

Locking devices

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Locking devices

Locking devices for the axial location of high-precision bearings on the shaft must be made very accurately. Normal design lock nuts with locking washers are not entirely suitable for high-precision bearings because of the relatively large manufacturing tolerance for the thread and the abutment surfaces, which may lead to shaft deformation and alterations in the axis of rotation. They should provide even support for the inner ring around its whole circumference, preventing shaft deformation, particularly under conditions of heavy preload. They should also be simple to mount and dismount. To meet the high demands of machine tool applications, both technically and economically, SKF produces precision lock nuts, and also developed the stepped sleeve.

SKF lock nuts of the KMT and KMTA designs were developed for use with high-precision bearings and their dimensions were chosen to match. KMT and KMTA nuts have both locking pins and differ principally in their external form and also, in part, in the pitch of the thread.

Stepped sleeves are pressure joints with two fitting surfaces, of slightly different diameters, arranged adjacent to each other. They enable bearing arrangements having high running accuracy to be produced. The sleeves are not supplied by SKF but recommendations regarding design and suitable dimensions are given in the relevant section (**page 276**).



Lock nuts

Two different designs

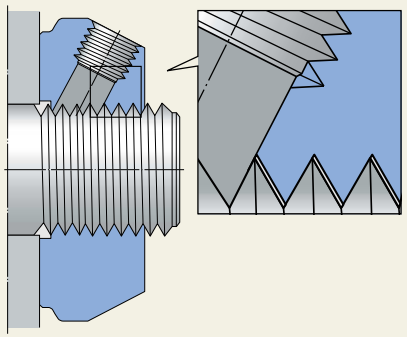
SKF manufactures two different types of precision lock nuts with locking pins: the KMT and the KMTA. Both enable bearings and other components to be simply and reliably located in the axial direction on shafts, with high accuracy. Their special design feature consists of three sintered steel locking-pins, which are equally spaced around the circumference. These pins are pressed against the shaft thread by grub screws with an internal hexagon and prevent the nut from turning. Mounting is easy and the design simple. Additional locking washers or slots in the shaft are not required. The locking pins and grub screws are arranged at the same angle to the shaft axis as that of the thread flanks. The ends of the pins are machined in a single operation with the nut thread and consequently also have a threaded profile. The nut is locked in position purely as a result of the friction between the locking pins and the shaft thread, and the adhesive friction between the flanks of the thread.

Therefore, the locking pins are not subjected to the axial loads that act on the nut. When the nut is locked, the thread flanks are not relieved of loads axially and the nut is not deformed (→ **fig 1**). Another advantage of the KMT and KMTA nuts is that they are adjustable. The three equally spaced locking pins enable the nut to be accurately positioned at right angles to the shaft, or they can be used to adjust for inaccuracies or deviations of other components that are to be located on the shaft. As the locking pins are not deformed, KMT and KMTA nuts retain their high precision irrespective of the number of times they are mounted and dismounted.

An example of application of KMT lock nuts is shown in **fig 4** **page 262**.

The locking pins and grub screws are arranged at the same angle to the shaft as that of the thread flanks

Fig 1



KMT lock nuts

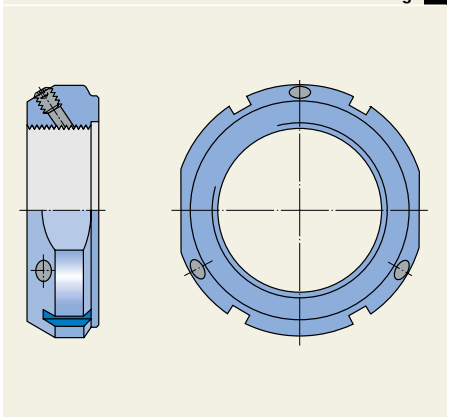
KMT lock nuts (→ **fig** 2) are designed as slotted nuts. Up to and including size 15 they are also provided with two diametrically opposed flats to accept a spanner. They are particularly suitable for applications where simple assembly and reliable locking with high precision are required.

KMTA lock nuts

KMTA lock nuts (→ **fig** 3) differ from the KMT nuts in their external form and in some cases in the thread that has a different pitch, but offer the same benefits. They have a smooth cylindrical outside surface and are intended for positions where space is limited. As the outside surface is cylindrical, the nut can also be used to form part of a gap-type seal. Holes around the circumference and in one side face facilitate mounting.

KMT design

Fig 2



KMTA design

Fig 3

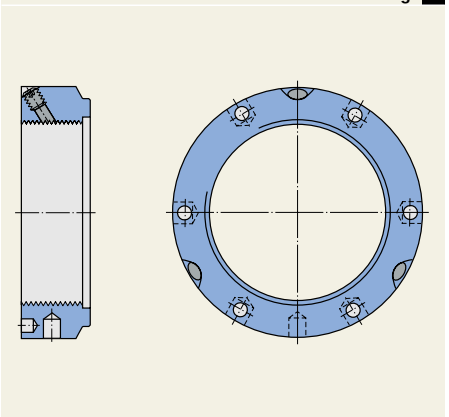
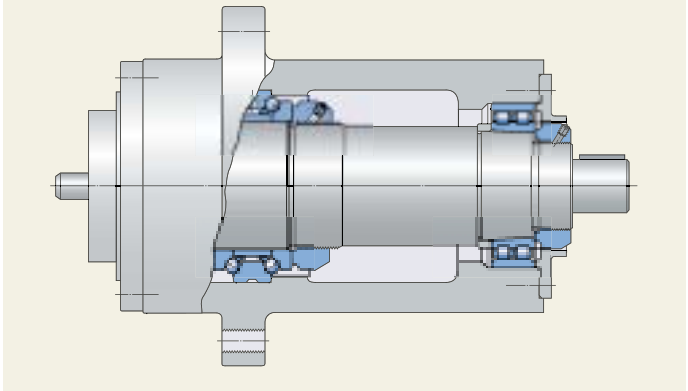


