the entire life of the bearing. Experience has shown that it is advisable to check the bolt torques on a regular basis and to retighten the bolts to compensate for any settlement phenomena.

Checking of the raceway system

DANGER

Exceeding the maximum permissible wear rates involves the risk of accidents and danger of life
- When reaching the wear limits the machine must be put out of operation

SAFETY INSTRUCTIONS

- While in operation it must be assured that the wear limits of the bearing will not be reached. With regard to further information (sketches/procedures) see www.thyssenkrupp-rotheerde.com.
- The resulting wear must be regularly determined and recorded
- The procedure is included in the manual
- In case of open questions thyssenkrupp rothe erde Germany GmbH must be contacted

When the bearing is put into operation, we recommend that tilting play or subsidence should be measured (see the "Bearing inspection" chapter in the catalog rothe erde® Slewing Bearings or www.thyssenkrupp-rotheerde.com). Make sure that the wear limits of the bearing are not reached. We recommend repeating this measurement at suitable intervals. In addition, a sample of the used grease can be taken for analysis.

Checking of the seal
Check seals at least every 6 months, renew the seal if it is damaged.

Inspecting the gearing
Gear teeth become smoothed and worn in the course of use. A permissible wear limit depends very much on the application. Experience indicates that a wear value of up to 0.1 x module per flank is permissible.

thyssenkrupp rothe erde Germany GmbH Service assistance
For a continuos and undisturbed operation of our bearings we offer our following service:

Installation
- Assessment of the contact surfaces/ laser measurement
- Bearing installation
- Reference measurement
- Commissioning

Maintenance and inspection
- Wear measurement
- Check of bolts
- Lubricant analysis
- Seal exchange

Reconditioning
- Repair
- General overhaul

Others
- Trainings
- Technical support

Bearing inspection

Preventing damage
Wear measurements enable early detection of technical problems before they result in unscheduled plant stoppages. Unnecessary repair costs and expensive production downtimes are thus avoided. We therefore recommend regular bearing wear measurements in order to assess the condition of a bearing.

The wear which affects the raceway system makes itself felt in a change of the axial motion or the axial reduction. Depending on the application or bearing version, this increase in wear can be determined by measuring the tilting clearance or by taking reduction measurements.

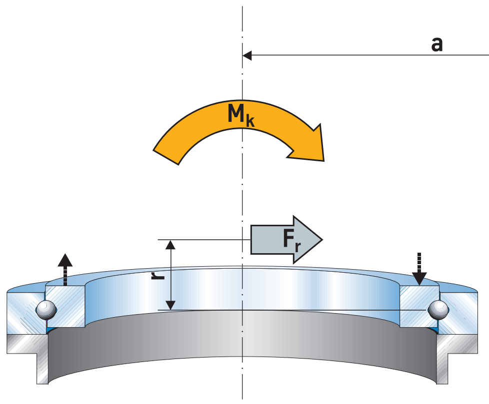


Figure 33: Loading principle of the tilting clearance measurement (axial motion)

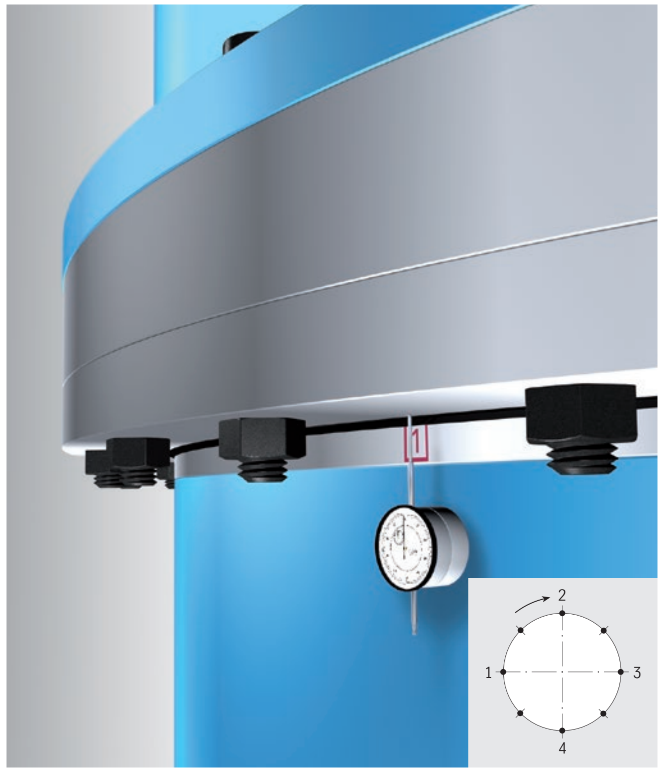


Figure 34: Basic setup for measuring the tilting clearance

Measuring the tilting clearance
To determine the wear, we recommend carrying out tilting clearance measurements wherever possible. The loading principle for such measurements is shown in figure 33.

