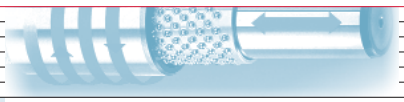
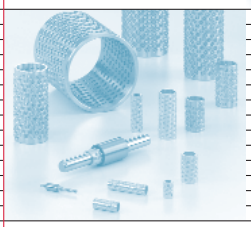
MARMOTION I HIGH-PRECISION ROTARY STROKE BEARINGS





Mahr

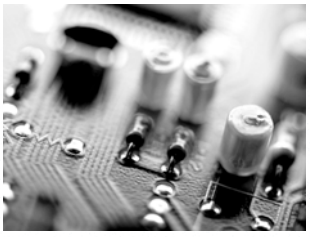
EXACTLY

AUTOMOTIVE

AEROSPACE

MEDICINE

ELECTRONICS



► | MarMotion high-precision rotary stroke bearings.

For every industry. It has its origins in tool building and is at home in mechanical engineering. We work closely with our customers to develop ever new solutions that are application and process focussed and can be used in all industries. The precision bearing for rotary and stroke movements makes metrology more exact, medical engineering safer, precision mechanics easier to work with, optical systems more reproducible and movements tangibly more reliable. The expertise behind the MarMotion

MACHINE BUILDING

PLASTICS

OPTICS

MECHANICS

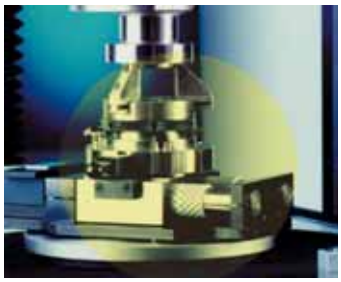
high-precision rotary stroke bearing includes precise computation principles and customized advice on design and installation. The knowledge this yields helps designers optimize rotary stroke bearings for specific applications. The result is precision guidance, high reliability and long service life.

The computation principles can be found in this catalog, on the CD-ROM or on the Internet. Advice is available if you require it. Certified production and order processing are standard at Mahr.

MarMotion. Application examples
OPTIMIZED MOVEMENT

► I High-precision rotary stroke bearings are design elements. They can be calculated, are standardized to a certain degree and can be exchanged without loss of quality. This applies for both standard and customized versions.
High-precision rotary stroke bearings can be used in all industries wherever stroke or rotary movements – even both simultaneously – need to be performed. Here are a number of examples:

Metrology
Mahr is acknowledged as one of the market leaders in the field of industrial metrology. What perhaps is less well known, however, is the fact that Mahr developed the MarMotion high-precision rotary stroke bearing from standard die set guides in order to increase the measuring accuracy and certainty of its products. In the field of industrial metrology, high-precision rotary stroke bearings are used in probes and dial comparators, positioning units, centering and tilting tables and in other modules that have an influence on the measuring result. High-precision rotary stroke bearings must exhibit no backlash, stick slip or wear and the motion must be smooth and reproducible.



Mechanical engineering

picture: Wendt

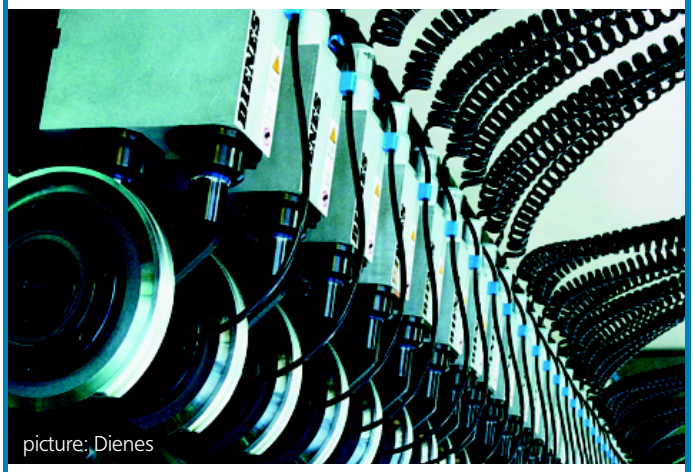
The high-precision rotary stroke bearing is most popular in mechanical engineering applications. It is used for die-cutting and molds in tool building applications and in machine tools where it is used, for example, for center sleeve bearings. It is an indispensable component for packaging machines in a wide range of industries, in automatic assembly units, textile machines and high-quality special-purpose machines. These bearings exhibit high rigidity, excellent load-bearing capacity and absence of stick slip.

Medical technology


picture: Schick

Medical equipment is subject to particularly high standards. In dental technology, rotary stroke bearings are therefore used in freehand milling machines for machining soft materials (wax, plaster). The requirements on apparatus that come into contact with patients are even higher. In the case of ophthalmological instruments, the stick-slip-free rotary stroke bearing supports the doctor's touch and experience.

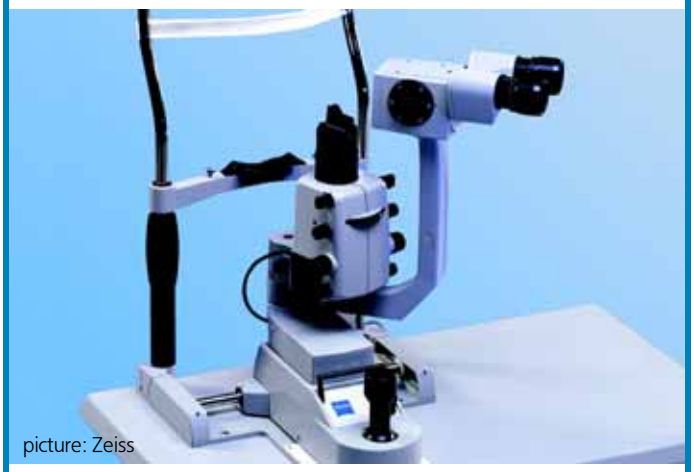
Precision engineering



picture: Dienes

The degree of miniaturization in these industries requires compact instruments. Rotary stroke bearings in the MINI series satisfy this need. Small ball diameters reduce the installation space required. The "Minis" come paired without play and are essential for a wide range of applications including small control elements for placer heads and laser welding technology as well as blade holders, jigs or fixtures. Stick-slip freedom, easy movement and maintenance-free operation are all-important.

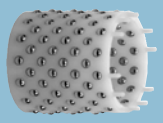
Electronics, optics

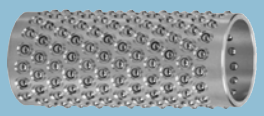

picture: Zeiss

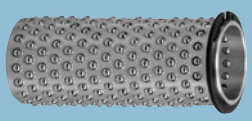
The production of electronic components requires machines that are able to approach positions with pinpoint accuracy at high speeds. High-precision rotary stroke bearings are crucial components in printed circuit board production and lithographic processing of wafers.This is also true of optical metrology, microscopy, spectrography and lens guides in different areas of application. Stick-slip-free movement and absolute cleanliness (clean-room production) are vital.

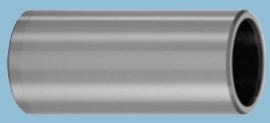
Mahr

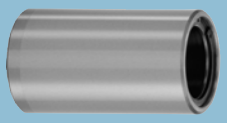
MARMOTION. HIGH-PRECISION ROTARY STROKE BEARINGS

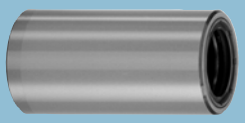


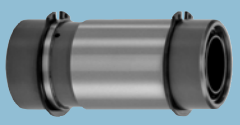


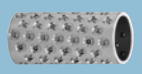


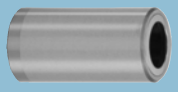


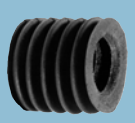








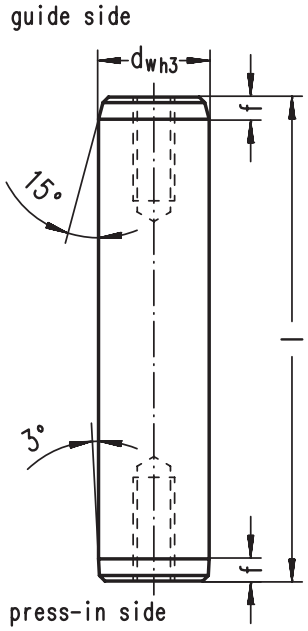




Contents

Guide Shaft

N 400 / N 421 / N 423 / N 425



Types

N 400 Guide shaft to DIN 9825
N 421 Guide shaft with internal thread on press-in side
N 423 Guide shaft with internal thread on guide side
N 425 Guide shaft with internal thread on both sides

Suitability

Hardened guide shaft with precision ground surface.
- Suitable for high-precision rotary stroke bearings.
- When used with MarMotion guide bushes and ball cages, preloading is ensured.

Features

- Guide diameter dw is precision ground and lapped to ISO h3, R_z <1 µm.
- Roundness within 1/3 ISO-IT3.
- Straightness within 5 µm/100 mm.
- Ends are either rounded or have lead-in taper.
- See page 37-41 for instructions on installation and servicing.

Material

- Diameter d_w = 2.5 - 6 material X155 CrVMo 12 1 (1.2379). Diameter d_w = 8 - 40 material 100 Cr 6 (1.3505) or 16 MnCr 5 (1.7131) or comparable special roller bearing steel.
- Carefully heat-treated, hardness rating HRC 60–64/HV 720–815.
- Minimum depth of case hardness 0.8–1.5 mm depending on diameter (up to diameter d_w = 10 through-hardened).

Special designs

- Other dimensions or designs based on workpiece drawings are available. These can also be produced using stainless steel (1.4112).

Order Information

Guide Shaft N 4 . . /d_w/l
Order No. 5010 . . .

			N 400
d_w	l	f	Order No.
2.5	**30**	1	**5010000**
	40		**5010001**
	50		**5010238**
	60		**5010002**
	80		**5010003**
3	**30**	1.5	**5010229**
	40		**5010218**
	60		**5010219**
	80		**5010220**
4	**50**	1.5	**5010230**
	60		**5010004**
	80		**5010005**
	100		**5010006**
5	**50**	1.5	**5010231**
	60		**5010221**
	80		**5010222**
	100		**5010223**
6	**60**	2	**5010232**
	80		**5010007**
	100		**5010008**
	125		**5010009**
	140		**5010207**
	160		**5010208**
	180		**5010010**
8	**60**	2	**5010233**
	80		**5010011**
	90		**5010234**
	100		**5010012**
	125		**5010013**
	140		**5010014**
	160		**5010209**
	180		**5010210**
	200		**5010015**
10	**80**	3	**5010235**
	100		**5010016**
	125		**5010017**
	140		**5010018**
	160		**5010019**
	180		**5010020**
	200		**5010211**
	250		**5010021**

Guide Shaft

N 400 / N 421 / N 423 / N 425

d_w	l	f	N 400 Order No.	N 421 Order No.	N 423 Order No.	N 425 Order No.
				d_w = 12 - 20: M6x15		
12	80	3	5010236	5010432	5010632	5010832
	100		5010022	5010433	5010633	5010833
	125		5010023	5010434	5010634	5010834
	140		5010024	5010435	5010635	5010835
	160		5010025	5010436	5010636	5010836
	180		5010026	5010437	5010637	5010837
	200		5010212	5010438	5010638	5010838
	250		5010213	5010439	5010639	5010839
	300		5010027	5010440	5010640	5010840
14	100	3	5010028	5010441	5010641	5010841
	125		5010029	5010442	5010642	5010842
	140		5010030	5010443	5010643	5010843
	160		5010031	5010444	5010644	5010844
	180		5010032	5010445	5010645	5010845
	220		5010034	5010446	5010646	5010846
15	125	3	5010036	5010447	5010647	5010847
	160		5010038	5010448	5010648	5010848
	180		5010039	5010449	5010649	5010849
	200		5010040	5010450	5010650	5010850
16	100	3	5010043	5010451	5010651	5010851
	125		5010044	5010452	5010652	5010852
	140		5010045	5010453	5010653	5010853
	160		5010046	5010454	5010654	5010854
	180		5010047	5010455	5010655	5010855
	200		5010048	5010456	5010656	5010856
	220		5010049	5010457	5010657	5010857
	250		5010214	5010458	5010658	5010858
	300		5010215	5010459	5010659	5010859
	350		5010050	5010460	5010660	5010860
18	100	3	5010051	5010461	5010661	5010861
	140		5010053	5010462	5010662	5010862
	160		5010054	5010463	5010663	5010863
	180		5010056	5010464	5010664	5010864
	200		5010058	5010465	5010665	5010865
	250		5010060	5010466	5010666	5010866
	300		5010061	5010467	5010667	5010867
20	110	3	5010237	5010468	5010668	5010868
	125		5010074	5010469	5010669	5010869
	140		5010075	5010470	5010670	5010870
	160		5010076	5010471	5010671	5010871
	180		5010078	5010472	5010672	5010872
	200		5010080	5010473	5010673	5010873
	250		5010082	5010474	5010674	5010874
	300		5010083	5010475	5010675	5010875
	350		5010216	5010476	5010676	5010876
	400		5010084	5010477	5010677	5010877

d_w	l	f	N 400 Order No.	N 421 Order No.	N 423 Order No.	N 425 Order No.
				d_w = 25 - 40: M8x20		
25	140	4	5010099	5010478	5010678	5010878
	150		5010100	5010479	5010679	5010879
	160		5010101	5010480	5010680	5010880
	180		5010103	5010481	5010681	5010881
	200		5010105	5010482	5010682	5010882
	220		5010106	5010483	5010683	5010883
	250		5010107	5010484	5010684	5010884
	300		5010108	5010485	5010685	5010885
	350		5010110	5010486	5010686	5010886
	400		5010217	5010487	5010687	5010887
	500		5010111	5010488	5010688	5010888
32	160	4	5010129	5010489	5010689	5010889
	180		5010131	5010490	5010690	5010890
	200		5010133	5010491	5010691	5010891
	300		5010139	5010492	5010692	5010892
	350		5010140	5010493	5010693	5010893
	400		5010141	5010494	5010694	5010894
	500		5010142	5010495	5010695	5010895
	600		5010143	5010496	5010696	5010896
40	180	5	5010146	5010497	5010697	5010897
	200		5010148	5010498	5010698	5010898
	220		5010149	5010499	5010699	5010899
	240		5010150	5010500	5010700	5010900
	260		5010152	5010501	5010701	5010901
	300		5010154	5010502	5010702	5010902
	350		5010155	5010503	5010703	5010903
	450		5010227	5010504	5010704	5010904

Plastic Ball Cage

N 500

Suitability

Cage made of polyacetal resin with steel balls.
- High acceleration is possible due to the light composition of the plastic material.
- Excellent dry running characteristics.
- Smoothest possible run.

Features

- Injection-molded.
- The balls are captive but can move easily.
- Balls which are staggered in the axial direction extend the service life of the rotary stroke bearing.
- The cages which are provided with mating pins and slots can be used for combining individual sections to form any desired length.
- See page 37-41 for instructions on installation and servicing.