Fig 4



Application example

General data

Tolerances

The threads of KMT and KMTA nuts are made to tolerance 5H and conform to ISO 965-3:1998.

The recommended tolerance for the mating thread on the shaft is 6g and conforms also to ISO 965-3:1998.

Materials

KMT and KMTA lock nuts are made of high-strength steel; their surfaces are phosphated and oiled.

Sintered material is used for the locking pins. The grub screws conform to DIN 915:1980, strength class 45 H.

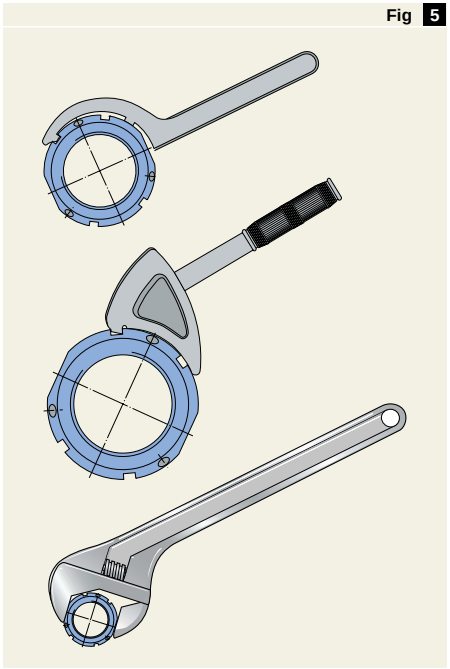
Mounting

KMT lock nuts are very simple to mount. Slots are provided around the circumference and there are two diametrically opposed flats on all nuts up to and including size 15. Various types of spanners can be used depending on the application and nut size, including hook and impact spanners (→ **fig** 5). Appropriate sizes of spanner and key (for the grub screws) are given in the product table.

The KMTA lock nuts can be tightened using hook spanners with studs to engage the holes in the circumference. Alternatively a pin-type face spanner, or a tommy bar can be used. Appropriate hook spanners are given in the product table.

Mounting KMT and KMTA lock nuts using spanners or keys

Fig 5

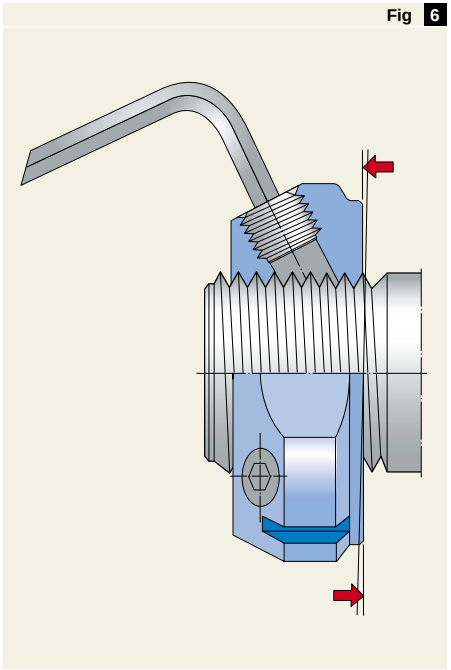


To lock the KMT and KMTA nuts, the grub screws should first be gently tightened until the thread of the locking pin engages the shaft thread. The grub screws should then be firmly tightened alternately and evenly, until the recommended tightening torque quoted in the product tables is obtained.

If it is necessary to correct for any misalignment between the abutment surfaces of the nut and adjacent component, the grub screw at the position of greatest deviation should first be loosened and the other two screws should be tightened to an equal degree. The loosened screw should then be retightened. If this correction for the misalignment is found to be inadequate, the procedure should be repeated until the desired accuracy has been achieved (→ **fig** 6). This can be checked using a dial gauge, for example.

Correction of misalignment between the abutment of the nut and adjacent component

Fig 6

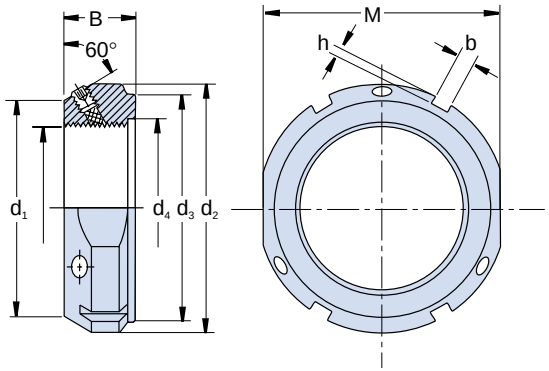


Dismounting

It should be remembered when dismounting KMT and KMTA lock nuts that the locking pins will still firmly engage the shaft thread, even after the grub screws have been loosened. Light blows with a rubber hammer to the nut, in the vicinity of the grub screws will serve to loosen the pins. The nuts can then easily be unscrewed from the shaft thread.