The measurements are taken between the lower companion structure and the bearing ring which is bolted to the superstructure (figure 5). The measurements must be taken as close to the raceway system as possible in order to minimize the impact of elastic deformations in the companion structure.

The procedure is as follows:
- Take a reference measurement when the equipment is put into operation.
- Mark the measuring points around the circumference starting from a defined position.
- First apply the maximum retrograde moment in order to set the dial gauges to zero (the gauges must have a measuring accuracy of 0.01 mm). Then apply a forward tilting moment, with load uptake if necessary.
- Swivel the superstructure and repeat the measurements at the marked measuring points (see table 14 on page 239).

Maximum permissible increase in bearing clearance (uniform wear)
These increases in bearing clearance are not permissible for special applications, e.g. 50 % of the listed values for fairground ride slewing bearings (contact thyssenkrupp rothe erde Germany GmbH).

Table 11: Series* 01, 08 (double-row ball bearings/axial ball bearings)

Measuring method	Ball diameter mm									
	18	20	22	25	30	35	40	45	50	60	70
	max. permissible wear values up to mm										
Axial reduction measurement	1.8				2.2		3.0			3.8	
Tilting clearance measurement	2.5				3.0		4.0			5.0	

*see 1. and 2. figure of the drawing number (fold-out back page "Structure of the drawing number")

Table 12: Series* 06, 09, 25, 23, 28 (four-point bearings/profile bearings)

Measuring method	Ball diameter mm									
	20	22	25	30	35	40	45	50	60	70
	max. permissible wear values up to mm									
Axial reduction measurement	1.6		2.0			2.6			3.3	
Tilting clearance measurement	2.0		2.6			3.2			4.0	

*see 1. and 2. figure of the drawing number (fold-out back page "Structure of the drawing number")

Table 13: Series* 12, 13, 16, 19 (roller bearing slewing rings)

Measuring method	Roller diameter mm													
	16	20	25	28	32	36	40	45	50	60	70	80	90	100
	max. permissible wear values up to mm													
Axial reduction measurement	0.8			1.2			1.6			2.0		2.4		
Tilting clearance measurement	1.4			2.0			2.8			3.5		4.2		

*see 1. and 2. figure of the drawing number (fold-out back page "Structure of the drawing number")

Bearing inspection

Measuring the axial reduction
Where tilting clearance measurements are not possible we recommend the axial reduc-tion measurement method. In this case the center of the load combinations lies within the race diameter of the bearing. The loading principle is shown in figure 35.

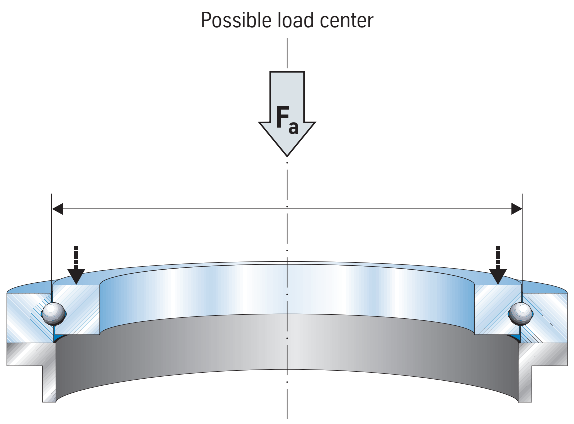


Figure 35: Loading principle of the axial reduction measurement

The measurements are taken between the lower companion structure and the bearing ring which is bolted to the superstructure (figures 36, 37). The procedure is similar to that for measuring the tilting clearance:

- Here too, record reference values when the equipment is put into operation.
- Mark the measuring points around the circumference starting from a defined position.

Repeat the tilting clearance or axial reduc-tion measurements under the same con-ditions at appropriate intervals, after first checking the bearing fastening bolts. The difference between the current measure-ment and the reference measurement is the wear which has occurred in the inter-vening period. If the wear values show a rising trend, you should carry out the mea-surements more often.