Material

Cage:
- Polyacetal resin, injection-molded
- Density 1.42 kg/dm^3
- Heat resistance 100°C, maximum constant working temperature 80°C

Balls:
- Hardened, special roller bearing steel 100 Cr 6 (1.2067)
- DIN 5401/ISO 3290 grade 5 sorting group P0

Loading capacity

Column C shows the load ratings of the ball cages under uniform radial load.
The loading capacity must be computed when moments are in play.

Special designs

The ball cages can be supplied with stainless steel or ceramic balls. Based on workpiece drawings, other dimensions are available in small-scale production lots or, for batches from approx. 10,000 units, as injection-molded parts.
The combinable ball cages are also available without balls (ball-free spacers).

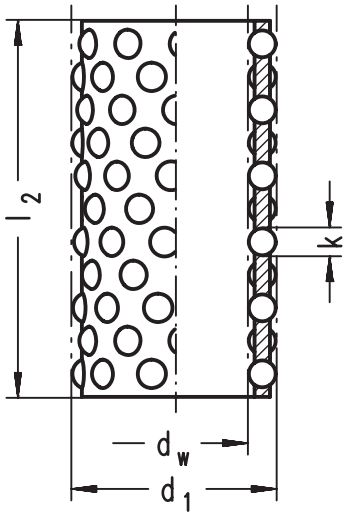
Order Information

Ball Cage N 500/d_w/d_1/l_2 **Order No. 50000 . .**

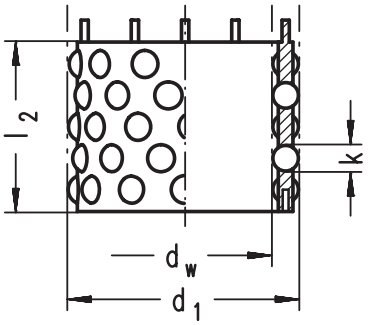
Plastic Ball Cage

N 500

d_w	d_1	l_2	k	Balls [pcs.]	C [N]	Order No.
10	**15**	**21**	2.5	36	270	**5000050**
		42		72	540	**5000051**
		27		45	360	**5000052**
		54		90	720	**5000053**
12	**16**	**21**	2	54	270	**5000054**
		42		108	540	**5000055**

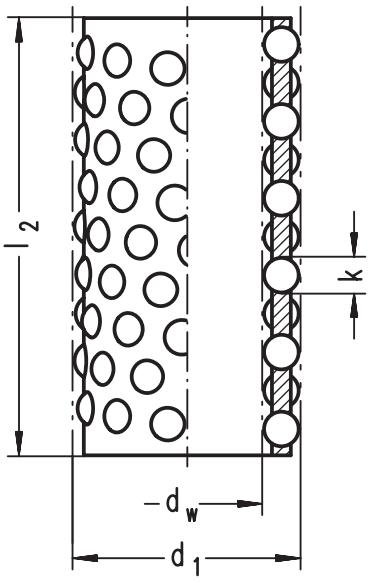


d_w	d_1	l_2	k	Balls [pcs.]	C [N]	Order No.
12	**17**	**21**	2.5	36	290	**5000021**
18	**24**	**23**	3	66	740	**5000001**
		30		88	960	**5000002**
19	**25**	**23**	3	66	740	**5000003**
		30		88	960	**5000004**
20	**26**	**23**	3	66	740	**5000017**
		30		88	960	**5000018**
24	**30**	**23**	3	84	1060	**5000005**
		30		112	1320	**5000006**
25	**31**	**23**	3	84	1060	**5000007**
		30		112	1320	**5000008**
30	**38**	**25**	4	75	1400	**5000009**
		30		90	1680	**5000010**
32	**40**	**25**	4	75	1400	**5000011**
		30		90	1680	**5000012**
38	**46**	**25**	4	90	1625	**5000019**
		30		108	1950	**5000020**
40	**48**	**25**	4	90	1625	**5000013**
		30		108	1950	**5000014**
42	**50**	**25**	4	90	1625	**5000015**
		30		108	1950	**5000016**



Brass Ball Cage

N 501



Suitability

Brass ball cage with steel balls in a helical arrangement.
- Allows universal use.
- Provides an optimum combination of smooth running and long service life.
- The helical arrangement of the balls is ideal for linear and rotary movements.

Features

- The ball chambers are mechanically caulked so that the balls remain captive but still move easily.
- The balls are arranged in an optimum formation so that each ball can run on its own track for both linear and rotary movements.
- The ball formation ensures smooth running and substantially lengthens the service life of the rotary stroke bearing.
- Brass offers high mechanical stability, optimum sliding properties, and high resistance to abrasion and heat.
- See page 37-41 for instructions on installation and servicing.

Material

Cage:
- Brass
- Maximum constant working temperature 150°C
  (In case of higher temperatures, please ask us for advice)

Balls:
- Hardened, special roller bearing steel 100 Cr 6 (1.2067)
- DIN 5401/ISO 3290 grade 5 sorting group P0

Loading capacity

Column C shows the load ratings of the ball cages under uniform radial load.
The loading capacity must be computed when moments are in play.

Special designs

The ball cages can be supplied with stainless steel or ceramic balls.
Other dimensions or designs are available on the basis of workpiece drawings and can be produced using different cage materials.

Order Information

Ball Cage N 501/d_w/d_1/l_2 **Order No. 50010 . .**

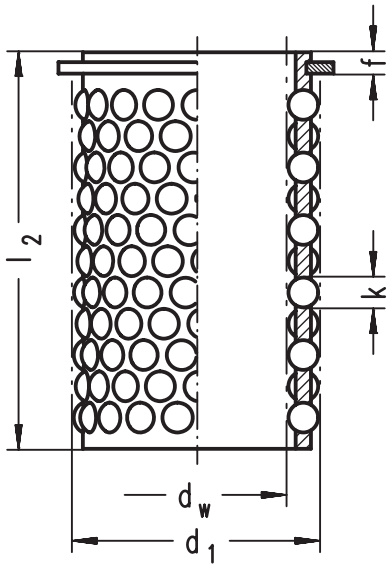
Brass Ball Cage

N 501

d_w	d_1	l_2	k	Balls [pcs.]	C [N]	Order No.
4	**7**	**12**	1.5	18	30	**5001003**
		20		34	50	**5001004**
		30		54	75	**5001005**
6	**10**	**16**	2	26	72	**5001006**
		25		42	110	**5001007**
		40		72	180	**5001008**
8	**13**	**20**	2.5	30	150	**5001009**
		25		36	190	**5001010**
		30		46	225	**5001011**
		40		64	300	**5001012**
10	**15**	**20**	2.5	30	220	**5001013**
		28		46	310	**5001014**
		40		70	440	**5001015**
		50		90	550	**5001016**
12	**17**	**20**	2.5	34	260	**5001017**
		28		50	365	**5001018**
		40		78	520	**5001019**
		50		100	650	**5001020**
14	**20**	**34**	3	60	580	**5001021**
		48		90	910	**5001022**
15	**21**	**34**	3	60	645	**5001023**
		48		90	910	**5001024**
16	**22**	**25**	3	40	525	**5001025**
		34		60	715	**5001026**
		48		90	1025	**5001027**
		63		124	1325	**5001028**
18	**24**	**40**	3	88	1000	**5001029**
		56		130	1400	**5001030**
		68		162	1700	**5001031**
19	**25**	**40**	3	88	1080	**5001032**
		56		130	1510	**5001033**
		68		162	1840	**5001034**
20	**26**	**28**	3	56	870	**5001093**
		40		88	1160	**5001035**
		48		108	1390	**5001036**
		56		130	1620	**5001037**
		68		162	1970	**5001038**
		80		194	2320	**5001039**
24	**30**	**51**	3	146	1730	**5001040**
		68		202	2310	**5001041**
		80		242	2720	**5001042**
25	**31**	**40**	3	108	1440	**5001043**
		51		146	1840	**5001044**
		58		168	2100	**5001045**
		68		202	2450	**5001046**
		80		242	2880	**5001047**
		100		308	3600	**5001048**
30	**38**	**54**	4	138	2800	**5001049**
		78		212	4050	**5001050**
		93		258	4850	**5001051**
32	**40**	**54**	4	138	3030	**5001052**
		68		180	3800	**5001053**
		78		212	4350	**5001054**
		93		258	5200	**5001055**
		110		310	6150	**5001056**
40	**48**	**62**	4	176	4030	**5001057**
		68		196	4420	**5001058**
		87		258	5650	**5001059**
		102		308	6650	**5001060**
		110		336	7150	**5001061**
		125		386	8130	**5001062**
		150		468	9750	**5001063**
42	**50**	**62**	4	176	4030	**5001064**
		68		196	4420	**5001065**
		87		258	5650	**5001066**
		102		308	6650	**5001067**
		110		336	7150	**5001068**
50	**60**	**77**	5	218	6150	**5001069**
		90		262	7200	**5001070**
		110		328	8800	**5001071**
		140		428	11200	**5001072**
		180		562	14400	**5001073**
52	**62**	**77**	5	218	6150	**5001074**
		90		262	7200	**5001075**
		110		328	8800	**5001076**
		140		428	11200	**5001077**
63	**73**	**88**	5	256	8800	**5001078**
		108		322	10800	**5001079**
		140		428	14000	**5001080**
		185		578	18500	**5001081**
		220		696	22000	**5001082**
80	**92**	**95**	6	268	13300	**5001083**
		110		318	15400	**5001084**
		135		402	18900	**5001085**
		160		486	22400	**5001086**
		215		668	30100	**5001087**
100	**112**	**110**	6	382	22000	**5001088**
		165		602	33000	**5001089**
		180		662	36000	**5001090**
		245		922	49000	**5001091**

Brass Ball Cage with Circlip

N 511



Suitability

Brass ball cage with steel balls and circlip for path limitation.
- Provides an optimum combination of smooth running and long service life.
- High loading capacity due to large number of balls.
- Particularly suitable for linear movements in tools and machines which require high precision.
- Reliable ball cage path limitation using circlip.

Features

- The ball chambers are mechanically caulked so that the balls remain captive but still move easily.
- Large number of balls ensures high loading capacity.
- Brass offers high mechanical stability, optimum sliding properties, and high resistance to abrasion and heat.
- See page 37-41 for instructions on installation and servicing.

Material

Cage:
- Brass
- Maximum constant working temperature 150°C
  (In case of higher temperatures, please ask us for advice)

Balls:
- Hardened, special roller bearing steel 100 Cr 6 (1.2067)
- DIN 5401/ISO 3290 grade 5 sorting group P0

Loading capacity

Column C shows the load ratings of the ball cages under uniform radial load.
The loading capacity must be computed when moments are in play.

Special designs

The ball cages can be supplied with stainless steel or ceramic balls.
Other dimensions or designs are available on the basis of workpiece drawings and can be produced using different cage materials.

Order Information

Ball Cage N 511/d_w/d_1/l_2 **Order No. 50011 . .**

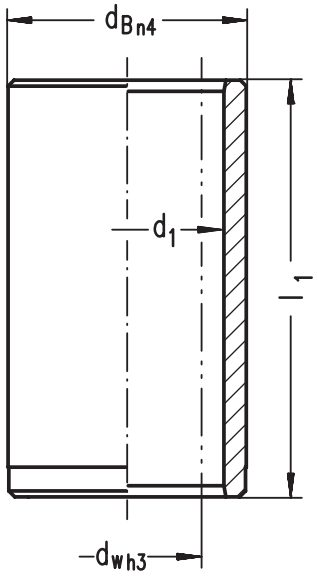
Brass Ball Cage with Circlip

N 511

d_w	d_1	l_2	f	k	Balls [pcs.]	C [N]	Order No.
12	**16**	**40**	2.5	2	132	670	**5001110**
		56			192	970	**5001111**
12	**17**	**36**	2.5	2.5	80	580	**5001115**
		48			110	790	**5001116**
		60			140	1010	**5001117**
16	**22**	**34**	2.8	3	70	750	**5001120**
		48			110	1180	**5001121**
		63			150	1610	**5001122**
18	**24**	**48**	2.8	3	120	1290	**5001126**
		56			144	1550	**5001127**
		60			156	1680	**5001128**
		71			192	2070	**5001129**
		76			204	2200	**5001130**
20	**26**	**48**	2.8	3	120	1390	**5001135**
		56			144	1670	**5001136**
		71			192	2220	**5001137**
		76			204	2360	**5001138**
24	**30**	**52**	2.8	3	198	2360	**5001140**
		70			270	3210	**5001141**
		84			342	4070	**5001142**
25	**31**	**52**	2.8	3	198	2360	**5001145**
		70			270	3210	**5001146**
		84			342	4070	**5001147**
30	**38**	**56**	4.8	4	162	3040	**5001150**
		70			216	4050	**5001151**
		75			234	4390	**5001152**
		90			288	5400	**5001153**
		95			306	5740	**5001154**
		110			360	6750	**5001155**
32	**40**	**56**	4.8	4	162	3040	**5001160**
		75			234	4390	**5001161**
		95			306	5740	**5001162**
		110			360	6750	**5001163**

Open Guide Bush

N 550



Suitability

Open guide bush with tapered inside edges on both sides.
- Allows universal use.
- When used in combination with shaft diameter dw ISO-h3, preloading of the rotary stroke bearing is guaranteed.
- The ball cage can project out of the guide bush on both sides. This permits long stroke paths even with short guide bushes used in combination with long ball cages (note minimum contact length).

Features

- Guide bore diameter d1 is finely honed to ISO tolerance IT 3, R_z 0.5 – 1.5 µm depending on diameter.
- Roundness within 1/3 ISO-IT 3.
- Cylindricity within IT 1.
- Radial run-out of a shaft inserted under preloading is within 0.0005 mm.
- Tapered inside edges on both sides ensure smooth running.
- Outside diameter d_B n4 with radial run-out error within IT 4, ground to guide bore diameter d_1 lead-in taper on one side.
- See page 37-41 for instructions on installation and servicing.

Material

- Special roller bearing steel 100 Cr 6 (1.2067 or 1.3505)
- Carefully heat-treated, hardness rating HRC 60–64/HV 720–815

Special designs

Other dimensions or designs based on workpiece drawings are available.
These can also be produced using stainless steel (1.4112).