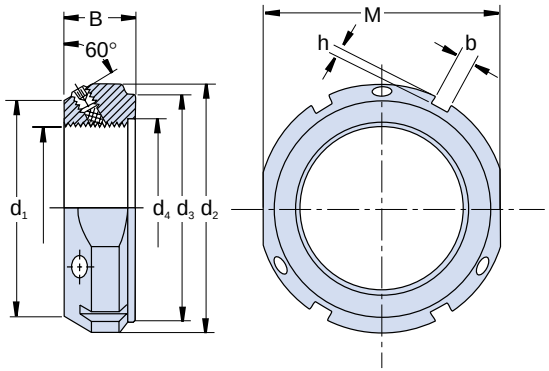
Product tables

KMT precision lock nuts

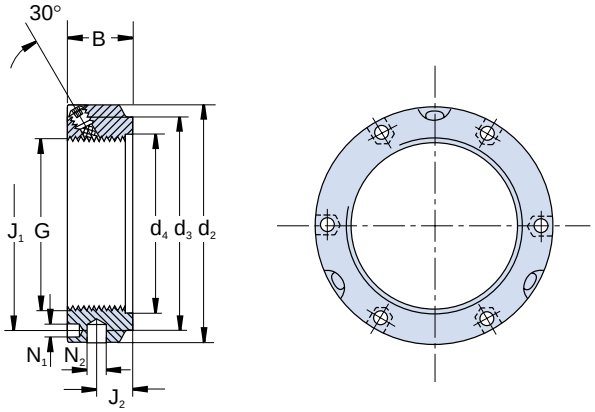


Dimensions									Axial load carrying capacity	Grub screws		Mass	Designation	Appropriate hook/impact spanner
										Size	Tightening torque max			to DIN 1810
G	d1	d2	d3	d4	B	b	h	M	static					
mm									kN	–	Nm	kg	–	–
M 10×0,75	21	28	23	11	14	4	2	24	35	M 5	4,5	45	**KMT 0**	HN 2/3
M 12×1	23	30	25	13	14	4	2	27	40	M 5	4,5	50	**KMT 1**	HN 3
M 15×1	26	33	28	16	16	4	2	30	60	M 5	4,5	75	**KMT 2**	HN 4
M 17×1	29	37	33	18	18	5	2	34	80	M 6	8	0,10	**KMT 3**	HN 4
M 20×1	32	40	35	21	18	5	2	36	90	M 6	8	0,11	**KMT 4**	HN 5
M 25×1,5	36	44	39	26	20	5	2	41	130	M 6	8	0,13	**KMT 5**	HN 5
M 30×1,5	41	49	44	32	20	5	2	46	160	M 6	8	0,16	**KMT 6**	HN 6
M 35×1,5	46	54	49	38	22	5	2	50	190	M 6	8	0,19	**KMT 7**	HN 7
M 40×1,5	56	65	59	42	22	6	2,5	60	210	M 6	8	0,30	**KMT 8**	HN 8/9
M 45×1,5	61	70	64	48	22	6	2,5	65	240	M 6	8	0,33	**KMT 9**	HN 9/10
M 50×1,5	65	75	68	52	25	7	3	70	300	M 6	8	0,40	**KMT 10**	HN 10/11
M 55×2	74	85	78	58	25	7	3	80	340	M 8	18	0,54	**KMT 11**	HN 12/13
M 60×2	78	90	82	62	26	8	3,5	85	380	M 8	18	0,61	**KMT 12**	HN 13
M 65×2	83	95	87	68	28	8	3,5	90	460	M 8	18	0,71	**KMT 13**	HN 14
M 70×2	88	100	92	72	28	8	3,5	95	490	M 8	18	0,75	**KMT 14**	HN 15
M 75×2	93	105	97	77	28	8	3,5	100	520	M 8	18	0,80	**KMT 15**	HN 15/16
M 80×2	98	110	100	83	32	8	3,5	–	620	M 8	18	0,90	**KMT 16**	HN 16/17
M 85×2	107	120	110	88	32	10	4	–	650	M 10	35	1,15	**KMT 17**	HN 17/18
M 90×2	112	125	115	93	32	10	4	–	680	M 10	35	1,20	**KMT 18**	HN 18/19
M 95×2	117	130	120	98	32	10	4	–	710	M 10	35	1,25	**KMT 19**	HN 19/20
M 100×2	122	135	125	103	32	10	4	–	740	M 10	35	1,30	**KMT 20**	HN 20
M 110×2	132	145	134	112	32	10	4	–	800	M 10	35	1,45	**KMT 22**	HN 22
M 120×2	142	155	144	122	32	10	4	–	860	M 10	35	1,60	**KMT 24**	TMFN 23-30
M 130×2	152	165	154	132	32	12	5	–	920	M 10	35	1,70	**KMT 26**	TMFN 23-30