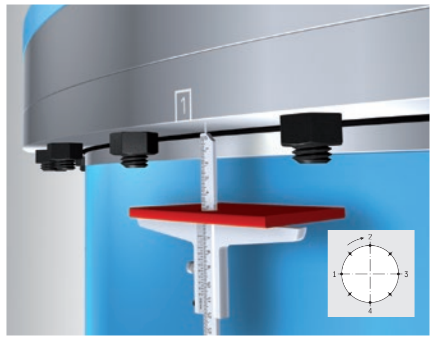


Figure 36: Basic setup for measuring the axial reduction with a depth gauge

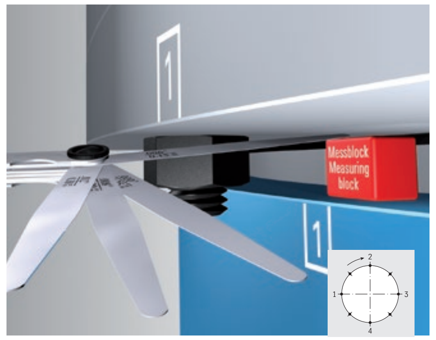


Figure 37: Basic setup for measuring the axial reduction with a feeler gauge

Advantage Given conclusive assessment of the bearing's condition, worn parts can be replaced in good time. In conjunction with optimum spare parts management, it is thus possible to avoid incidents of dam-age and lengthy downtimes.

Note If the permissible wear values (tables 11, 12 and 13 on page 233) are exceeded, we recommend that the equip-ment should be shut down.

The alternative:
IWM (integrated wear measuring device)
thyssenkrupp rothe erde Germany GmbH always focuses on developing innovative solutions for permanently monitoring the condition of a bearing in order to further optimize the function and reliability of plant operations. The integrated wear measuring device for slewing bearings is a patented invention which enables online inspection of the maximum permissible axi-al clearance or axial reduction of a slewing connection.

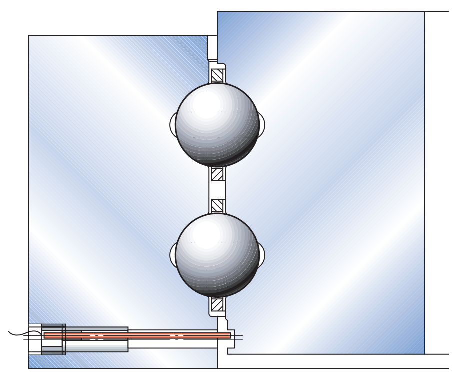


Figure 38

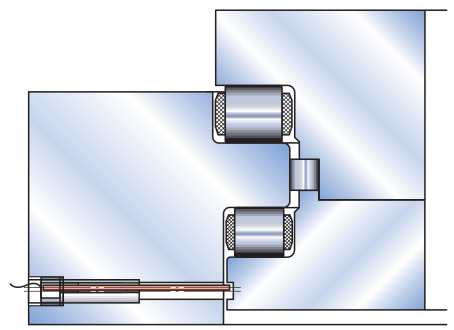


Figure 39

Advantage It is no longer necessary to interrupt operations in order to determine the axial clearance.

A pin made of stainless steel is located in the peak load area of the raceways. The electrically isolated pin is mounted in one ring and protrudes into a groove in the oth-er ring. The maximum tolerated clearance can be adjusted by means of the groove width.

If the clearance changes by an impermissi-ble amount, the ring and the pin will make contact with each other. The pin's electrical connection results in a signal being trig-gered when the pin touches the other ring. This signal indicates that the permissible relative movement of the rings has been reached and that it is time to inspect the bearing.

Advantage The deformation of the com-panion structure and the elasticity of the bolt connections do not significantly influ-ence the measurement result. The elastic appro-ximation of the raceways, the axial clearance of the bearing and the out-of-flatness of the contact surface are com-pensated. Costs for maintenance person-nel are minimized.

Bearing inspection

Figure 40: Grease sampling set

Grease sampling set
Grease samples are taken in parallel with, i.e. at the same time as, the inspection measurements. The analysis of the used grease provides additional information about the raceway condition.

Bearings with grease sampling ports

⚠ CAUTION	
	Risk of skin irritation caused by lubricants • Safety gloves must be worn when handling lubricants • Pay attention to the producer's data

The grease sampling set comprises a plastic tube, various cap plugs, a suction device, a sample box for up to 5 grease samples, and an information sheet. The procedure is described in detail.