Order Information

Rotary stroke bearing consisting of:

Guide bush N 550/d_w/d_1/l_1	**Order No. 5002 . . .**
Ball cage N 501/d_w/d_1/l_2	**Order No. 50010 . .**
or	
Ball cage N 500/d_w/d_1/l_2	**Order No. 50000 . .**
or	
Ball cage N 511/d_w/d_1/l_2	**Order No. 50011 . .**

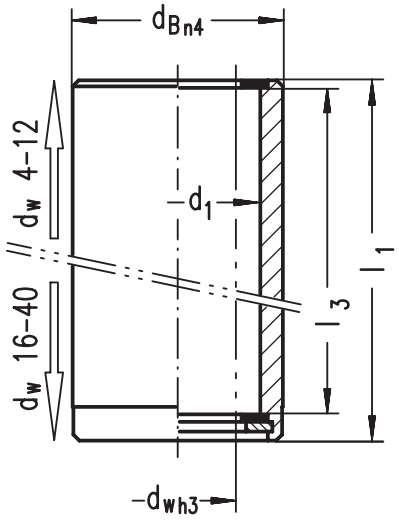
Open Guide Bush

N 550

d_w	d_1	d_B	l_1	Order No.
4	7	10	12	5002002
			20	5002003
			30	5002068
6	10	14	16	5002004
			25	5002005
			40	5002071
			60	5002072
8	13	18	20	5002006
			30	5002007
			40	5002073
			65	5002074
10	15	20	25	5002008
			36	5002009
			50	5002075
			70	5002076
12	17	22	25	5002010
			36	5002011
			50	5002077
			75	5002078
14	20	25	33	5002012
			45	5002013
15	21	25	33	5002014
			45	5002015
16	22	28	25	5002016
			33	5002017
			45	5002018
			60	5002019
			92	5002081
18	24	30	42	5002082
			56	5002083
18	24	32	33	5002020
			56	5002021
			64	5002022
19	25	32	33	5002023
			56	5002024
			64	5002025
20	26	32	33	5002026
			42	5002027
			56	5002028
			64	5002029
			112	5002088
24	30	38	45	5002030
			63	5002031
			70	5002032
			79	5002033
25	31	38	45	5002034
			63	5002035
			70	5002036
			79	5002037
			132	5002089
30	38	48	50	5002038
			75	5002039
			90	5002040
32	40	48	50	5002041
			63	5002042
			75	5002043
			90	5002044
			145	5002090
40	48	60	63	5002045
			80	5002046
			90	5002047
			96	5002048
			120	5002049
			172	5002091
42	50	60	80	5002051
			96	5002053
50	60	72	80	5002054
			100	5002055
52	62	72	80	5002057
			100	5002058
63	73	90	125	5002060
80	92	120	140	5002062
100	112	140	160	5002063

Closed Guide Bush with Stop Rings

N 552



Suitability

Design as for N 550, with stop rings fixed on both sides.
- When used in combination with shaft diameter d_w ISO-h3, preloading of the rotary stroke bearings is guaranteed.
- The stop rings ensure the cage is effectively restricted for linear and rotary movements.
- Smooth running of the rotary stroke bearing is not impaired by the stop rings.

Features

- Stop rings fixed on both sides.
- The closed guide bush and integrated ball cage form a separate component.
- Guide bore diameter d_1 is finely honed to ISO tolerance IT 3, R_z 0.5 – 1.5 µm depending on diameter.
- Roundness within 1/3 ISO-IT 3.
- Cylindricity within IT 1.
- Radial run-out of a shaft inserted under preloading is within 0.0005 mm.
- Outside diameter d_B n4 with radial run-out error within IT 4, ground to guide bore diameter d_1, lead-in taper on one side.
- The maximum stroke path H_{max} is determined from the length of guide bush l_3 and the length of the ball cage l_2: $H_{max} = 2\ (l_3-l_2)$.
- See page 37-41 for instructions on installation and servicing.

Material

- Special roller bearing steel 100 Cr 6 (1.2067 or 1.3505)
- Carefully heat-treated, hardness rating HRC 60–64/HV 720–815
- Steel stop rings

Special designs

Other dimensions or designs based on workpiece drawings are available.
These can also be produced using stainless steel (1.4112).

Order Information

Rotary stroke bearing consisting of:

Guide bush N 552/d_w/d_1/l_1	**Order No. 5003 . . .**
Ball cage N 501/d_w/d_1/l_2	**Order No. 50010 . .**
or	
Ball cage N 500/d_w/d_1/l_2	**Order No. 50000 . .**

Closed Guide Bush with Stop Rings

N 552

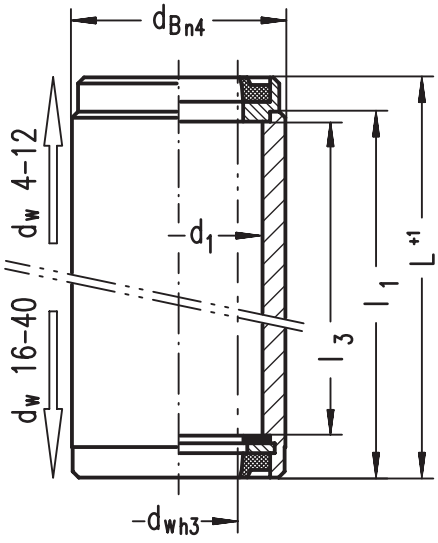
d_w	d_1	d_B	l_1	l_3	Order No.	Cage length l_2/stroke H_{max} (Selected examples)					
4	**7**	10	**20**	18	**5003027**	12/12					
			30	28	**5003028**	20/16	12/32				
6	**10**	14	**25**	23	**5003035**	16/14					
			40	38	**5003036**	25/26	16/44				
			60	58	**5003037**	40/36	25/66	16/84			
8	**13**	18	**30**	28	**5003043**	25/6	20/16				
			40	38	**5003044**	30/16	25/26	20/36			
			65	63	**5003045**	40/46	30/66	25/76	20/86		
10	**15**	20	**25**	22	**5003050**	20/4					
			36	33	**5003051**	28/10	20/26				
			50	47	**5003052**	40/14	28/38	20/54			
			70	67	**5003053**	50/34	40/54	28/78	20/94		
12	**17**	22	**25**	22	**5003058**	20/4					
			36	33	**5003059**	28/10	20/26				
			50	47	**5003060**	40/14	28/38	20/54			
			75	72	**5003061**	50/44	40/64	28/88	20/104		
16	**22**	28	**33**	27	**5003071**	25/4					
			45	39	**5003072**	34/10	25/28				
			60	54	**5003073**	48/12	34/40	25/58			
			92	86	**5003074**	63/46	48/76	34/104	25/122		
20	**26**	32	**42**	36	**5003083**	28/16					
			56	50	**5003084**	48/4	40/20	28/44			
			64	58	**5003085**	56/4	48/20	40/36	28/60		
			112	106	**5003086**	80/52	68/76	56/100	48/116	40/132	28/156
25	**31**	38	**45**	38	**5003093**	30/16	23/30				
			63	56	**5003094**	51/10	40/32	30/52	23/66		
			79	72	**5003095**	68/8	58/28	51/42	40/46	30/84	23/98
			132	125	**5003096**	100/50	80/90	68/114	58/134	51/148	40/170
32	**40**	48	**63**	55	**5003099**	54/2	30/50	25/60			
			75	67	**5003100**	54/26	30/74	25/84			
			90	82	**5003101**	78/8	68/28	54/56	30/104	25/114	
			145	137	**5003102**	110/54	93/88	78/118	68/138	54/166	30/214
40	**48**	60	**80**	70	**5003104**	68/4	62/16	55/30	30/80	25/90	
			96	86	**5003105**	68/36	62/48	55/62	30/112	25/122	
			120	110	**5003106**	110/0	102/16	87/46	68/84	62/96	55/110
			172	162	**5003107**	150/24	125/74	110/104	102/120	87/150	68/188

Stroke H

Dependent on length l_2 of the ball cage used.
$H_{max} = 2\ (l_3 - l_2)$

Closed Guide Bush with Sealing Rings

N 553



Suitability

Design as for N 550, with sealing and stop rings fixed on both sides.
- When used in combination with shaft diameter d_w ISO-h3, preloading of the rotary stroke bearing is guaranteed.
- Guide bush N 553 is designed for use in dirty environments.
- The sealing rings prevent any dirt particles from penetrating. (The rubbing action of the sealing rings on the shaft affects the smooth running of the rotary stroke bearing slightly.)
- Secure path limitation for the ball cage is ensured.

Features

- Sealing and stop rings fixed on both sides.
- The closed guide bush and integrated ball cage form a separate component.
- Guide bore diameter d_1 is finely honed to ISO tolerance IT 3, R_z 0.5 – 1.5 µm depending on diameter.
- Roundness within 1/3 ISO-IT 3.
- Cylindricity within IT 1.
- Radial run-out of a shaft inserted under preloading is within 0.0005 mm.
- Outside diameter d_B n4 with radial run-out error within IT 4, ground to guide bore diameter d_1, lead-in taper on one side.
- The maximum stroke path H_{max} of the rotary stroke bearing is determined from the length of guide bush l_3 and the length of the ball cage l_2: $H_{max} = 2\ (l_3 - l_2)$.
- See page 37-41 for instructions on installation and servicing.

Material

- Special roller bearing steel 100 Cr 6 (1.2067 or 1.3505)
- Carefully heat-treated, hardness rating HRC 60–64/HV 720–815
- Steel stop rings
- Sealing rings NBR rubber in steel shell
- Maximum constant working temperature 100°C

Special designs

Other dimensions or designs based on workpiece drawings are available.
These can also be produced using stainless steel (1.4112).

Order Information

Rotary stroke bearing consisting of:

Guide bush N 553/d_w/d_1/L	**Order No. 5009 . . .**
Ball cage N 501/d_w/d_1/l_2	**Order No. 50010 . .**
or	
Ball cage N 500/d_w/d_1/l_2	**Order No. 50000 . .**

Closed Guide Bush with Sealing Rings

N 553

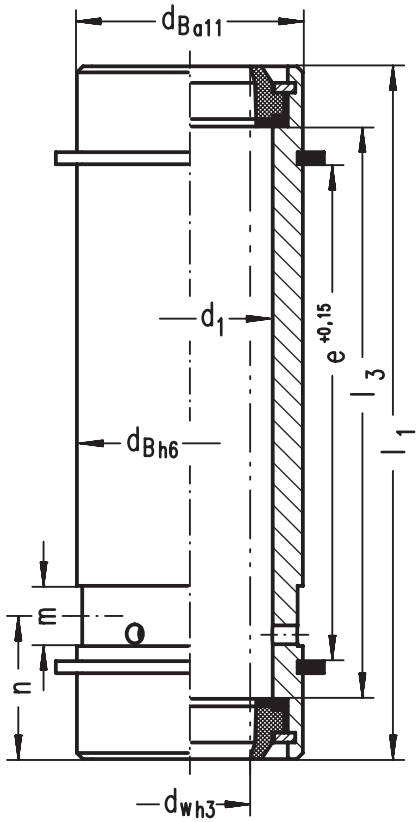
d_w	d_1	d_B	L	l_1	l_3	Order No.	Cage length l_2/stroke H_{max} (Selected examples)					
4	**7**	10	**26**	20	18	**5009039**	12/12					
			36	30	28	**5009040**	20/16	12/32				
6	**10**	14	**31**	25	23	**5009047**	16/14					
			46	40	38	**5009048**	25/26	16/44				
			66	60	58	**5009049**	40/36	25/66	16/84			
8	**13**	18	**38**	30	28	**5009055**	25/6	20/16				
			48	40	38	**5009056**	30/16	25/26	20/36			
			73	65	63	**5009057**	40/46	30/66	25/76	20/86		
10	**15**	20	**33**	25	22	**5009062**	20/4					
			44	36	33	**5009063**	28/10	20/26				
			58	50	47	**5009064**	40/14	28/38	20/54			
			78	70	67	**5009065**	50/34	40/54	28/78	20/94		
12	**17**	22	**33**	25	22	**5009070**	20/4					
			44	36	33	**5009071**	28/10	20/26				
			58	50	47	**5009072**	40/14	28/38	20/54			
			83	75	72	**5009073**	50/44	40/64	28/88	20/104		
16	**22**	28	**38**	38	27	**5009083**	25/4					
			50	50	39	**5009084**	34/10	25/28				
			65	65	54	**5009085**	48/12	34/40	25/58			
			97	97	86	**5009086**	63/46	48/76	34/104	25/122		
20	**26**	32	**49**	49	36	**5009095**	28/16					
			63	63	50	**5009096**	48/4	40/20	28/44			
			71	71	58	**5009097**	56/4	48/20	40/36	28/60		
			119	119	106	**5009098**	80/52	68/76	56/100	48/116	40/132	28/156
25	**31**	38	**70**	70	56	**5009106**	51/10	40/33	30/52	23/64		
			86	86	72	**5009107**	68/8	58/28	51/42	40/64	30/84	23/98
			139	139	125	**5009108**	100/50	80/90	68/114	58/134	51/148	40/170
32	**40**	48	**57**	57	42	**5009110**	30/24	25/34				
			82	82	67	**5009112**	54/26	30/74	25/84			
			97	97	82	**5009113**	78/8	68/28	54/56	30/104	25/114	
			152	152	137	**5009114**	110/54	93/88	78/118	68/138	54/166	30/214
40	**48**	60	**86**	86	70	**5009116**	68/4	62/16	55/30	30/80	25/90	
			126	126	110	**5009118**	102/16	87/46	68/84	62/96	55/110	
			178	178	162	**5009119**	150/24	125/74	110/104	102/120	87/150	68/188

Stroke H

Dependent on length l_2 of the ball cage used.
$H_{max} = 2\ (l_3 - l_2)$

Closed Guide Bush with Wiper Seals

N 570



Suitability

Particularly thick-walled and robust design with wiper seals.
- When used in combination with shaft diameter d_w ISO-h3, preloading of the rotary stroke bearing is guaranteed.
- Primarily used in mechanical engineering applications or where conditions require wiper seals to be employed.
- The wiper seals prevent any penetration of dirt particles, even in the dirtiest working conditions. (The rubbing action of the wiper seals on the shaft affects the smooth running of the rotary stroke bearing slightly.)
- Three radial bores permit lubrication during operation.
- Circlips DIN 471 on outside diameter d_B permit easy installation in the location bore.
- Stop rings fastened with snap rings ensure the ball cage path is effectively limited.

Features

- Stop rings and wiper seals fixed on both sides.
- The closed guide bush and integrated ball cage form a separate component.
- Guide bore diameter d_1 is finely honed to ISO tolerance IT 3, R_z 0.5 – 1.5 µm depending on diameter.
- Roundness within 1/3 ISO-IT 3.
- Cylindricity within IT 1.
- Radial run-out of a shaft inserted under preloading is within 0.0005 mm.
- Outside diameter d_B h6 with radial run-out error within IT 4, ground to guide bore diameter d_1.
- Outside diameter with circlips DIN 471 for installation of the guide bush in the location bore.
- The maximum stroke path H_{max} is determined from the length of the guide bush l_3 and the length of the ball cage l_2: $H_{max} = 2\ (l_3 – l_2)$.
- See page 37-41 for instructions on installation and servicing.

Material

- Special roller bearing steel 100 Cr 6 (1.2067 or 1.3505)
- Carefully heat-treated, hardness rating HRC 60–64/HV 720–815
- Steel stop rings
- Wiper seals NBR rubber in steel shell
- Circlips DIN 471 steel
- Maximum constant working temperature 100°C

Special designs

Other dimensions or designs based on workpiece drawings are available.
These can also be produced using stainless steel (1.4112).