KMT precision lock nuts

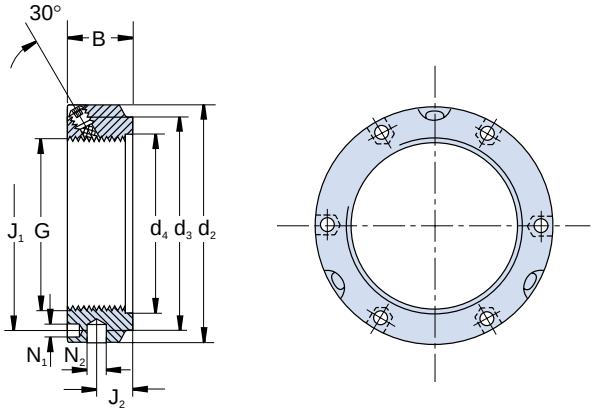


Dimensions									Axial load carrying capacity	Grub screws		Mass	Designation	Appropriate hook/impact spanner to DIN 1810
										Size	Tightening torque max			
G	d1	d2	d3	d4	B	b	h	M	static					
mm									kN	–	Nm	kg	–	–
M 140×2	162	175	164	142	32	14	6	–	980	M 10	35	1,80	**KMT 28**	TMFN 23-30
M 150×2	172	185	174	152	32	14	6	–	1 040	M 10	35	1,95	**KMT 30**	TMFN 23-30
M 160×3	182	195	184	162	32	14	6	–	1 100	M 10	35	2,10	**KMT 32**	TMFN 30-40
M 170×3	192	205	194	172	32	14	6	–	1 160	M 10	35	2,20	**KMT 34**	TMFN 30-40
M 180×3	202	215	204	182	32	16	7	–	1 220	M 10	35	2,30	**KMT 36**	TMFN 30-40
M 190×3	212	225	214	192	32	16	7	–	1 280	M 10	35	2,40	**KMT 38**	TMFN 30-40
M 200×3	222	235	224	202	32	18	8	–	1 340	M 10	35	2,50	**KMT 40**	TMFN 30-40



Dimensions									Axial load carrying capacity	Grub screws		Mass	Designation	Appropriate hook spanner
										Size	Tightening torque			
G	d_2 h11	d_3	d_4	B	J_1	J_2	N_1	N_2	static					to DIN 1810 Form B
mm									kN	–	Nm	kg	–	–
M 25×1,5	42	35	26	20	32,5	11	4,3	4	130	M 6	8	0,13	**KMTA 5**	HN 5B
M 30×1,5	48	40	32	20	40,5	11	4,3	5	160	M 6	8	0,16	**KMTA 6**	HN 6B
M 35×1,5	53	47	38	20	45,5	11	4,3	5	190	M 6	8	0,19	**KMTA 7**	HN 7B
M 40×1,5	58	52	42	22	50,5	12	4,3	5	210	M 6	8	0,23	**KMTA 8**	HN 8B
M 45×1,5	68	58	48	22	58	12	4,3	6	240	M 6	8	0,33	**KMTA 9**	HN 9B
M 50×1,5	70	63	52	24	61,5	13	4,3	6	300	M 6	8	0,34	**KMTA 10**	HN 10B
M 55×1,5	75	70	58	24	66,5	13	4,3	6	340	M 6	8	0,37	**KMTA 11**	HN 11B
M 60×1,5	84	75	62	24	74,5	13	5,3	6	380	M 8	18	0,49	**KMTA 12**	HN 12B
M 65×1,5	88	80	68	25	78,5	13	5,3	6	460	M 8	18	0,52	**KMTA 13**	HN 13B
M 70×1,5	95	86	72	26	85	14	5,3	8	490	M 8	18	0,62	**KMTA 14**	HN 14B
M 75×1,5	100	91	77	26	88	13	6,4	8	520	M 8	18	0,66	**KMTA 15**	HN 15B
M 80×2	110	97	83	30	95	16	6,4	8	620	M 8	18	1,00	**KMTA 16**	HN 16B
M 85×2	115	102	88	32	100	17	6,4	8	650	M 10	35	1,15	**KMTA 17**	HN 17B
M 90×2	120	110	93	32	108	17	6,4	8	680	M 10	35	1,20	**KMTA 18**	HN 18B
M 95×2	125	114	98	32	113	17	6,4	8	710	M 10	35	1,25	**KMTA 19**	HN 19B
M 100×2	130	120	103	32	118	17	6,4	8	740	M 10	35	1,30	**KMTA 20**	HN 20B
M 110×2	140	132	112	32	128	17	6,4	8	800	M 10	35	1,45	**KMTA 22**	HN 22B
M 120×2	155	142	122	32	140	17	6,4	8	860	M 10	35	1,85	**KMTA 24**	HN 22B
M 130×3	165	156	132	32	153	17	6,4	8	920	M 10	35	2,00	**KMTA 26**	B 155-165
M 140×3	180	166	142	32	165	17	6,4	10	980	M 10	35	2,45	**KMTA 28**	B 180-195
M 150×3	190	180	152	32	175	17	6,4	10	1 040	M 10	35	2,60	**KMTA 30**	B 180-195
M 160×3	205	190	162	32	185	17	8,4	10	1 100	M 10	35	3,15	**KMTA 32**	B 205-220