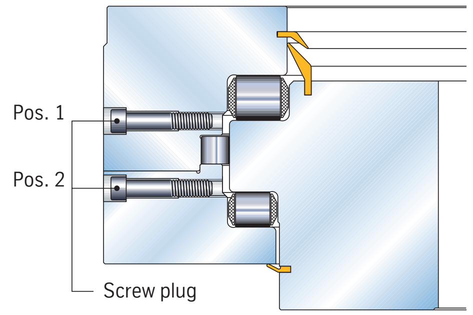


Figure 41: Three-row roller bearing slewing ring with grease sampling ports

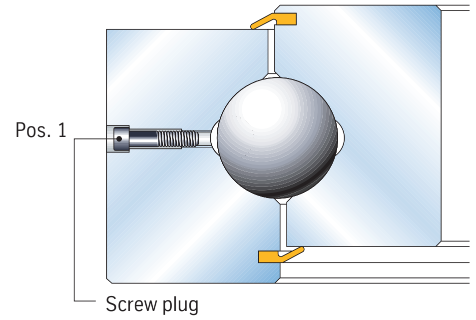


Figure 42: Single-row ball bearing with grease sampling port

Take the grease samples from the main loading zone.

Remove the screw plug (M16 EN ISO 4762) selected for taking the sample: item 1 and if necessary item 2 opposite (figures 41 and 42).

Before taking the grease sample, cut the supplied tube at an angle of 45° so that it is slightly longer than the grease sampling port. Then insert the tube into the raceway area of the port (figure 43).

Make sure that the surface cut at 45° faces in the opposite direction to the direction of rotation (figure 44).

The sampling ports must be closed again with the screw plugs.

When the sample has been taken, close both tube ends with the plastic caps.

Number the grease sample and place it in the labeled sample box.

Add the necessary information (see the grease sampling set in figure 41 on page 236) to the top of the sample box.

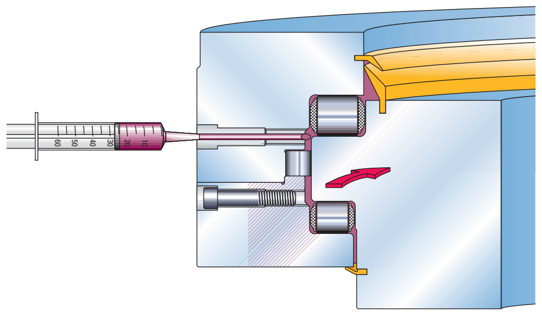


Figure 43: Taking a sample

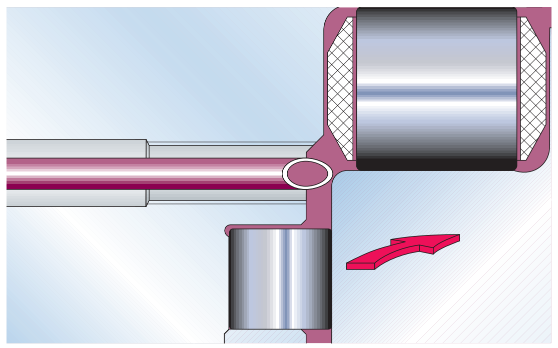


Figure 44: Detail of the sampling

Bearing inspection

Bearings without grease sampling ports
If there are no grease sampling ports provided on the bearing, one or more grease samples are taken at the seal. This area near a grease nipple must be cleaned. The sample should be taken preferably in the main working area and/or offset 180° to it.

During regreasing at the prepared grease nipple (without rotation of the bearing), the first grease escaping from the sealing lip is taken as the sample (figure 45). 3 ccm are enough.

Note Be careful when taking the sample or the result may be falsified by contamination.