Order Information

Rotary stroke bearing consisting of:

Guide bush N 570/d_w/d_1/l_1	**Order No. 5009 . . .**
Ball cage N 501/d_w/d_1/l_2	**Order No. 50010 . .**
or	
Ball cage N 500/d_w/d_1/l_2	**Order No. 50000 . .**

Closed Guide Bush with Wiper Seals

N 570

d_w	d_1	d_B	l_1	l_3	e	m	n	Order No.	Cage length l_2/stroke H_{max} (Selected examples)					
10	**15**	22	**70**	51	50	6	15	**5009006**	50/2	40/22	28/46	20/62		
12	**17**	26	**75**	59	53	6	16	**5009008**	50/18	40/38	28/62	20/78		
14	**20**	30	**92**	74	66	8	19	**5009009**	48/52	34/80				
15	**21**	30	**92**	74	66	8	19	**5009010**	48/52	34/80				
16	**22**	30	**92**	79	66	8	19	**5009012**	63/32	48/62	34/90	25/108		
20	**26**	35	**80**	64	51	8	22	**5009015**	56/16	48/32	40/48	28/72		
			112	96	83	8	22	**5009016**	80/32	68/56	56/80	48/96	40/112	28/136
25	**31**	42	**90**	66	56	10	25	**5009018**	58/16	51/30	40/52			
			132	108	98	10	25	**5009019**	100/16	80/56	68/80	58/100	51/114	40/136
30	**38**	55	**145**	124	115	10	25	**5009020**	93/62	78/92	54/140			
32	**40**	55	**145**	125	115	10	25	**5009022**	110/30	93/64	78/94	68/114	54/142	30/190
40	**48**	65	**172**	147	135	12	28	**5009024**	125/44	110/74	102/90	87/120	68/158	62/170
50	**60**	77	**150**	123	110	12	31	**5009026**	110/26	90/66	77/92			
			210	183	170	12	31	**5009027**	180/6	140/86	110/146	90/186	77/212	
63	**73**	90	**180**	150	138	15	34	**5009028**	140/20	108/84	88/124			
			260	230	218	15	34	**5009029**	185/90	140/180	108/244	88/284		
80	**92**	120	**220**	178	180	15	34	**5009030**	160/36	135/86	110/136	95/166		
			315	273	275	15	34	**5009031**	215/116	160/226	135/276	110/326	95/356	
100	**112**	140	**355**	320	310	15	36	**5009033**	245/150	180/280	165/310	110/420		

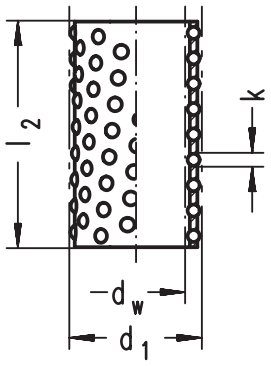
Stroke H

Dependent on length l_2 of the ball cage used.

$H_{max} = 2\ (l_3 - l_2)$

Brass Ball Cage

N 502 Mini Range



Suitability

Brass ball cage with steel balls arranged in helical formation for use with guide bushes from the Mini Range.

- The »Mini Range« was specifically developed for the precision engineering and optical industries.
- Uses smaller balls than type N 501.
- Smaller installation space by the use in combination with guide bushes from the Mini Range.
- The helical arrangement of the balls is ideal for linear and rotary movements.

Features

- The ball chambers are mechanically caulked so that the balls remain captive but still move easily.
- The balls are arranged in an optimum formation so that each ball can run on its own track for both linear and rotary movements.
- The ball formation ensures smooth running and substantially lengthens the service life of the rotary stroke bearing.
- Brass offers high mechanical stability, optimum sliding properties, and high resistance to abrasion and heat.
- See page 37-41 for instructions on installation and servicing.

Material

Cage:

- Brass
- Maximum constant working temperature 150°C (In case of higher temperatures, please ask us for advice.)

Balls:

- Hardened stainless steel X90 CrMoV 18 (1.4112)
- DIN 5401/ISO 3290 grade 5 sorting group P0

Loading capacity

Column C shows the load ratings of the ball cages under uniform radial load. The loading capacity must be computed when moments are in play.

Special designs

The ball cages can be supplied with ceramic balls. Other dimensions or designs are available on the basis of workpiece drawings and can be produced using different cage materials.

Order Information

Ball Cage N 502/d_w/d_1/l_2 **Order No. 50002 . .**

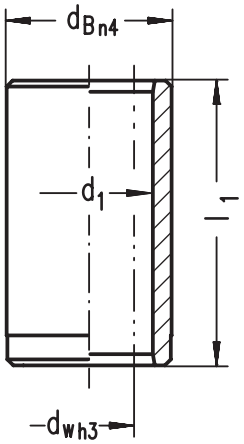
Brass Ball Cage

N 502 Mini Range

d_w	d_1	l_2	k	Balls [pcs.]	C [N]	Order No.
2.5	**4.1**	**10**	0.8	24	7	**5000236**
		12.5		30	9	**5000237**
		15		38	11	**5000238**
3	**5**	**10**	1	22	14	**5000240**
		12.5		28	19	**5000241**
		15		36	24	**5000242**
		20		50	34	**5000243**
4	**6**	**10**	1	22	15	**5000244**
		15		36	26	**5000245**
		20		50	35	**5000246**
		25		64	48	**5000247**
5	**7**	**10**	1	30	23	**5000248**
		15		50	40	**5000249**
		20		70	56	**5000250**
		30		110	89	**5000251**
6	**8**	**10**	1	30	29	**5000252**
		15		50	50	**5000253**
		20		70	60	**5000254**
		25		90	78	**5000255**
		35		130	112	**5000256**
8	**10**	**15**	1	50	50	**5000257**
		20		70	60	**5000258**
		25		90	78	**5000259**
		30		110	95	**5000260**
		40		150	130	**5000261**
10	**13**	**20**	1.5	56	122	**5000262**
		30		76	146	**5000263**
		40		104	202	**5000264**
		50		134	258	**5000265**
12	**15**	**20**	1.5	66	128	**5000266**
		30		88	170	**5000267**
		40		122	235	**5000268**
		50		154	300	**5000269**
14	**17**	**20**	1.5	66	128	**5000270**
		30		88	170	**5000271**
		40		122	235	**5000272**
16	**20**	**30**	2	84	290	**5000273**
		40		102	350	**5000274**
		50		130	450	**5000275**
18	**22**	**30**	2	84	295	**5000276**
		40		118	415	**5000277**
		50		152	530	**5000278**
20	**24**	**30**	2	84	300	**5000279**
		40		118	420	**5000280**
		50		152	520	**5000281**
		60		184	660	**5000282**
22	**26**	**40**	2	118	425	**5000283**
		50		152	550	**5000284**
		60		184	670	**5000285**

Open Guide Bush

N 550 Mini Range



Suitability

Open guide bush with tapered inside edges on both sides for use with Mini Range ball cage N 502.

- Minimal installation space when used with Mini Range ball cages N 502.
- Allows universal use.
- When used in combination with shaft diameter d_w ISO-h3, preloading of the rotary stroke bearing is guaranteed.
- The ball cage can project out of the guide bush on both sides to permit longer stroke paths (note minimum contact length).

Features

- Guide bore diameter d_1 is finely honed to ISO tolerance IT 3, R_z 0.5 – 1.5 µm depending on diameter.
- Roundness within 1/3 ISO-IT 3.
- Cylindricity within IT 1.
- Radial run-out of a shaft inserted under preloading is within 0.0005 mm.
- Tapered inside edges on both sides ensure smooth running.
- Outside diameter d_B n4 with radial run-out error within IT 4, ground to guide bore diameter d_1, lead-in taper on one side.
- See page 37-41 for instructions on installation and servicing.

Material

- Special roller bearing steel 100 Cr 6 (1.2067 or 1.3505)
- Carefully heat-treated, hardness rating HRC 60–64/HV 720–815

Special designs

Other dimensions or designs based on workpiece drawings are available.
These can also be produced using stainless steel (1.4112).

Order Information

Rotary stroke bearing consisting of:

Guide bush N 550/d_w/d_1/l_1	**Order No. 5002 . . .**
Ball cage N 502/d_w/d_1/l_2	**Order No. 50002 . .**

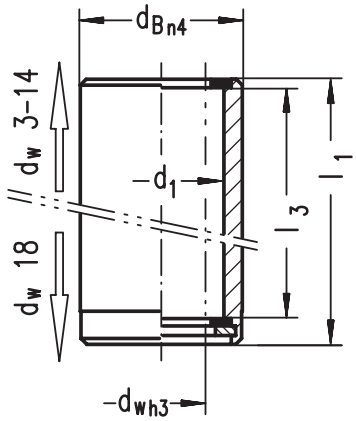
Open Guide Bush

N 550 Mini Range

d_w	d_1	d_B	l_1	Order No.
2.5	**4.1**	6	**10**	**5002092**
			12.5	**5002093**
			15	**5002094**
3	**5**	7	**12.5**	**5002064**
			15	**5002079**
			20	**5002065**
4	**6**	8	**15**	**5002066**
			25	**5002067**
5	**7**	10	**12**	**5002002**
			20	**5002003**
			30	**5002068**
6	**8**	11	**12**	**5002080**
			20	**5002069**
			35	**5002070**
8	**10**	14	**16**	**5002004**
			25	**5002005**
			40	**5002071**
			60	**5002072**
10	**13**	18	**20**	**5002006**
			30	**5002007**
			40	**5002073**
			65	**5002074**
12	**15**	20	**25**	**5002008**
			36	**5002009**
			50	**5002075**
			70	**5002076**
14	**17**	22	**25**	**5002010**
			36	**5002011**
			50	**5002077**
			75	**5002078**
16	**20**	25	**33**	**5002012**
			45	**5002013**
18	**22**	28	**25**	**5002016**
			33	**5002017**
			45	**5002018**
			60	**5002019**
			92	**5002081**
20	**24**	30	**42**	**5002082**
			56	**5002083**
22	**26**	32	**33**	**5002026**
			42	**5002027**
			56	**5002028**
			64	**5002029**
			112	**5002088**

Closed Guide Bush with Stop Rings

N 552 Mini Range



Suitability

Design as for N 550, with stop rings fixed on both sides for use with Mini Range ball cage N 502.

- Minimal installation space when used with Mini Range ball cages N 502.
- When used in combination with shaft diameter d_w ISO-h3, preloading of the rotary stroke bearing is guaranteed.
- The stop rings ensure the cage is effectively restricted for linear and rotary movements.
- Smooth running of the rotary stroke bearing is not impaired by the stop rings.

Features

- Stop rings fixed on both sides.
- The closed guide bush and integrated ball cage form a separate component.
- Guide bore diameter d_1 is finely honed to ISO tolerance IT 3, R_z 0.5 – 1.5 µm depending on diameter.
- Roundness within 1/3 ISO-IT 3.
- Cylindricity within IT 1.
- Radial run-out of a shaft inserted under preloading is within 0.0005 mm.
- Outside diameter d_B n4 with radial run-out error within IT 4, ground to guide bore diameter d_1, lead-in taper on one side.
- The maximum stroke path H_{max} is determined from the length of the guide bush l_3 and the length of the ball cage l_2: $H_{max} = 2\ (l_3-l_2)$.
- See page 37-41 for instructions on installation and servicing.

Material

- Special roller bearing steel 100 Cr 6 (1.2067 or 1.3505)
- Carefully heat-treated, hardness rating HRC 60–64/HV 720–815
- Steel stop rings

Special designs

Other dimensions or designs based on workpiece drawings are available.
These can also be produced using stainless steel (1.4112).

Order Information

Rotary stroke bearing consisting of:

Guide bush N 552/d_w/d_1/l_1	**Order No. 5003 . . .**
Ball cage N 502/d_w/d_1/l_2	**Order No. 50002 . .**

Closed Guide Bush with Stop Rings

N 552 Mini Range

d_W	d_1	d_B	l_1	l_3	Order No.	Cage length l_2/stroke H_{max} (Selected examples)				
3	**5**	7	**12.5**	11	**5003022**	10/2				
			15	13	**5003108**	12.5/1	10/16			
			20	18	**5003023**	15/6	12.5/11	10/16		
4	**6**	8	**15**	13	**5003024**	10/6				
			25	23	**5003025**	20/6	15/16	10/26		
5	**7**	10	**20**	18	**5003030**	15/6	10/16			
			30	28	**5003031**	20/16	15/26	10/36		
6	**8**	11	**20**	18	**5003032**	15/6	10/16			
			35	33	**5003033**	25/16	20/26	15/36	10/46	
8	**10**	14	**25**	23	**5003039**	20/6	15/16			
			40	38	**5003040**	30/16	25/26	20/36	15/46	
			60	58	**5003041**	40/36	30/56	25/66	20/76	15/86
10	**13**	18	**30**	28	**5003047**	20/16				
			40	38	**5003048**	30/16	20/36			
			65	63	**5003049**	50/26	40/46	30/66	20/86	
12	**15**	20	**25**	22	**5003054**	20/4				
			36	33	**5003055**	30/6	20/26			
			50	47	**5003056**	40/14	30/34	20/54		
			70	67	**5003057**	45/34	40/54	30/74	20/84	
14	**17**	22	**25**	22	**5003062**	20/4				
			36	33	**5003063**	30/6	20/26			
			50	47	**5003064**	40/14	30/34	20/54		
			75	72	**5003065**	40/64	30/84	20/104		
18	**22**	28	**45**	39	**5003076**	30/18				
			60	54	**5003077**	50/8	40/28	30/48		
			92	86	**5003078**	50/72	40/92	30/112		

Stroke H

Dependent on length l_2 of the ball cage used.
$H_{max} = 2\ (l_3 - l_2)$

Chrome Leather Bellows

N 820

Suitability

Chrome leather bellows for covering open rotary stroke bearings.
- Prevents dirt particles penetrating open rotary stroke bearings.
- No impairment of the smooth running of the rotary stroke bearing.
- Customized to the installation conditions.

Features

- The relationship between the inside diameter d_i and the outside diameter d_a has been selected to give the bellows good stability.
- Optimum contraction ratio (l/l_e).
- Unlike rubber or plastic bellows, leather bellows do not impair the smooth running of the rotary stroke bearing.
- The natural material is resistant to most environmental influences. (Caution should be exercised when using certain coolants!)

Material

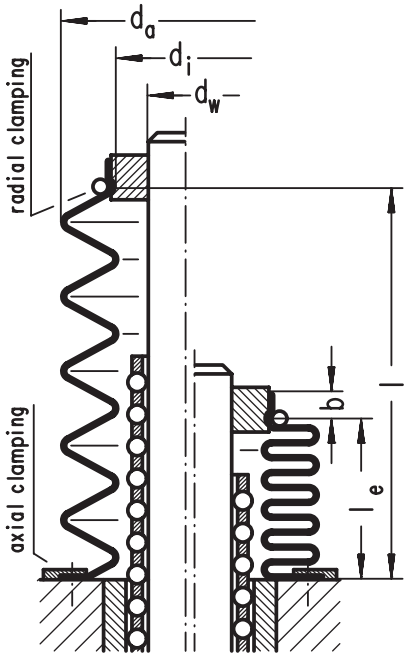
- Chrome-tanned black leather
- Impregnated, and thus resistant to oil, water and atmospheric influences

Availability

Bellows are manufactured to order. See preferred dimensions.