KMTA precision lock nuts



Dimensions									Axial load carrying capacity	Grub screws		Mass	Designation	Appropriate hook spanner
G	d_2 h11	d_3	d_4	B	J_1	J_2	N_1	N_2	static	Size	Tightening torque max			to DIN 1810 Form B
mm									kN	–	Nm	kg	–	–
M 170×3	215	205	172	32	195	17	8,4	10	1 160	M 10	35	3,30	**KMTA 34**	B 205-220
M 180×3	230	215	182	32	210	17	8,4	10	1 220	M 10	35	3,90	**KMTA 36**	B 230-245
M 190×3	240	225	192	32	224	17	8,4	10	1 280	M 10	35	4,10	**KMTA 38**	B 230-245
M 200×3	245	237	202	32	229	17	8,4	10	1 340	M 10	35	3,85	**KMTA 40**	B 230-245

Stepped sleeves

Two different designs

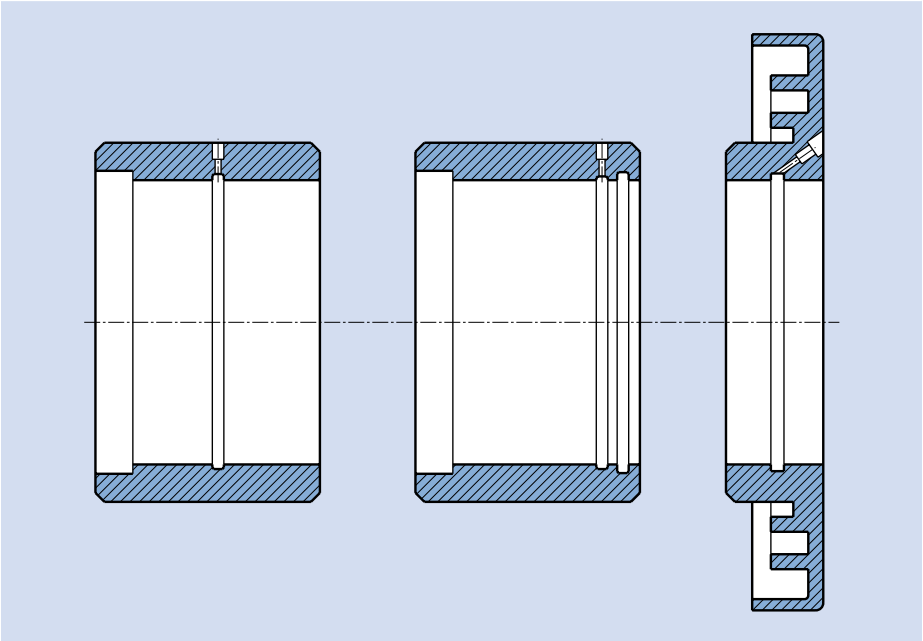
Stepped sleeves can either have a conventional sleeve form, or it may be ring-shaped. Ring-shaped stepped sleeves are used, for example, where the sleeve is not only intended for the axial location of a bearing, it is also required to form part of a labyrinth seal (→ **fig 1**). The stepped design of the fitting surface was chosen principally to facilitate removal of the sleeve, but also to simplify alignment after mounting. If pressurised oil is injected through the sleeve to its seating, a directed axial force will be produced which causes the sleeve to slide from its seating as soon as a sufficient thickness of oil film has been built up to separate the mating surface. For manufacturing reasons, or where relatively small axial forces are needed, the side of the sleeve having the smaller diameter surface can be given a loose fit on the shaft. In order to be able to use the oil injection method to dismount the sleeve, its bore at this side should be sealed by means of an O-ring. Stepped sleeves of this design exert only half of the axial retaining force of normal stepped sleeves.

Compared to threaded locking nuts, stepped sleeves ensure a superior accuracy, provided they are manufactured to a high degree of accuracy. Conversely, stepped sleeves are expensive to manufacture, have to be designed properly, and require a proper mounting procedure.

Stepped sleeves are generally used in very high-speed spindles, where the accuracy granted by conventional locking devices may not be sufficient.

Stepped sleeves: design examples

Fig 1



General data

Dimensions

Stepped sleeves are not supplied by SKF and must be produced by the user.

Recommended dimensions for stepped sleeves with and without an O-ring, and their seating are given in the product tables (**pages 280 – 283**). When dimensioning and manufacturing stepped sleeves, and the corresponding shaft seating, it is necessary to keep the difference in the degree of interference, between the two seats of fitting surfaces as small as possible. Experience has shown that dismounting is difficult if the difference is too large. The best approach is to start with the difference between diameters – the so-called step – as it is easier to keep within narrow tolerances for this diameter difference than for the diameter itself.

Material

It is recommended that a steel, which can be heat-treated, with a yield point of at least 550 MPa should be used for the sleeve. Both sleeve and shaft should be hardened. The fitting surfaces in the sleeve and on the shaft should be ground.

Axial load carrying capability

The axial load carrying capacity of the joint can be calculated with the following formula:

$F = \mu \pi d L p$

F = axial load carrying capacity of the joint, N
μ = friction coefficient
L = length of the joint, mm

The friction coefficient, μ, can be assumed to be 0,14.