Figure 45: Taking a sample of grease from the sealing lip

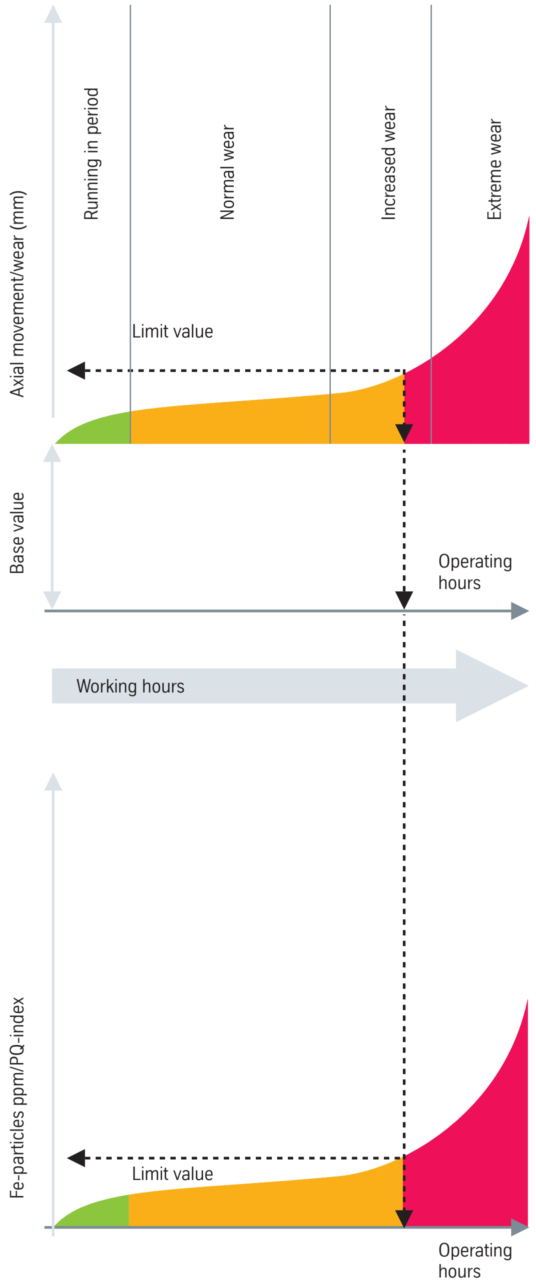


Figure 46: Wear curves

Fe limit values
A limit value for Fe contamination in the lubricant depends greatly on the operating parameters and the lubrication intervals. Depending on the application, the value can be as high as 20 000 ppm.

Wear curves
The diagrams show the increase in wear and the increases in Fe particles and the PQ index as a function of the operating hours (figure 46).

For standard applications see the values in tables 11 – 13 on page 233. When the limit values are reached, please contact thyssenkrupp rothe erde Germany GmbH.

Table 14: Measurement table

Customer		Application			Location			
thyssenkrupp rothe erde Germany GmbH drawing no.		thyssenkrupp rothe erde Germany GmbH order no.			Year of manufacture			
Date								
Operating hours								
Measuring point	Basic measurement	Repeated measurement (12 months interval)						
		1	2	3	4	5	6	7
1 Main load area								
180° opposite								
2 Main load area								
180° opposite								
3 Main load area								
180° opposite								
4 Main load area								
180° opposite								
Grease sample no. Fe particles ppm/PQ index 1								
2								
3								
4								
5								
Grease								
Lubrication system Quantity/interval								
Comments								

The measurement values, analysis values and bearing-specific information should be entered in a separate table (see table 14) and forwarded to thyssenkrupp rothe erde Germany GmbH.

thyssenkrupp rothe erde Germany GmbH
Service
Beckumer Strasse 87
59555 Lippstadt , Germany
service.rotheerde@thyssenkrupp.com

thyssenkrupp rothe erde Germany GmbH sends the grease samples to an approved, qualified laboratory.

Advantage Short processing time and notification by e-mail about the analysis results and wear measurement.

For the **grease sampling** set please contact the following address:

thyssenkrupp rothe erde Germany GmbH
Tremoniastrasse 5–11
44137 Dortmund, Germany
Telephone +49 (2 31) 1 86 - 0
Telefax +49 (2 31) 1 86 - 25 00
sales.rotheerde@thyssenkrupp.com

Disposal at end of useful life

ATTENTION

Disposal may involve environmental risks
- Follow the directives for waste disposal
- Mind the national laws

Bearing to be dismantled. Grease, seals and plastic parts to be disposed of in accordance with waste guidelines. Bearing rings and rolling elements to be taken to the relevant material recycling points.

After sales service

The availability of your systems as well as long service life of the bearings are important components in your success!

Due to its many years of experience in plant manufacture, monitoring and maintenance of slewing bearings, thyssenkrupp rothe erde Germany GmbH possesses the highest levels of expertise and has developed a comprehensive support concept that is integrated into its service. Our service is centrally controlled, divided into three areas, and includes the following tasks:

Figure 47: Prestressing bolts

Figure 48: Seal renewal

Advantage Optimization of system productivity. Reliable guarantee of continuous and trouble-free, economical operation.

In-house service

External service

Installation

- Bearing assembly
- Measurement and assessment of the contact surface
- Commissioning

Maintenance and inspection

- Lubricant analysis
- Wear measurement
- Bolt check
- Examination regarding continued use
- Examination of replacement bearings
- Long-term packaging up to 5 years
- Renewal of packaging
- Seal exchange

Repair
(up to 8 m in one piece, up to 20 m divided)

- Repair
- General overhaul

Training measures

- Installation, lubrication, maintenance
- Bearing check
- Preliminary discussion regarding assembly

Proactive service

Customer care

- Working out service concepts
- Creating inspection schedules
- Status analyses of the bearings in your systems
- Detailed reporting

Sample areas

- Ports
- Steel mills
- Wind farms
- Mines
- Amusement park

We are available at all times to ensure your satisfaction, and are ready to help you anywhere in the world:

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Figure 49: Assembly