Order Information

N 820/d_i/d_a/l/l_e .../a for axial clamping
.../r for radial clamping
.../a, r for axial and radial clamping



d_w	d_i	d_a	q	l_{max}	b
12	**22**	**40**	0.25	500	6
14-16	**27**	**45**	0.25	500	6
		50	0.22		
18-20	**31**	**50**	0.25	500	6
		58	0.22		
24-25	**36**	**55**	0.25	1000	6
		60	0.20		
30-32	**42**	**65**	0.25	1500	8
	46	**70**	0.25	1500	8
		75	0.20		
40-42	**56**	**80**	0.25	1500	8
		85	0.18		
50-52	**68**	**100**	0.20	1500	8
		110	0.15		
63	**80**	**110**	0.20	1500	10
		120	0.15		
80	**100**	**140**	0.12	1500	10
100	**120**	**160**	0.12	1500	10

$l_e = l \cdot q$
q = factor for contracted length l_e

FAX – Questionnaire MarMotion High-precision Rotary Stroke Bearings
Mahr GmbH Göttingen Fax No. +49(0)551/7073-422

Sender: _____
Company: _____
Address: _____

Ref. No.: _____

Techn. contact: _____ Dept.:_____ Phone: _____ Fax:_____
Commerc. contact: _____ Dept.:_____ Phone: _____ Fax:_____

Rotary stroke bearing requirements:

Application: ○ Mech. Engineering ○ Tool ○ Equipment ○ Machine Tool
○ Packaging Machine ○ Assembling ○ Special Machines ○ Accessories
○ Prec.Mech./Optics ○ Medicine ○ _____ ○ Micro Optics
○ Metrology ○ _____ ○ other _____

Environment: Temperature:_____ ○ Liquids: _____
○ Dirt / dust: _____ ○ Aggressive media:_____
○ Cleanroom requirement: _____ ○ Vacuum: _____
○ other: _____

Load: ○ Linear motion Stroke length:_____ Strokes / min. _____
○ Rotary motion RPM: _____
○ Linear/Rotary motion
Radial load (N): _____ Moment (Nm):_____ (Sketch)

Requirements: ○ Guiding precision of stroke: _____ ○ Smooth running

Rotary stroke bearing consisting of:

	Type	**Size** ($d_W/d_1/l$)	**Order No.**	**Quantity** (pcs)	**Requested Delivery**
Guide Shaft	○ N 400 ○ N 421 ○ N 423 ○ N 425				
	○ Special design acc. to drawing				
Ball Cage	○ N 500 ○ N 501 ○ N 511 ○ N 502 Mini				
	○ Special design acc. to drawing				
Guide Bush	○ N 550 ○ N 552 ○ N 553 ○ N 570				
	○ Special design acc. to drawing				

Attachment: _____

High-precision Rotary Stroke Bearings

MARMOTION BY MAHR

- Maximum guiding accuracy
- Backlash-free guiding
- Linear and rotary motion
- Smooth running
- High loading capacity and guiding rigidity
- Long service life

Mahr

EXACTLY

► | Technical Description

1. General description

Recent decades have seen high-precision Mahr MarMotion rotary stroke bearings for linear and rotary motion extend their area of application from the pressing tool sector to include general mechanical engineering, precision mechanical and optical engineering and a wide range of specialized fields.

In the course of this development work, Mahr has devised computation formulae based on the company's long experience and supported by close cooperation with various technical colleges and universities. This expertise helps designers to optimize the rotary stroke bearing for a particular application. This results in excellent guiding accuracy, optimum reliability and long service life.

The rotary stroke bearings manufactured with great precision by Mahr mean that the user can be sure that components are interchangeable. The MarMotion high-precision rotary stroke bearing can therefore be considered an integral part of the mechanical and design elements.

Features

The main features of the MarMotion high-precision rotary stroke bearings are as follows:

Maximum guiding accuracy

The MarMotion high-precision rotary stroke bearing offers high guiding accuracy for both linear and rotary movements.
This is guaranteed by the micro-finished running faces of shafts and bushes, whose accuracy of form in terms of roundness and cylindricity lies within 1/3 of ISO tolerance class IT 3.
The exclusive use of grade 5, sorting class P0 steel balls (DIN 5401 or ISO 3290) also contributes to the high degree of guiding accuracy.

Backlash-free guiding

There is no backlash whatsoever in the guide because the balls are preloaded under a tension of a few µm between the shaft and the bush. Optimum preloading is ensured in the factory by pairing the shaft, ball cage and bush. This simplifies the process of fitting the rotary stroke bearing.

Smooth running

The MarMotion high-precision rotary stroke bearing ensures both maximum guiding accuracy and very low friction.
A pure contact rolling motion of the balls on the micro-finished running faces ensures very low friction. The coefficient of friction lies between 0.001 and 0.008 and ensures smooth running.

High loading capacity and guiding rigidity

The dense arrangement of the balls and the high form and dimensional accuracy of the balls and bearing faces provide a large number of contact points, thereby ensuring uniform distribution of the load in the guide. The designer can make optimum use of the available space. The functional reliability of the guide is significantly increased.

Rapid movements, high acceleration

The low friction rolling action in the MarMotion high-precision rotary stroke bearing enables rapid movements and high acceleration. The low inertia forces of plastic cages make these particularly well suited for high-frequency linear and rotary movements.

Long service life

Careful selection and heat treatment of the materials used, coupled with top quality bearing faces, means that the MarMotion high-precision rotary stroke bearings are particularly resistant to abrasion.

Minimum maintenance

In most cases, a thin film of lubricant is sufficient for several months' continuous operation. The outlay required for maintenance during operation is minimal.

Interchangeability

All individual components are interchangeable. This is due to continuous quality control, the exclusive use of balls of sorting group P0, and the machining of shafts and bushes to a high standard of precision. This ensures problem-free continuous operation.

Special designs

The extensive range of MarMotion high-precision rotary stroke bearings offers appropriate solutions for many different applications. We can also manufacture special designs for particular applications and requirements on the basis of workpiece drawings. Using alternative materials can also open up new possibilities.

2. Design, Functions, Features

2.1 Design and functions

MarMotion high-precision rotary stroke bearings consist of the cylindrical shaft and bush, which act as guiding elements, and the steel balls, which act as the rolling bearing elements. The balls are held in a brass or plastic smooth-moving tube where they roll easily.

The guide shaft, balls and guide bush are specially hardened and micro-finished. The structure is stabilized through careful application of heat treatment.

The balls roll non-positively between the bush and shaft under a preloading tension. Linear, rotary and combined movements are possible. The frictional connection of the balls means the cage moves in accordance with the laws of kinematics.

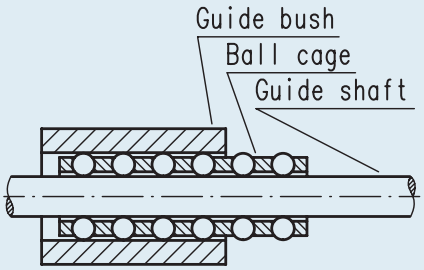


Fig. 1

2.2 Preloading

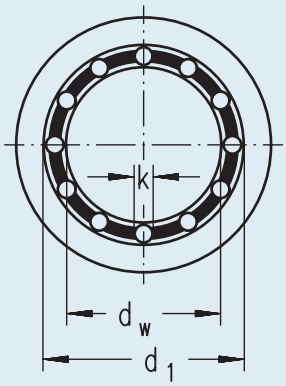
Preloading must be set with great precision to ensure problem-free operation. This is achieved and defined using the manufacturing tolerances. Preloading value v is the difference between the size of the inside diameter of the guide bush d_1 and the distance between two balls lying opposite each other and touching the shaft.

Recommended preloading

The preloading values given in the following table are recommended for most applications. These values are based on theoretical knowledge and practical experience.

Preloading values

d_w [mm]	v [µm]	d_w [mm]	v [µm]
2.5/ 3	0.5 - 2	14/ 25	4 - 7
4/ 5	1 - 3	30/ 42	4 - 8
6/ 8	2 - 4	50/ 63	6 - 10
10/12	3 - 5	80/100	8 - 12



$v = d_w + 2 \cdot k - d_1$ [mm]
$d_1 = d_w + 2 \cdot k - v$ [mm]

Fig. 2

These preloading values ensure that the rotary stroke bearing has both excellent rigidity and smooth running. In the case of orders for complete rotary stroke bearings consisting of a guide shaft, ball cage and guide bush, the components are paired in the factory. This ensures optimum and uniform preloading.

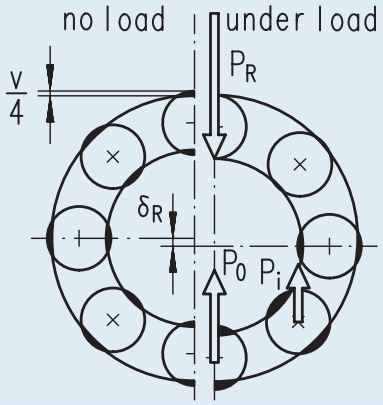
Due to the range of scatter of the manufacturing tolerances (IT 3), indiscriminate pairing of shafts, ball cages and bushes can result in unfavorable preloading values which deviate from those listed in the table. The rotary stroke bearings of the Mini Range should always be ordered in pairs.

The significance of preloading

Preloading guarantees that the MarMotion high-precision rotary stroke bearing has absolutely no backlash. In the case of applications where special conditions have to be satisfied, the required preloading value can be specified at the time of ordering.

A very low preloading value means that the rotary stroke bearing runs smoothly but rigidity is limited. A higher preloading value increases loading capacity and rigidity. A very high preloading value leads to the rotary stroke bearing running less smoothly.

If the preloading value is too high, the run will be rough and stiff. The rotary stroke bearing can also be overloaded by excessive surface pressure. This is prevented by the narrow manufacturing tolerances of the rotary stroke bearing. It must therefore be ensured that the guide bush is not deformed when being installed. The guide bush should thus not be pressed into the location bore or secured with pressure screws.



Stationary guide bush
P_R = radial force acting on the shaft
P_0 = force acting on the ball at the load apex
P_i = force on a ball outside the load apex
δ_R = radial offset of the bush and shaft axes
v = preloading

Fig. 3

2. Design, Functions, Features

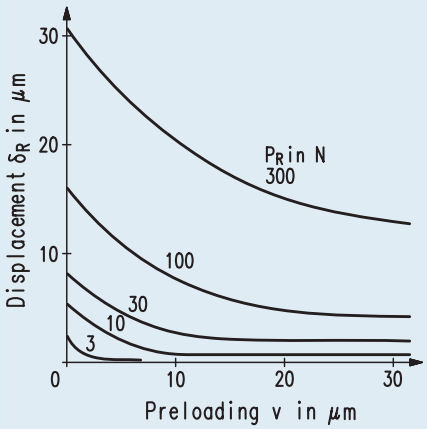


Fig. 4

Optimum preloading

If the rotary stroke bearing is loaded radially with a force P_R, the guide bush axis and shaft axis are displaced by an amount δ_R. The permissible amount of displacement δ_R depends on preloading value v. The calculation of the optimum preloading value should take into account factors of service life, running behavior and guiding stability.

The diagram shows the radial offset of a rotary stroke bearing as a function of the preloading value and the radial load. For a given radial force, the offset with a small preloading value is relatively large (the guide is soft). With high preloading values, however, the offset is significantly smaller for the same radial force (the guide is rigid).

Taking into account the Hertzian stress, manufacturing tolerances and deformation of components during installation and operation of the rotary stroke bearing, and also taking into account the most favorable resilience conditions for the rotary stroke bearing, a value of

$\delta_R = 0{,}5 \cdot v$

has been taken as the basis for the computations. This satisfies the call for "high-precision". This condition is met for the indicated "specific rated loads" C_{10}.

2.3 Matching of the shaft and ball diameters

From the rules of rolling friction, it is known that ball diameter k affects the degree of friction, i.e. a larger ball rolls more smoothly than a smaller one.

On the other hand, a large number of smaller balls results in better vibration dampening than a small number of large balls.

For this reason, and in order to save space, the smaller sized ball is often preferred. Moreover, with a low degree of roughness and greater geometrical accuracy of form for the rolling element, the ball diameter becomes relatively unimportant for the running characteristics.

The shaft and ball diameters of the MarMotion high-precision rotary stroke bearings have been matched to optimum effect and the optimum number of balls defined on the basis of thorough testing.

2.4 Coefficient of friction µ

The coefficients of friction µ apply for the start-up run and movement alike.

Influencing variables:

- Surface condition of the rolling elements
- Degree of preloading and load
- Number of balls
- Friction of cage

The MarMotion high-precision rotary stroke bearings run free of stick-slip. The following coefficients of friction apply to radial load:

high $\mu = 0.001–0.002$
medium $\mu = 0.003–0.004$
low $\mu = 0.005–0.008$

The rolling resistance of a rotary stroke bearing derives from the inner load caused by preloading and from the influence of outside radial forces. With a low radial load, the preloading and cage friction components predominate. The coefficient of friction µ thus increases as the radial load decreases. Consequently, when there is a small radial load and extremely smooth motion is required, a low preloading value must be used.

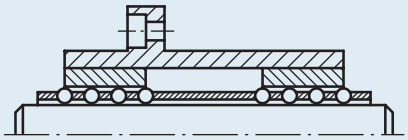
3. Notes on Design and Installation

3.1 Important notes on design

As already described, preloading value v represents an important criterion for the functioning of the MarMotion high-precision rotary stroke bearing. It influences the loading capacity, the smooth running and, if the recommended values are exceeded, the service life.

The following installation notes should therefore be observed:

- Load the rotary stroke bearing more with radial force than with moments in order to prevent local overloading of the balls.
- In the case of high moments, arrange two guide zones one after the other with a gap in between.
- If necessary, fit a joint support tube with screw-on flange.
- Set the points of application of the driving force in the guide plane if possible (refer also to chapter 5.2).
- Protect from impact. Impacts can leave ball impressions even on hardened running faces.



Separate ball operating zones

Fig. 5

3.2 Mounting the guide bush

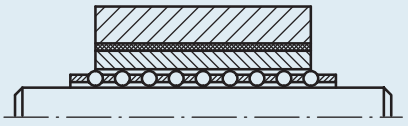
Avoid pressing the guide bush!

Avoid pressing the guide bushes as this may damage the micro-finished guide diameter d_1. The bush adapts to the location bore. This results in form errors and excessive preloading, thereby impairing the correct functioning of the rotary stroke bearing. Clamp-type fittings and pressure screws are also unsuitable for the same reasons.

The tolerance of outside diameter dB of the MarMotion guide bushes corresponds to ISO-n4 (or ISO-h6 for type N 570). The tolerance of the location bore should be selected so that there is no press fit of the guide bush.

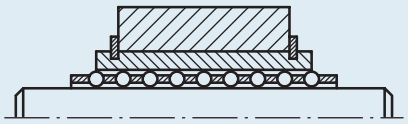
We recommend:

- Mechanical clamping by means of flanges, stop bits, safety rings, etc.
- Bonding by means of commercially available single-component or two-component systems. The manufacturers bonding instructions in terms of the bonding aperture, hardening time, etc. must be adhered to. Experience has shown that a bonding agent that hardens slowly is advantageous.
- The walls of the bush should not be made too thin. Thin-walled bushes are hard to manufacture and can easily be damaged during installation. Suggested value for wall thickness: Inside diameter $d_1 \cdot 0{,}1$
- The required wall thickness is also determined by the type of clamping used.