Assuming that both components are made of steel, the surface pressure between sleeve and shaft can be determined by the following equation:

$$p = \frac{206\,000\,\Delta}{\left(\frac{1+c_i^2}{1-c_i^2} + \frac{1+c_e^2}{1-c_e^2}\right) d}$$

where (→ **fig 2**):

p = surface pressure, MPa
Δ = interference fit, mm
$c_i = d_i/d$
$c_e = d_e/d$
d_i = bore diameter of shaft, mm
d = outside diameter of shaft, mm
d_e = outside diameter of sleeve, mm

For stepped sleeves on solid shafts or thick-walled hollow shafts, the following surface pressures are obtained in the sleeve/shaft contacts, if recommendations regarding dimensions and tolerances have been followed:

- approximately 40 MPa for diameters of approximately 30 mm
- approximately 35 MPa for diameters of approximately 100 mm
- approximately 22 MPa for diameters of approximately 200 mm

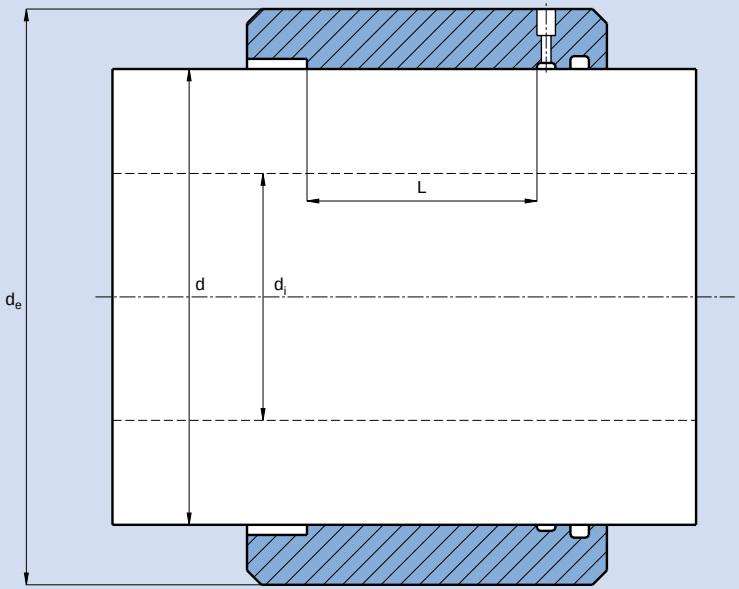
These produce retaining forces of approximately 300, 550 and 1 000 N per mm hub width respectively. Based on these values, it is possible to make a rough estimate of the retaining force that can be exerted by a mounted stepped sleeve.

When designing the stepped sleeve, shock forces acting in an axial direction on the sleeve must also be taken into consideration. If necessary, a threaded nut which is lightly tightened, and which can also serve as a mounting aid, can be used to secure the sleeve.

Thin-walled shafts may be subject to a relatively large diametrical deformation as the contact pressure must be high. Therefore, the sleeve for shafts of this kind should be made with a relief closest to the bearing, to avoid deformation of the bearing seating. The length of the relief should be 15 – 20 % of the shaft diameter.

Dimensions for the calculation of the axial load carrying capability

Fig 2



Mounting and dismounting

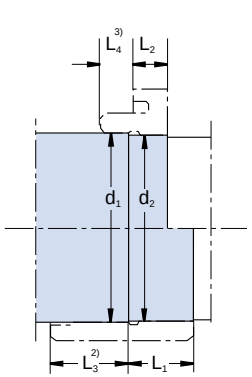
To mount the stepped sleeve on the shaft, it should first be heated to a temperature higher than that of the shaft, by the number of degrees given in the dimension tables. It should then be pushed on its shaft seating. After it has cooled, oil should be injected between the mating surfaces and a suitable tool used to bring the sleeve into its correct position. In order to avoid localised stress peaks from occurring, the oil should be injected slowly and the oil pressure regulated. As the sleeve 'swims' on an oil film, any stresses produced during the shrinking on the sleeve will be relieved, and the components can be correctly positioned with respect to each other. After mounting has been completed the oil between the mating surfaces must be allowed to drain and the mounting tool must remain in position whilst this happens. Normally it takes some 24 hours before the sleeve can support its full load. If stepped sleeves are to be mounted against bearings that are already greased, care should be taken to see that the injected oil does not mix with the grease and impair its lubricating properties.

To dismount the sleeve it is only necessary to inject oil between the sleeve and shaft. When an oil film has been built up and separates the mating surfaces, an axial force will result from the stepped diameters, and the sleeve will slide from its seating without any external force being required. As the sleeve may be ejected from its seating quite suddenly, it is recommended that a stop be provided on the shaft.

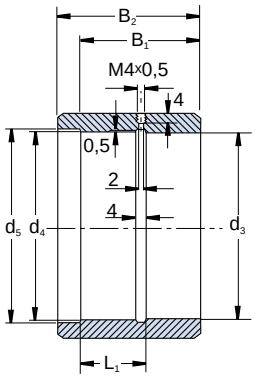
Further information on stepped sleeves dismounting and mounting are shown in the Chapter Principles of bearing selection and application, section dismounting, mounting and inspection **page 84**.