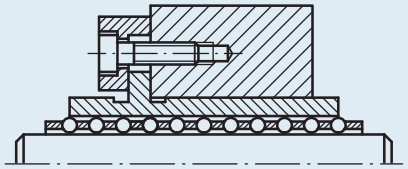
Bonding aperture

Fig. 6



Safety rings

Fig. 7



Flange with stop bit

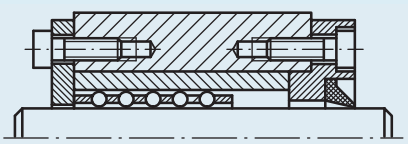
Fig. 8

Installation with seals

A seal is necessary when there is a lot of dirt present, especially when this takes the form of abrasive substances or if particularly high demands are placed on smooth running, ease of movement and durability.

Sealing options:

- Sealing rings (see type N 553)
- Wiper seals (see type N 570)
- Bellows (see type N 820)



Cap Sealing rings, wiper seals

Fig. 9

3. Notes on Design and Installation

3.3 Mounting the guide shaft

Unlike the guide bush, the guide shaft can be clamped or pressed in.

A radially loaded rotary stroke bearing is subject to elastic deformation on the rolling faces and the guide shaft. The rigidity of the guide shaft is largely determined by the type of clamping used.

With a relatively high load, a long shaft and a need for very accurate guiding over the entire stroke path, at least one of the two holders should be designed with a clamping length of

$s \geq 1.5 \cdot d_w$

If there is a clamp on one side only (cantilever beam), the application point of the load should be placed as close as possible to the clamped end.

Beam "on two supports" (loose bearing)
f(a) Deflection at force application point
g(a) Elastic curve

Clamped beam

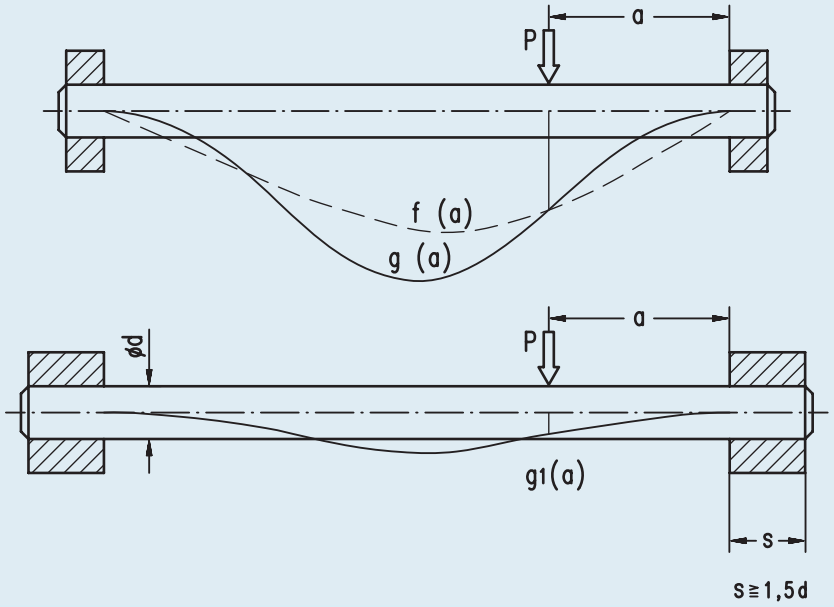


Fig. 10

Pressing in

Make the location bore e.g. ISO-R6 with axis in true alignment. The parallelism deviation of two paired shafts should not exceed the preloading value.

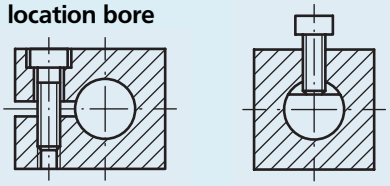
Clamping in the location bore, e.g. ISO-H6

- Indirectly with a slot and tension bolt.
- Directly with a pressure screw. The end of the shaft must be slightly flattened, tapped or turned in to secure it axially.

Clamping in vee-block

- With a clamp
- With a tension bolt

Clamping in location bore



Clamping in vee-block

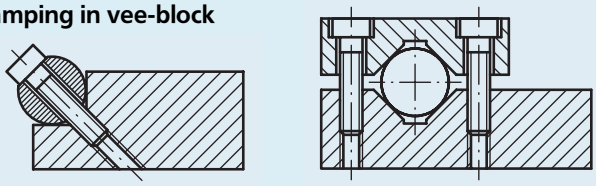


Fig. 11

Adhesive fittings

Poorly aligned location bores can result in tension in the shaft and rotary stroke bearing. This can be prevented by providing the bores with some fitting clearance, e.g. ISO F7-H7. At the final assembly stage, glue the shafts together with the rotary stroke bearing and allow to harden when properly aligned. The manufacturers' gluing instructions in terms of the gluing aperture, hardening time, etc. must be adhered to.

3. Notes on Design and Installation

3.4 Installing the ball cage

If ball cages are used in conjunction with open guide bushes, the ball cage and the guide shaft should run together into the bush. Since undersizing (preloading) is employed, this method is only one that can prevent the balls sliding between the bush and shaft.

In the case of rotary stroke bearings with closed guide bushes, the guide shaft must be inserted against the preloading pressure. Lubrication grease is advisable to prevent the balls becoming flattened.

Particularly in the case of ball cages with larger diameters, it must be ensured that the cage is properly centered in the guide bush.

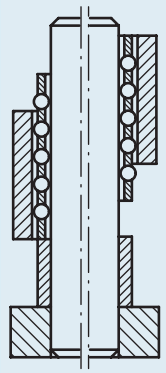
Limit stops for the ball cage

Despite the fact that the guide moves non-positively subject to preloading, the ball cage can alter its position axially ("cage creeping").

In rotary stroke bearings with an open guide bush, the path of the cage must be limited such that the ball cage cannot move out of the guide beyond a certain amount. This can be ensured by using fixed or sprung stops.

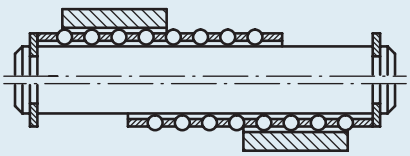
- Stop bush which is pushed loose over the shaft and stops the cage at the linear reversing points.
- Clamping bush which can be fixed to any point of the shaft.
- Safety rings which limit a defined path.
- Pressure springs

Fixed stops



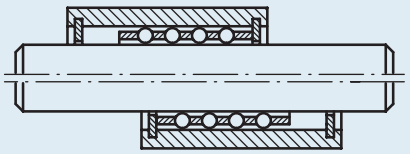
Stop bush

Fig. 12



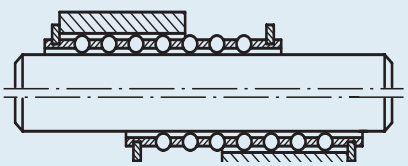
Safety rings on the shaft

Fig. 13



Safety rings in the bush

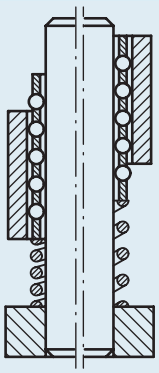
Fig. 14



Safety rings on the ball cage

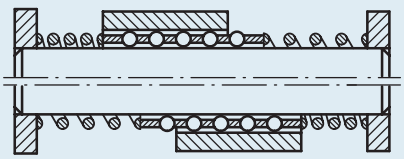
Fig. 15

Sprung stops



Pressure spring on one side

Fig. 16



Pressure springs on both sides

Fig. 17

3. Notes on Design and Installation

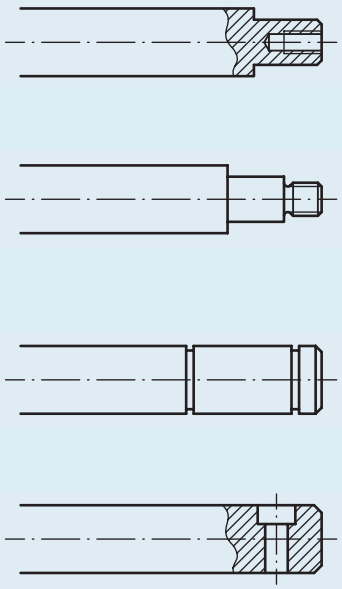


Fig. 18

3.5 Special designs

In addition to the standard sizes and catalog dimensions, all guide elements can be adapted to your specific requirements and produced on the basis of workpiece drawings.

Examples of guide shafts:

- Guide shafts of customized lengths
- Internal thread
- Shoulder with internal or external thread
- Recess for safety ring
- Collar for clamping
- Through-bore for screwing into a vee-block
- Guide shaft made of stainless rolling bearing steel 1.4112

Examples of guide bushes:

- With dimensions d_1, d_B, l_1 deviating from the standard dimensions
- With recesses for mounting with safety rings
- With flange for axial clamping
- Made of stainless rolling bearing steel 1.4112

Examples of ball cages:

- Ball cages with dimensions d_w, l_2, k differing from those of the standard ranges
- Ball cages with higher number of balls for particularly high loading
- Ball cages with balls made of stainless rolling bearing steel (1.4112) or other materials

4. Maintenance and Service Life

MarMotion high-precision rotary stroke bearings require virtually no maintenance. They are treated with anticorrosive agent before dispatch. After delivery, this agent must be removed, preferably with a cleansing agent containing oil. The rotary stroke bearing is then ready for operation.

4.1 Lubrication

In principle, the same rules apply here as for ball bearings. A thin film of lubricant will last for long-term operation, depending on the type of loads acting. Commercial "rolling bearing lubricants" - only this type of lubricant may be used - possess all the properties required to ensure the trouble-free operation of rotary stroke bearings.

Rolling bearing lubricants offer good consistency, are chemically neutral, non-resinating and are free from abrasive particles. Lubricant additives must be selected in accordance with the given application conditions (temperature, pressure, rpm, corrosion behavior, etc.). In principle, greases and oils are equally well suited. Greases should be used very sparingly, however, in order to avoid overheating.

Greases for lifetime lubrication are preferred. Rotary stroke bearings can naturally also be lubricated by central lubrication systems.

Solid lubricants are unsuitable for rotary stroke bearings.

4.2 Dry running

There are some applications where lubrication is not possible, e.g. in the food and textile industries or in high vacuums. Assuming the load is low, the MarMotion high-precision rotary stroke bearing is also suitable for dry running thanks to the high standard of manufacturing quality.

In such cases, designs in stainless rolling bearing steel 1.4112 (special design) offer distinct advantages.

4.3 Wear

Assuming the maintenance instructions are observed, the wear suffered by rotary stroke bearings is so slight that it can be ignored.

If signs of wear do appear, however, e.g. in the form of clearly visible running traces on the rolling surfaces, these may be attributable to one of the following causes:

- The guide is soiled with grinding or abrasive particles.
- Corrosion due to condensation water occurs in the places where the balls touch the shaft and bush.
- A strong moment has led to partial overloading.

With a high number of linear strokes or rotations, the causes mentioned above can lead to rapid spoiling of the rolling faces. Wherever wear marks are perceived, the cause of the problem must be thoroughly eliminated.

4.4 Regularity of maintenance checks

Open or only partially protected rotary stroke bearings are best serviced through regular cleaning and lubrication performed within the scope of general maintenance work. This improves the working properties and service life of the rotary stroke bearings.

4.5 Service life

MarMotion high-precision rotary stroke bearings are preloaded rolling bearings and therefore are subject, in essence, to the same laws as apply to ball bearings.

Service life of rolling bearings

The service life of a rolling bearing is defined as the minimum number of hours in service reached by 90% of a large number of the same bearings under the same operating conditions, even though some of them may last considerably longer, while the other 10% may become worn out beforehand. Accordingly, the service life rating is a probability factor.

Service life of MarMotion high-precision rotary stroke bearings

The loading capacity C_{10} given in the catalogue were computed based on the premise of a high-precision guide and thus do not necessarily represent the maximum loading capacity. Assuming absolute cleanliness and proper lubrication the service life of the rotary stroke bearing can be regarded as virtually unlimited. The ball zone carrying the heaviest load should not to be loaded with more than $P_{10} \leq C_{10}$.

Reliability increases the more the loading capacity C_{10} of the selected rotary stroke bearing exceeds the force P_{10} on the most heavily loaded ball zone.

5. Computation of the Rotary Stroke Bearing

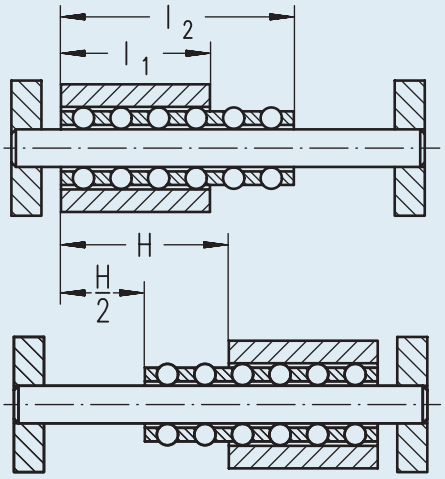


Fig. 19

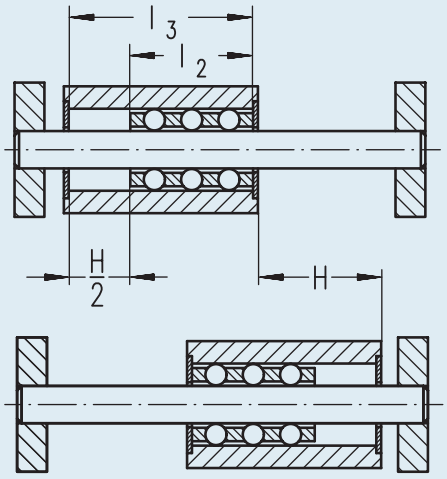


Fig. 20

d_w [mm]	E [mm]		
	N 500	**N 501**	**N 502**
3	-	-	5
4 - 5	-	10	8
6 - 8	-	12	10
10 - 12	12	15	12
14 - 16	-	18	15
18 - 20	12	18	15
25	12	20	-
32 - 40	15	22	-
50 - 63	-	30	-
80 -100	-	45	-

Fig. 21

The computation formulae are intended to assist the designer in determining the rotary stroke bearing which is suited for a given design task.

Computation of the rotary stroke bearings is based in principle on the laws governing ball bearings. However, they differ essentially from the latter in that they allow movement in two degrees of freedom, so that length dimensions and acceleration values must be taken into account. Furthermore, the internal osculating conditions differ substantially from those of most ball bearings.

The following features and characteristics are of primary importance in determining a suitable rotary stroke bearing:
- Freedom from backlash
- Guiding accuracy
- Smooth running
- Loading capacity
- Stroke and rotary frequency
- Service life
- Dimensions

The following variables are to be determined:
- Shaft diameter d_w
- Bush length l_1, l_3
- Cage length l_2

Nominal diameter dw and the cage type determine specific loading capacity C_{10}.
The lengths of the guide bush and ball cage determine the contact length of the rotary stroke bearing. These values are used to calculate the operational loading capacity of the rotary stroke bearing.

5.1 Stroke path and contact lengths

The ball contact lengths are determined by the mutual positions of guide bush, ball cage and guide shaft at the end of the stroke. The dimensions l_1 and l_2 lead to a distinction between different operating modes.

Open rotary stroke bearing (Fig. 19)
Cage length l_2 equal to or greater than bush length l_1.
Stroke: $\mathbf{H = 2\ (l_2 - l_1)}$

Closed rotary stroke bearing (Fig. 20)
Bush length l_3 greater than cage length l_2, ball cage remains within the bush.
Stroke: $\mathbf{H = 2\ (l_3 - l_2)}$

A contact length E which remains constant across the entire stroke (in every stroke position) is desirable for both operating modes. This is always fulfilled for closed rotary stroke bearings. In the case of open rotary stroke bearings, the bush should be flush with the cage in the end stroke positions. If the bush extends beyond the end of the cage, this shortens the contact length and thus reduces the loading capacity of the rotary stroke bearing in this stroke position.

The minimum permissible contact length E must be determined by calculating the loading capacity. The loading capacities of the ball cages can be taken as guideline values.

Reference contact length e
In order to compute a rotary stroke bearing, it is necessary to determine the reference contact lengths e = contact length with unfavorable load distribution.
(see Fig. 23 and Fig. 24)

With a small load
The table (Fig. 21) shows the recommended minimum contact length E depending on d_w for accurate guiding using the rotary stroke bearing without significant load.

5. Computation of the Rotary Stroke Bearing

5.2 Loading capacity with radial load

The radial load of a rotary stroke bearing is determined by the position of the point of application of the radial force P_R in relation to the center of the contact length e.

The radial force P_R can also be the resultant of several forces. The forms of radial load illustrated below depend on the position of the point of application of the force.

The illustrations shown below take into account the deflection of the rotary stroke bearing under load which results from the elastic deformation of the balls and rolling faces of the guide bush and shaft. The axes of the guide bush and shaft are assumed to be rigid. The deflection of the shaft must therefore be incorporated into the calculation if necessary.

Load of the rotary stroke bearing by

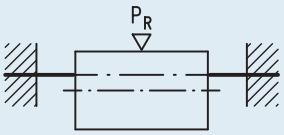
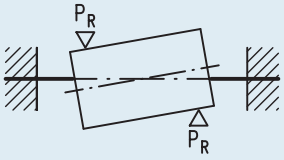
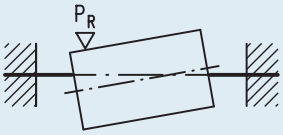
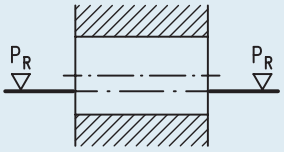
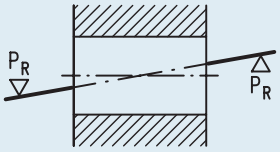
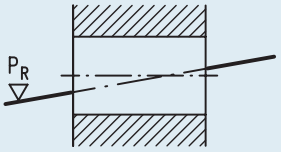
	Centrally acting radial force P_R (see 5.2.1)	Pure moment M (see 5.2.2)	Combination of radial force P_R and moment M (see 5.2.3)
Guide shaft fixed, guide bush moving			
Guide bush fixed, guide shaft moving			
Load of ball zones	Equal load on all zones of the ball cage	The two end zones of the contact length carry the heaviest load	One end zone of the contact length carries the heaviest load

Fig. 22

The static radial load can take different forms:

1. The radial load is constant and evenly distributed and corresponds to a centrally acting radial force P_R.

2. The radial load is distributed unevenly over the length. In certain special cases, it comprises a pure moment M.

The various forms of radial load lead to different stresses on the individual ball zones. Computation of the loading capacity is based on the determination of the highest portion of radial force P_{10} of a ball zone 10 mm long. The relationships between the external load P_R or M and this specific radial force P_{10} are given below for various forms of static radial load.

The elastic deformation of the ball zones results in a deformation of the rotary stroke bearing axis. The elastic deformation of the individual ball zones varies depending on the load. With a specific radial force P_{10}, the radial deflection of the axis of the 10 mm ball zone which is under maximum load is defined as the specific deflection A_{10}. This value can be used to calculate the shaft deflection which can be expected at the force application point A.

5.2.1 Uniform constant radial load

The radial force portion of every 10 mm ball zone is:

$$\mathbf{P_{10} = \frac{P_R}{e} \cdot 10}\ [N]$$

P_R in N, contact length e in mm

The expected parallel displacement of the axis is:

$$\mathbf{A_{10} = P_{10} \cdot R_{10}}\ [\mu m]$$

P_{10} in N, R_{10} in µm/N from table (Fig. 27 or 28).

5. Computation of the Rotary Stroke Bearing

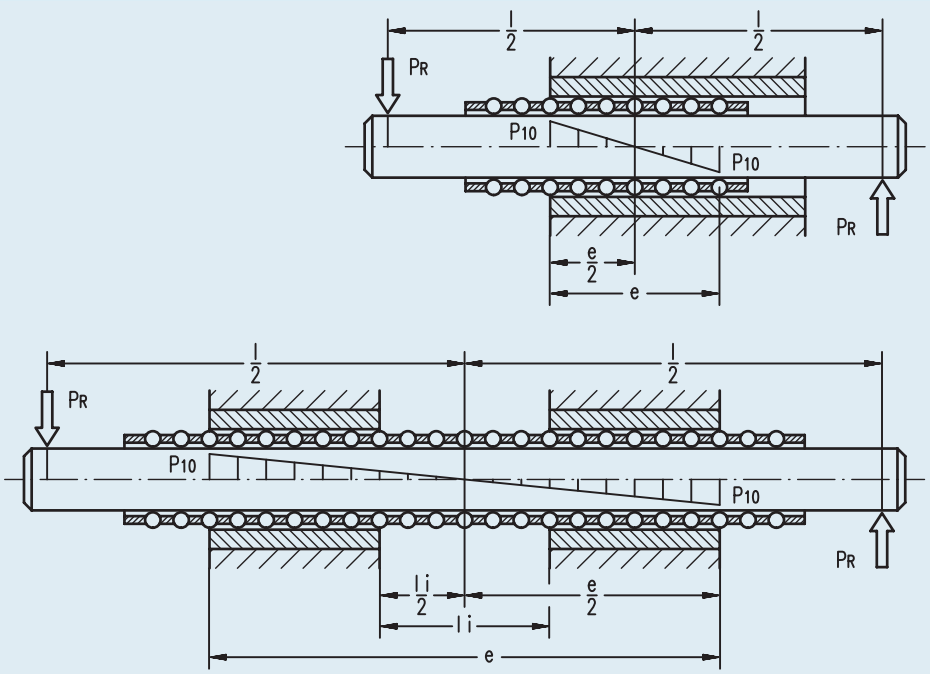


Fig. 23

5.2.2 Radial load as pure moment

The end zones of contact length e are the most heavily loaded for both divided and undivided contact zones.

Moment $\mathbf{M = P_R \cdot l}$ [Nm]
P_R in N, l in m

Specific radial force
$\mathbf{P_{10} = g \cdot M}$ [N]
g in m^{-1}

The factor g is taken from the diagram (Fig. 25). In the case of an undivided contact length, the distance is $l_i = 0$.

Deflection to be expected at the point of application of radial force P_R:

Deflection $\mathbf{A = \frac{l}{e} \cdot P_{10} \cdot R_{10}}$ [µm]

R_{10} in µm/N from table (Fig. 27 or 28)

The deflection of the shaft is not taken into account.

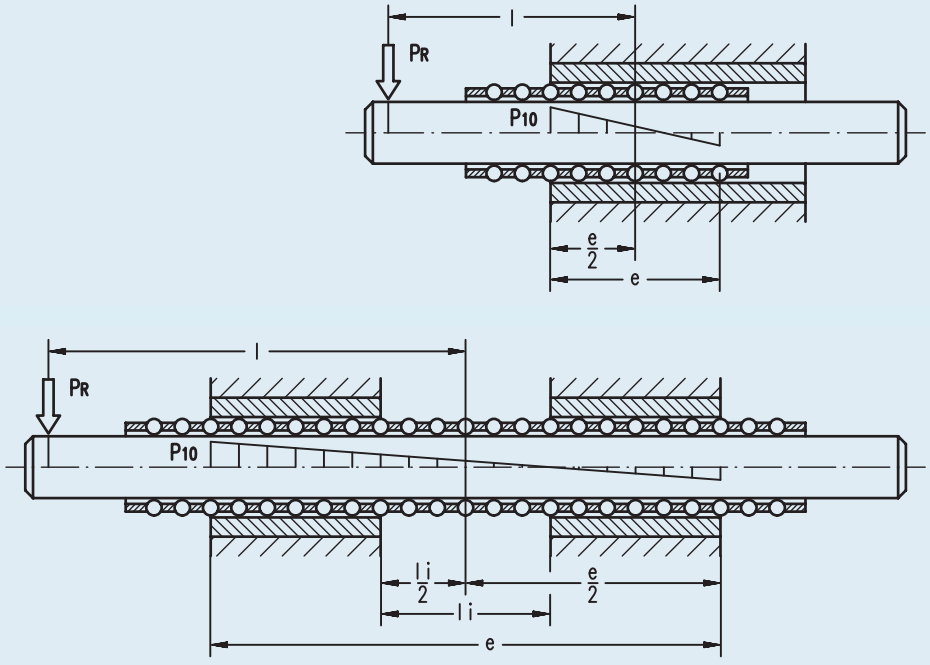


Fig. 24

5.2.3 Uneven radial load

The ball zone next to the point of application of the radial force is most heavily loaded.

The specific radial force P_{10} is a combination of the moment M and the radial force P_R.

Specific radial force

$\mathbf{P_{10} = g \cdot M + h \cdot P_R}$ [N]
g in m^{-1}, h dimensionless,
M in Nm, P_R in N

The factors g and h are taken from the diagrams (Fig. 25 and 26) depending on the distance l_i.
In the case of an undivided contact length, the distance is $l_i = 0$.

5. Computation of the Rotary Stroke Bearing

After P_{10} has been calculated, a comparison with the specific rated load C_{10} (tables in Fig. 27 and 28) reveals whether the rotary stroke bearing is correctly dimensioned.

Requirement: $P_{10} \leq C_{10}$

The deflection A is calculated as described in section 5.2.2.

Computation example:

To be determined: Load of the most heavily loaded ball zone

Given: Radial force acting on one side
$P_R = 1000$ N
$l = 300$ mm
Contact length $e = 200$ mm
Distance between the ball zones $l_i = 100$ mm

Solution:
$\mathbf{P_{10} = g \cdot M + h \cdot P_R}$
$\mathbf{M = P_R \cdot l}$
$= 1000 \text{ N} \cdot 0.3 \text{ m} = 300 \text{ Nm}$
$g = 2 \text{ m}^{-1}$ (from diagram Fig. 25)
$h = 0.11$ (from diagram Fig 26)
$P_{10} = 2 \text{ m}^{-1} \cdot 300 \text{ Nm} + 0.11 \cdot 1000 \text{ N}$
$\mathbf{P_{10} = 710 \text{ N}}$

5.3 Specific rated load C_{10}

Definition

The specific rated load C_{10} is the radial loading capacity of ball operating zone 10 mm long **of a MarMotion high-precision rotary stroke bearing**, taking into account the nominal diameter d_w, preloading value v and cage type N 500, N 501, N 511 or N 502.

In section 5.2, the specific radial force P_{10} was calculated from the load of the rotary stroke bearing.
The following must always apply:

$\mathbf{P_{10} \leq C_{10}}$

C_{10} depends on:
Nominal diameter d_w, ball diameter, number of balls, preloading value v and the following criteria: The surface pressure at the contact points between the rolling elements and the rolling faces of the shaft and the bush (Hertzian stress); and the elastic deflection of the shaft axis from the "0" position, which is determined by the rigidity R_{10} of a 10 mm ball zone.

The specific rated loads C_{10} of Mahr ball cages N 500 and N 501 set out in the tables (Fig. 27 and 28) were defined to justify our claim of manufacturing "high-precision rotary stroke bearings".

The elastic deviation under a load $P_{10} = C_{10}$ should not be more than half the preloading value v.

$\delta_{R,max} = \mathbf{0{,}5\ v}$ [µm]

The quoted values for C_{10} and R_{10} are given as a function of the preloading value v in such a way as to ensure that this condition is met.

The **rigidity R_{10}** [µm/N] is the axial deflection of a 10 mm ball zone under a radial load of 1 N.
The deflection of a 10 mm ball zone is computed from:

$\mathbf{A_{10} = P_{10} \cdot R_{10}}$ [µm]

Method I

The first step is to determine the specific radial force P_{10}. The required nominal diameter d_w and value for C_{10}, which must be greater than or equal to the value of P_{10}, are then read off from one of the tables.

Method II

From the known nominal diameter d_w, C_{10} is read off from one of the tables and then used in further computations as the **permissible** specific radial force P_{10}.

5. Computation of the Rotary Stroke Bearing

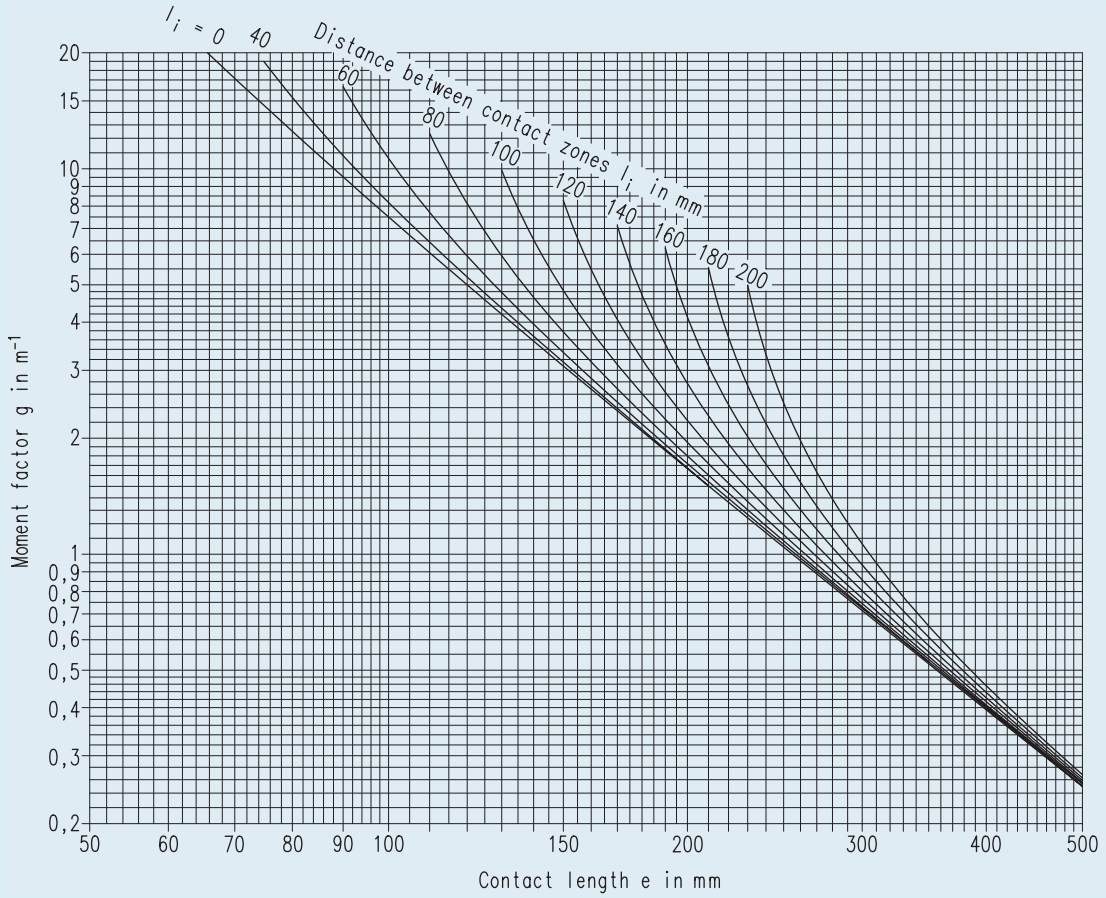


Fig. 25

Note: With a contact length **e < 60** mm, the formula for P_{10} (Section 5.2.2) can no longer be used because the **moment factor g** is too uncertain due to the empirical method of determination.