Dimension tables

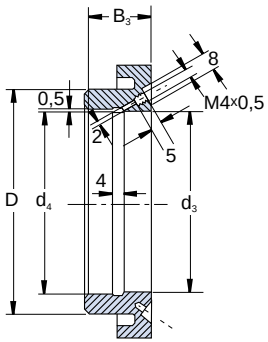
Recommended dimensions for stepped sleeve and their seatings



Shaft



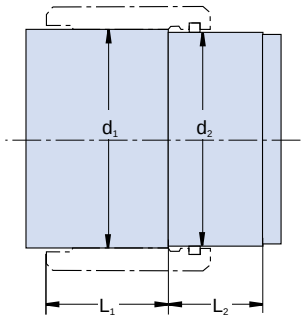
Stepped sleeve



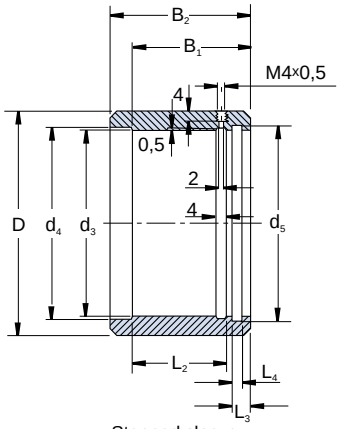
Stepped ring

Dimensions Shaft		Stepped sleeve or ring									Temperature differential[1]
d_1 h_4	d_2 h_4	d_3 H_4	d_4 H_4	d_5 +0,5	D	B_1	B_2	B_3	L_1 j_{13}	L_2 j_{13}	
mm											degrees
17	16,968	16,95	16,977	19	27	26	31	13	15	8,5	120
20	19,964	19,94	19,971	22	30	28	33	14	16	9	120
25	24,956	24,92	24,954	27	35	30	35	15	17	9,5	120
30	29,946	29,91	29,954	32	40	32	38	16	18	10	120
35	34,937	34,9	34,943	37	47	34	40	17	19	10,5	110
40	39,937	39,9	39,943	42	52	36	42	18	20	11	110
45	44,927	44,88	44,933	47	58	38	46	19	21	11,5	110
50	49,917	49,86	49,923	52	63	40	48	20	22	12	110
55	54,908	54,85	54,922	57	70	42	50	21	23	12,5	110
60	59,908	59,85	59,922	62	75	44	54	22	24	13	110
65	64,898	64,83	64,912	67	80	46	56	23	25	13,5	90
70	69,898	69,83	69,912	72	86	48	58	24	26	14	90
75	74,898	74,83	74,912	77	91	50	60	25	27	14,5	90
80	79,888	79,82	79,912	82	97	52	62	26	28	15	90
85	84,88	84,81	84,9	87	102	54	64	27	29	15,5	90
90	89,88	89,8	89,9	92	110	56	68	28	30	16	90
95	94,87	94,79	94,9	97	114	58	70	29	31	16,5	70
100	99,87	99,79	99,9	102	120	60	72	30	32	17	70
105	104,87	104,78	104,89	107	125	62	74	31	33	17,5	70
110	109,86	109,77	109,89	112	132	64	76	32	34	18	70
120	119,86	119,77	119,89	122	142	68	80	34	36	19	70
130	129,852	129,75	129,868	132	156	72	84	36	38	20	70
140	139,852	139,74	139,858	142	166	76	88	38	40	21	70
150	149,842	149,73	149,858	152	180	80	95	40	42	22	70