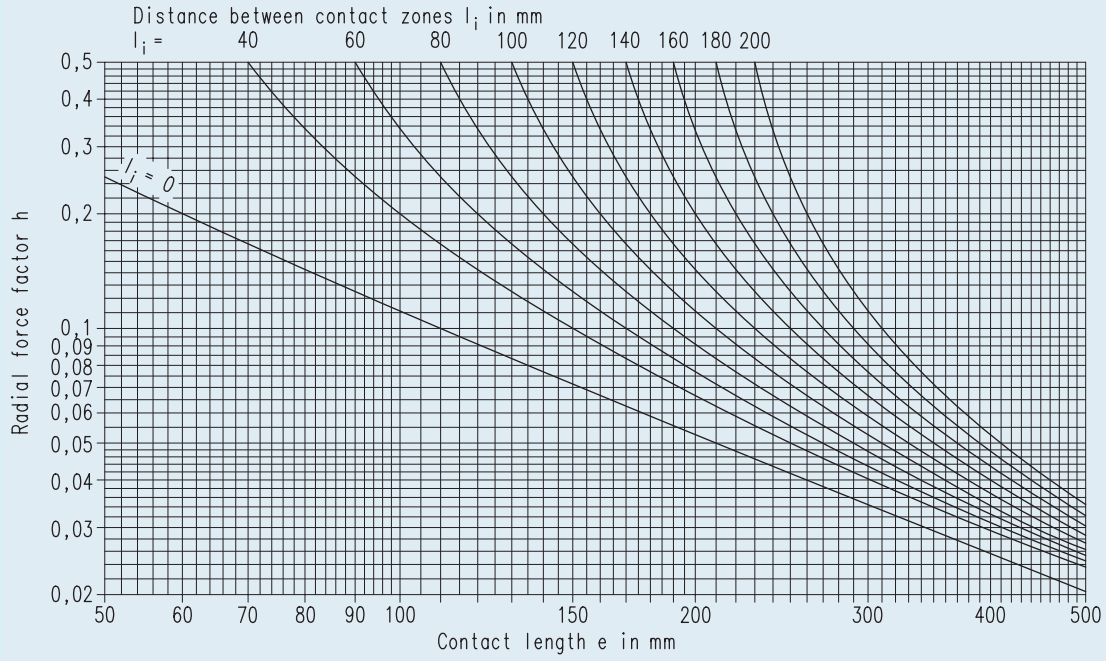


Fig. 26

5. Computation of the Rotary Stroke Bearing

Ball Cage Type N 501: Specific rated load C_{10} and rigidity R_{10}

Nom. size d_w [mm]	C_{10} [N] R_{10} [µm/N]	Preloading v [µm] 1	2	3	4	5	6	7	8	9	10	12	14	16	18	20
4	C_{10}	12	25	42												
	R_{10}	0.0075	0.055	0.042												
6	C_{10}	-	25	45	70											
	R_{10}	-	0.042	0.035	0.030											
8	C_{10}	-	-	50	75	101										
	R_{10}	-	-	0.033	0.03	0.027										
10	C_{10}	-	-	-	78	110	144									
	R_{10}	-	-	-	0.027	0.025	0.023									
12	C_{10}	-	-	-	92	130	170									
	R_{10}	-	-	-	0.023	0.021	0.019									
14-16	C_{10}	-	-	-	-	141	185	233	285							
	R_{10}	-	-	-	-	0.02	0.018	0.017	0.015							
18-20	C_{10}	-	-	-	-	163	215	270	331							
	R_{10}	-	-	-	-	0.017	0.015	0.014	0.013							
24-25	C_{10}	-	-	-	-	-	276	350	424	500						
	R_{10}	-	-	-	-	-	0.012	0.011	0.011	0.01						
30-32	C_{10}	-	-	-	-	-	-	380	462	560	650					
	R_{10}	-	-	-	-	-	-	0.01	0.01	0.009	0.009					
40-42	C_{10}	-	-	-	-	-	-	410	495	590	690	910				
	R_{10}	-	-	-	-	-	-	0.009	0.009	0.009	0.008	0.007				
50-52	C_{10}	-	-	-	-	-	-	-	552	658	770	1030				
	R_{10}	-	-	-	-	-	-	-	0.008	0.008	0.007	0.006				
63	C_{10}	-	-	-	-	-	-	-	-	670	780	1050	1370			
	R_{10}	-	-	-	-	-	-	-	-	0.008	0.007	0.006	0.006			
80	C_{10}	-	-	-	-	-	-	-	-	-	846	1110	1430	1720		
	R_{10}	-	-	-	-	-	-	-	-	-	0.007	0.006	0.006	0.005		
100	C_{10}	-	-	-	-	-	-	-	-	-	-	1230	1560	1880	2280	2660
	R_{10}	-	-	-	-	-	-	-	-	-	-	0.005	0.005	0.005	0.004	0.004

The values C_{10} and R_{10} are specified for the permitted preloading values.

Fig. 27

Ball Cage Type N 500: Specific rated load C_{10} and rigidity R_{10}

Nom. size d_w [mm]	C_{10} [N] R_{10} [µm/N]	Preloading v [µm] 5	6	7	8	9	10	12
18-20	C_{10}	188	248	312	382			
	R_{10}	0.014	0.013	0.012	0.011			
24-25	C_{10}	-	300	370	460	550		
	R_{10}	-	0.01	0.009	0.009	0.009		
30-32	C_{10}	-	-	380	470	560	660	
	R_{10}	-	-	0.01	0.009	0.009	0.008	
38-42	C_{10}	-	-	443	540	645	750	1000
	R_{10}	-	-	0.009	0.008	0.008	0.007	0.007

The values C_{10} and R_{10} are specified for the permitted preloading values.

Fig. 28

5. Computation of the Rotary Stroke Bearing

5.4 Permissible acceleration in the case of linear movement

	Installation			
	horizontal		vertical	
d_w [mm]	q [s^2/m]	b_{max} [m/s^2]	q [s^2/m]	b_{max} [m/s^2]
Plastic Ball Cage N 500				
18 - 19	0.5	200	1.35	75
24 - 25	0.5	200	1.4	71
30 - 32	1.1	91	3.1	32
40 - 42	1.1	91	3.2	31
Brass Ball Cage N 501				
4	0.7	150	0.9	110
6	1	100	1.4	70
8 - 12	1.5	67	2	50
14 - 16	1.75	57	2.3	43
18 - 20	2	50	2.6	38
24 - 25	2.5	40	3.3	30
30 - 32	3.3	30	4.4	23
40 - 42	4	25	5.3	19
50 - 52	5	20	6.7	15
63	6.6	15	8.6	11
80	10	10	13	7.6
100	10	10	14	7

Fig. 29

In the case of fast linear movements, large inertia forces can be exerted on the ball cage. With sinusoidal movements, the inertia forces are largest in the end stroke positions.

The magnitude of the inertia forces is affected by the following factors:
- Brass or plastic cage material
- Linear acceleration b
- Cage length l_2
- Horizontal or vertical installation position

The required contact length E is calculated used quotient q from the following equation:

$$\mathbf{E = q \cdot \frac{b \cdot l_2}{100}} \text{ [mm]}$$

b [m/s^2]; l_2 [mm]; q [s^2/m]

Acceleration b for sinusoidal movement:

$$\mathbf{b = (\frac{\pi \cdot f}{30})^2 \cdot \frac{H}{2000}} \text{ [m/s}^2\text{]}$$

H [mm]; f [min^{-1}]

The quotient q can be taken from the following tables (Fig 29).

The value calculated for E [mm] is to be compared with the recommended values in the table (Fig. 21). The larger of the two values is used in further calculations.

The tables contain recommended values for the permissible axial acceleration with a ball cage in contact at its full length. These values represent average values which can be exceeded, for example, by increasing the preloading value v.

5.5 Permissible rotary speeds for the ball cage

	Rotary speed of ball cage
d_w [mm]	$n_{k\ max.}$ [min^{-1}]
4 - 8	15000
10 - 12	14000
14 - 16	12000
18 - 20	10000
25	8000
32	6000
40	4000
50	2500
63	2000
80	1500
100	1000

Fig. 30

Computing the rotary speed

With rotary movements, the cage speed n_K – referred to the stationary bearing component in each case – is calculated as follows:

Rotating shaft

$$\mathbf{n_K = (1 - \frac{k}{k + d_W}) \cdot \frac{n_W}{2}} \text{ [min}^{-1}\text{]}$$

Rotating bush

$$\mathbf{n_K = (1 + \frac{k}{k + d_W}) \cdot \frac{n_B}{2}} \text{ [min}^{-1}\text{]}$$

where:
d_w [mm] = shaft diameter
k [mm] = ball diameter
n_w [min^{-1}] = rotary speed of shaft
n_B [min^{-1}] = rotary speed of bush

Recommended values for permissible rotary speeds

The maximum permissible rotary speed of a rotary stroke bearing depends on the pre-loading value v, the load, the lubricating agent and the dissipation of the generated heat.

The given values are to be regarded as recommendations for pure rotary motions. Should a linear motion be added, the conditions will become less favorable, depending on the stroke length and frequency, so that the permissible rotary speeds will be slowed down considerably.

With fast rotary and linear motion, it is best to separate the types of motion.

6. Annex

6.1 Abbreviations

	Unit	Explanation
A	µm	Axis displacement at force application point
A_{10}	µm	Axis displacement of a 10 mm ball operating zone
C	N	Loading capacity for uniform radial load
C_{10}	N	Specific rated load, based on a 10 mm ball operating zone
δ_R	µm	Radial offset of the bush and shaft axis
d_w	mm	Nominal diameter of rotary stroke bearing = shaft diameter
e	mm	Momentary contact length, reference length
E	mm	Minimum contact length at end of stroke
g	m^{-1}	Moment factor for offset loads
h	-	Radial force factor for asymmetrical loading
H	mm	Stroke of rotary stroke bearing
k	mm	Ball diameter
l	mm	Lever length of offset loads
l_i	mm	Distance between contact lengths
l_1	mm	Length of guide bush
l_2	mm	Length of ball cage
l_3	mm	Distance between stop rings in a closed guide bush
M	Nm	Moment loading the rotary stroke bearing
P_R	N	Radial force on rotary stroke bearing
P_{10}	N	Specific radial force, based on the 10 mm ball operating zone under highest load
R_{10}	µm/N	Rigidity of a 10 mm ball operating zone
v	µm	Preloading

6.2 International units of measurements and material designations

Length:

1 in = 25.4 mm
1 in = 25400 µm

1 mm = 0.03937 in
1 µm = 0.00003937 in

Temperature:

5/9 x (°F – 32) = °C

(9/5 x °C) + 32 = °F

Force:

1 ozf = 0.2781 N
1 lbf = 4.4497 N

1 N = 3.5957 ozf
1 N = 0.2247 lbf

Moment:

1 ozf in = 0.007064 Nm
1 lbf in = 0.1130 Nm

1 Nm = 141.5612 ozf in
1 Nm = 8.8478 lbf in

International material designations:

100 Cr 6 (1.2067 / 1.3505)	corresponds to	AISI L3 / AISI E 52100
X155 CrVMo 12 1 (1.2379)	corresponds to	AISI Type D2 Tool Steel
X90 CrMoV 18 (1.4112)	corresponds to	AISI 440B

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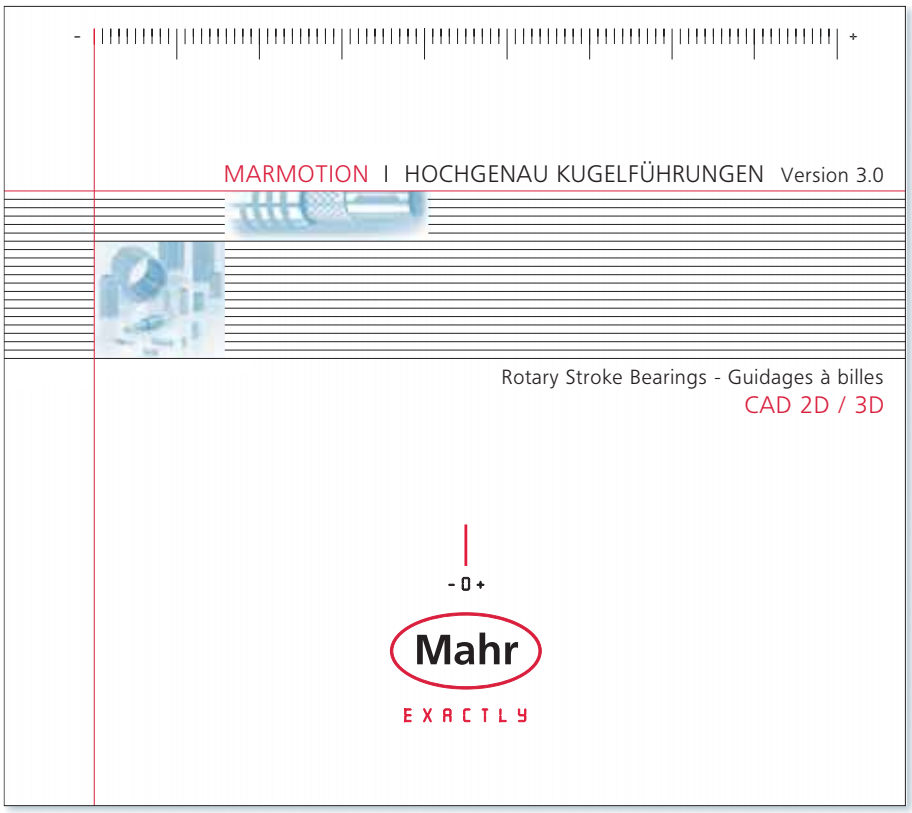

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