Recommended dimensions for stepped sleeve with O-ring and their seating



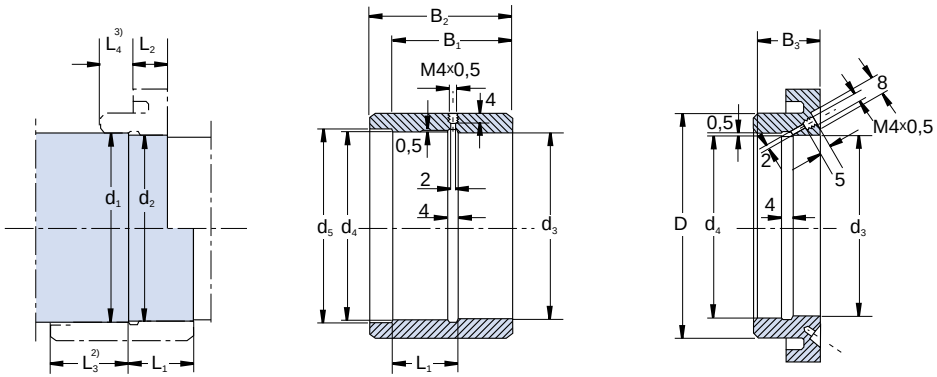
Shaft



Stepped sleeve

Dimensions Shaft		Stepped sleeve											Appropriate O-ring	Temperature differential[1]
d_1 h_4	d_2 f_7	L_1 j_{13}	d_3 H_4	d_4 +0,5	d_5 H_9	D	B_1	B_2	L_2 j_{13}	L_3	L_4 +0,2			
mm													–	degrees
17	16,95	17	16,977	19	20,6	27	26	31	16	6,5	3,1	16,3×2,4		120
20	19,95	19	19,971	22	23,6	30	28	33	18	6,5	3,1	19,3×2,4		120
25	24,9	21	24,954	27	29,5	35	30	35	20	7	3,9	24,2×3,0		120
30	29,9	24	29,954	32	34,5	40	32	38	22	7	3,9	29,2×3,0		120
35	34,9	26	34,943	37	39,5	47	34	40	24	7	3,9	34,2×3,0		110
40	39,9	28	39,943	42	44,5	52	36	42	26	7	3,9	39,2×3,0		110
45	44,9	32	44,933	47	49,5	58	38	46	28	7	3,9	44,2×3,0		110
50	49,9	34	49,923	52	54,5	63	40	48	30	7	3,9	49,2×3,0		110
55	54,9	36	54,922	57	59,5	70	42	50	32	7	3,9	54,2×3,0		110
60	59,9	40	59,922	62	64,5	75	44	54	34	7	3,9	60,0×3,0		110
65	64,85	42	64,912	67	69,5	80	46	56	36	7	3,9	65,0×3,0		90
70	69,85	42	69,912	72	74,5	86	48	58	36	8	3,9	69,5×3,0		90
75	74,85	44	74,912	77	79,5	91	50	60	38	8	3,9	74,5×3,0		90
80	79,85	46	79,912	82	84,5	97	52	62	40	8	3,9	79,5×3,0		90
85	84,85	48	84,9	87	89,5	102	54	64	42	8	3,9	85,0×3,0		90
90	89,85	52	89,9	92	94,5	110	56	68	44	8	3,9	90,0×3,0		90
95	94,85	54	94,9	97	99,5	114	58	70	46	8	3,9	94,5×3,0		70
100	99,85	54	99,9	102	104,5	120	60	72	46	9	3,9	100,0×3,0		70
105	104,85	56	104,89	107	109,5	125	62	74	48	9	3,9	105,0×3,0		70
110	109,85	58	109,89	112	114,5	132	64	76	50	9	3,9	110,0×3,0		70
120	119,85	62	119,89	122	124,5	142	68	80	54	9	3,9	120,0×3,0		70
130	129,8	66	129,868	132	134,4	156	72	84	58	9	3,9	130,0×3,0		70
140	139,8	70	139,858	142	144,4	166	76	88	62	9	3,9	140,0×3,0		70
150	149,8	73	149,858	152	159	180	80	95	62	13	7,4	149,2×5,7		70

Recommended dimensions for stepped sleeve and their seatings

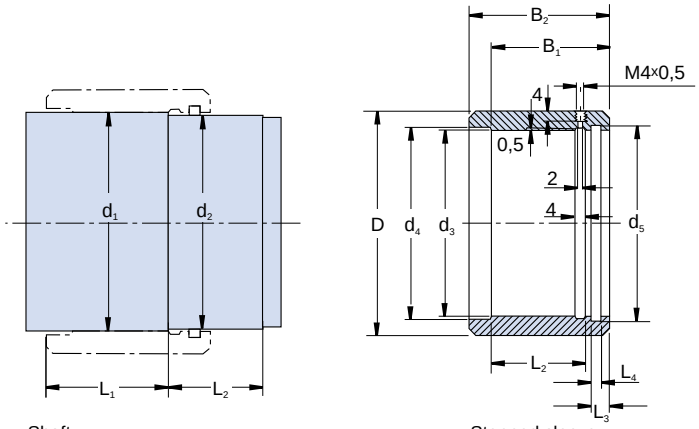


Shaft | Stepped sleeve | Stepped ring

Dimensions Shaft		Stepped sleeve or ring									Temperature differential[1]
d_1 h_4	d_2 h_4	d_3 H_4	d_4 H_4	d_5 +0,5	D	B_1	B_2	B_3	L_1 j_{13}	L_2 j_{13}	
mm											degrees
160	159,842	159,73	159,858	162	190	84	99	42	44	23	70
170	169,842	169,72	169,848	172	205	88	103	44	46	24	70
180	179,832	179,71	179,848	182	220	92	110	46	48	25	70
190	189,834	189,7	189,836	192	230	96	114	48	50	26	70
200	199,834	199,7	199,836	202	245	100	118	50	52	27	60

[1] The difference in temperature between shaft and sleeve (ring) when mounting
[2] L_3 = length of stepped sleeve over diameter $d_1 = L_1 + B_2 - B_1 - 4$ (mm)
[3] L_4 = length of stepped ring over diameter $d_1 = L_2 - 4 +$ recessed d_4 section (mm)

Recommended dimensions for stepped sleeve with O-ring and their seating



Shaft | Stepped sleeve

Dimensions Shaft		Stepped sleeve											Appropriate O-ring	Temperature differential[1]
d_1 h_4	d_2 f_7	L_1 j_{13}	d_3 H_4	d_4 +0,5	d_5 H_9	D	B_1	B_2	L_2 j_{13}	L_3	L_4 +0,2			
mm													–	degrees
160	159,8	77	159,858	162	169	190	84	99	66	13	7,4		159,2×5,7	70
170	169,8	81	169,848	172	179	205	88	103	70	13	7,4		169,2×5,7	70
180	179,8	88	179,848	182	189	220	92	110	74	13	7,4		179,2×5,7	70
190	189,8	92	189,836	192	199	230	96	114	78	13	7,4		189,2×5,7	70
200	199,8	96	199,836	202	209	245	100	118	82	13	7,4		199,2×5,7	60

[1] The difference in temperature between shaft and sleeve (ring) when mounting